Article

Visualization Analysis of Global Self-Regulated Learning Status, Hotspots, and Future Trends Based on Knowledge Graph

Linchao Huang [1], Jincheng Zhou [2,3,4,*], Dan Wang [1,3,4], Fang Wang [5], Jiu Liu [1], Dingpu Shi [2], Xiaohong Chen [1], Duo Yang [2] and Qingna Pan [2]

1 School of Mathematics and Statistics, Qiannan Normal University for Nationalities, Duyun 558000, China
2 School of Computer and Information, Qiannan Normal University for Nationalities, Duyun 558000, China
3 Key Laboratory of Complex Systems and Intelligent Optimization of Guizhou Province, Duyun 558000, China
4 Key Laboratory of Complex Systems and Intelligent Optimization of Qiannan, Duyun 558000, China
5 School of Chemistry and Chemical Engineering, Qiannan Normal University for Nationalities, Duyun 558000, China
* Correspondence: zjc8l@sgmtu.edu.cn

Abstract: Self-regulated learning (SRL) has been an important topic in the field of global educational psychology research since the last century, and its emergence is related to researchers' reflections on several educational reforms. To better study the research history and developmental trend of SRL, in this work, the Web of Science core collection database was used as a sample source, "self-regulated learning" was searched as the theme, and 1218 SSCI documents were collected from 30 September 1986, to 2022. We used CiteSpace software to visualize and analyze the number of publications, countries, institutions, researchers, keywords, highly cited literature, authors' co-citations, keyword clustering, and timeline in the field of self-regulated learning research, and to draw related maps. It was found that the articles related to self-regulated learning were first published in the American Journal of Educational Research in 1986, and that self-regulated learning-related research has received increasing attention in recent decades, wherein research on self-regulated learning is roughly divided into three periods: the budding period from 1986 to 2002, the flat development period from 2003 to 2009, and the rapid development period from 2010 to 2022. The number of papers published in the United States, China, Australia, and Germany is relatively high, and the number of papers published in Spain is low compared with that in the United States. During this period, the University of North Carolina in the United States and McGill University in Canada were the institutions with the most publications; Azevedo Roger and Lajoie Susanne P were the most-published scholars in the field of self-regulated learning research; the journal publication with the highest impact factor was Computers Education; and the primary research interests in self-regulated learning mainly focused on Performance, Strategy, Students, Achievement, Motivation, and Metacognition. Furthermore, the most-cited study related to SRL research was Formative assessment and self-regulated learning: a model and seven principles of good feedback practice.

Keywords: self-regulated learning; CiteSpace; knowledge graph

1. Introduction

Since the 1980s, self-regulated learning (SRL) has been an attractive topic in the field of global educational psychology research. The first publication on self-regulated learning, introduced as a form of autonomous learning, was produced by Zimmerman [1] in 1986 in The American Journal of Educational Research under the title Development of a Structured Interview for Assessing Student Use of Self-Regulated Learning Strategies, which did not provide a substantive definition. It was not until 1989 that Zimmerman [2] argued that self-regulated learning is a process in which learners actively engage, to varying extents, in their learning activities in terms of metacognition, motivation, and behavior. Endler, Kocorski, and Brown lee et al. (2000) [3] argued that self-regulated learning

should include goal setting, effort processes and strategies, feedback, and self-evaluation. Pintrich (2000) [4] considers self-regulated learning as an active, constructive learning process. Boekaerts (2002) [5], on the other hand, considers self-regulated learning to consist of the processing of thoughts and feelings and active attempts in which these are used to achieve personal goals. It is evident that different experts have different understandings of self-regulated learning, but their understanding of the nature of self-regulated learning is largely the same.

The most distinctive feature of self-regulated learning is that learners have actual control over their learning experience, mastering and directing cognitive and motivational processes to achieve their learning goals. As a result, Zimmerman proposed a three-dimensional model of self-regulated learning based on Bandura's sociological theory that self-regulated learning is determined by the interaction of the individual, the environment, and behavior. In 2002, Zimmerman [6] proposed another classic model of self-regulated learning that includes three cyclical stages: planning, implementation, and self-reflection. Although these models differ in terms of labeling and what is included, they all agree that learning is regulated by various dynamic interactions and cyclical cognitive, metacognitive, and motivational factors (Panadero, 2017) [7]. Similarly, Pokay [8] (1990) classified self-regulated-learning strategies into three categories, namely, metacognitive strategies, cognitive strategies, and resource manipulation strategies, wherein the learners control their learning experience by implementing metacognitive monitoring and strategies as well as motivational factors such as self-efficacy and the setting of task values. Some scholars (Boekaerts and Corno [9]; Pintrich [10]) also consider self-regulated learning as a process in which learners use self-awareness and self-reflection to monitor and regulate their internal abilities and responses to the internal and external environment. Through an experimental method, Shih [11] et al. (2010) tested the effectiveness of a self-regulated learning system with scaffolded instructions with regard to promoting self-regulated learning among secondary school students; consequently, the system significantly enhanced the self-regulated learning skills of students in the low self-regulation group. Furthermore, in their study of ePortfolios, Cheng (2013) et al. [12] identified five sub-processes associated with higher performance, namely, refinement strategies, resource organization, critical thinking, metacognitive self-regulation, and peer learning. Self-regulated learning serves as the key to learners' regulation of their learning strategies, and a large body of research has shown that external feedback from teachers can facilitate students' self-regulated learning, which emphasizes a holistic perspective on the impact of different psychological factors on students' ability to learn effectively. Although a large amount of work related to self-regulated learning research has been conducted, after reading and summarizing a large volume of the related literature, it is evident there is still a lack of systematic and objectively organized research. In this context, it is particularly important to conduct an effective, in-depth analysis of the field.

In recent years, knowledge mapping has been widely used as a new method for bibliometrics, but an analysis has not yet been conducted in which self-regulated learning research from the WOS database is analyzed using CiteSpace software. Therefore, this paper visualizes and analyzes the number of papers published in the field of self-regulated learning research, as well as the research countries, research institutions, researchers, hot keywords, the amount of highly cited literature, keyword clustering, the research timeline, and emergent citation analyses, and draws a relevant map using CiteSpace software. The software not only shows the evolution of a knowledge field and current trends, but it also has the characteristics of intuitiveness, scientificity, and objectivity, which helps to understand the research frontier and overall pulse more comprehensively.

2. Data Sources and Research Methods

2.1. Data Collection

To improve the directivity and authority of self-regulated learning research, the Web of Science (WOS) core collection database and the Social Sciences Citation Index (SSCI) were selected

as the sample data sources, and the search topic was set as Topic = "Self-Regulated Learning". The category perused on the Web of Science was limited to Education Educational Research, the document type was set to "article", the language was "English", and a total of 1239 documents were retrieved (search date: 1 September 2022). Finally, the data were exported as a plain text file with the contents of the "Full Record with Cited References" record. The 1239 documents were screened using CiteSpace software, and the results were validated by experienced computer researchers, resulting in the acquirement of 1218 documents related to self-regulated learning. According to the existing SSCI literature, research on self-regulated learning began in 1986 (Zimmerman, 1986); therefore, self-regulated learning research results from 1986–2022 (retrieved up to 30 September 2022) were selected for this study, and the period was set to 1986–2022, with each article containing author(s), institution keywords, abstract, date of publication, and other information.

2.2. Research Tools and Methods

This research uses CiteSpace software to visually analyze the literature data on self-regulated learning research and adopts a hybrid research method combining quantitative research, i.e., bibliometrics, and qualitative research, i.e., literature content analysis, to explore and analyze the current state and developmental trend of self-regulated learning research. CiteSpace [13] is a Java-based visualization software that can draw knowledge graphs, which was jointly developed by Professor Chen Chaomei of Drexel University and the WISE Laboratory of Dalian University of Technology. It is remarkably powerful social network analysis software. When running CiteSpace, we found that two metrics are important, namely, the Modularity Q value and the Silhouette value, which characterize good or bad clustering effects. When the Modularity Q value is expressed as the evaluation index of network modularity, the value range of Q is [0,1], and it is generally considered that Q > 0.3 means that the clustering effect is significant; its corresponding calculation formula is as follows:

$$Q = \frac{1}{2m} \sum (a_{ij} - p_{ij}) \sigma(C_i, C_j) \tag{1}$$

In Equation (1), $A = a_{ij}$ is the adjacency matrix in the actual network. p_{ij} is the expected value of the number of lines between nodes in the null model. C_i and C_j represent the community that node i and node j belong to in the network. If i and j belong to the same community, then $\sigma = 1$; otherwise, $\sigma = 0$.

Silhouette value is an elaboration proposed by Kaufman and Rousseeuw [14] to evaluate the effect of clustering, and the value of S is taken in the range of [−1,1]; it is generally considered that if S > 0.5, the degree of clustering is reasonable, and S > 0.7 implies that the clustering results are convincing. Its corresponding calculation formula is as follows:

$$S_i = \begin{cases} 1 - a(i)/b(i), & a(i) < b(i) \\ 0, & a(i) = b(i) \\ b(i)/a(i) - 1, & a(i) > b(i) \end{cases} \tag{2}$$

In Equation (2), a is the average distance between point i and other points in the class, and b is the average distance between point i and all points in the class of the nearest point i.

3. Analysis of Research Results

3.1. Annual Distribution of the Number of Studies

The annual distribution of the number studies reflects the overall situation and research trend, which can be used to analyze the relationship between the number of papers published in a specific field and the changes over time in a given field [15]. According to the retrieved literature, an annual graph of papers related to self-regulated learning was drawn (Figure 1). The research on self-regulated learning shows an increasing trend, which

indicates that self-regulated learning has attracted increasing attention from the global academic community. The research and development of self-regulated learning can be divided into three stages.
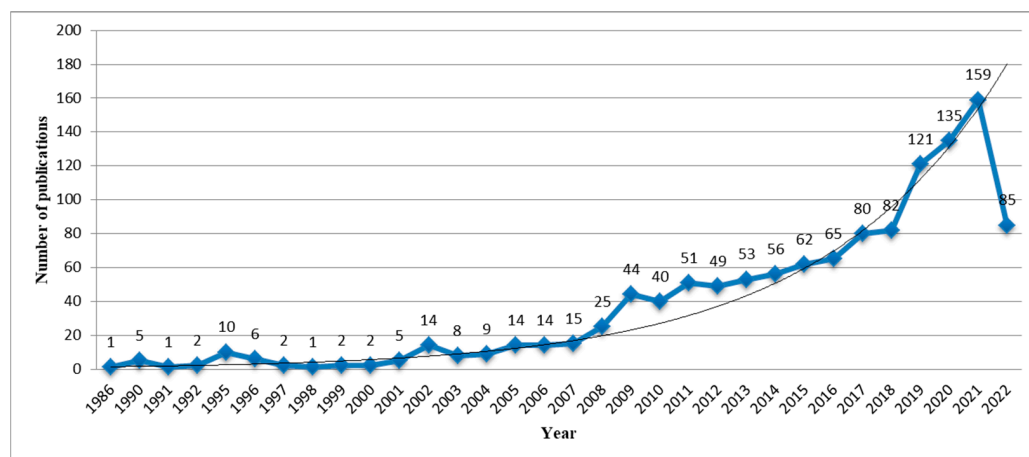

Figure 1. Annual distribution of publications on self-regulated learning from 1986 to 2022.

The first stage (1986–2002): As can be seen from the figure, before 2002, the number of research articles published each year was relatively small, with only 4.25 articles published annually, and the earliest one appeared in 1986; it was published by Zimmerman, and was titled [1] Development of a Structured Interview for Assessing Student Use of Self-Regulated Learning Strategies. In this early stage, Zimmerman [16] (2000) defined self-regulation from the perspective of social cognition as a specific environmental process that is reused to achieve personal goals, including metacognitive knowledge and skills, emotional and behavioral processes, and self-efficacy with respect to the regulatory process. Boekaerts [17] conducted a conceptual review of self-regulated learning according to four dimensions. The first dimension describes six types of prior knowledge. In the second dimension, according to relevant records in the literature, SRL is not only a complex, demanding, and deliberate activity, but it is also a simple, habitual, and automatic activity. In the third dimension, some scholars believe that cognitive self-regulation has been applied in some fields and can be taught; in the Fourth dimension, the position of motivational self-regulation in the model of the six components of self-regulated learning is clarified. During this period, Paris SG and Paris AH [18] (2001) mainly discussed how self-regulated learning was applied in classroom teaching practices, and its application in reading and writing strategies, cognitive engagement, and self-evaluation received a great deal of attention.

The second stage (2003–2009): At this stage, the number of studies showed a slow increase, with the average annual number of articles published in this period being 18.43, which were mainly concentrated in the USA, China, and Australia. According to Schraw [19], SRL consists of three main components: metacognition, motivation, and cognition. Furthermore, self-regulated learning (SRL) is a process in which learners use self-awareness and self-reflection to monitor and regulate their internal abilities and responses to internal and external environments [6,10] (Boekaerts and Corno [9], 2005; Pintrich [10], 2004; Zimmerman [6], 2002). Whitebread et al. [20] (2009) reported and discussed the development of measurement and evaluation tools for children's metacognition and self-regulated learning to achieve more effective measurement of children's metacognition and self-regulated learning ability. With the refinement of the theories and the continuous exploration of practice, this phase became an important foundational period for the development of self-regulated learning research.

The third stage (2010–2022): In this stage, the literature on self-regulated learning continues to increase; thanks to the improvement of the theoretical framework, the annual number of papers published is 79.8, which is 4.3 times the annual number of papers published in the previous stage. At this stage, the scholars Moos [21] (2014) and Panadero [22]

(2017) et al. believe that primary school teachers implement more self-regulated learning practices than middle school teachers, but these studies do not seem to be based on the same self-regulated learning measurement. In addition, with the development and alteration of tools for multi-modal data collection, the research on self-regulated learning has diversified and developed high precision.

3.2. Analysis of Important Publications

The quantified statistics of the research sample showed that 1239 papers related to self-regulated learning were published in 167 journals, and the top 10 of all SSCI-published journals were Metacognition and Learning, Computers & Education, Learning and Instruction, Educational Psychologist, Interactive Learning Environments, Internet and Higher Education, Instructional Science, Journal Of Computer-Assisted Learning, Educational Psychology, and Etr&D (Educational Technology Research and Development). The number of publications in these journals accounted for 39% of the total number of studies selected. Among them, more than 60 articles were published in the following journals: Metacognition and Learning, Computers and Education, and Learning and Instruction. These publications have a high impact factor and are important publications in the research into education or psychology (Table 1), which shows that self-regulated learning research has been scrutinized by the global academic community.

Table 1. Top ten publications on self-regulated learning from 1986 to 2022.

Title of Publication	Impact Factor	Article Number	Percentage
Metacognition and Learning	2.704	84	6.90%
Computers and Education	11.182	67	5.50%
Learning and Instruction	6.636	61	5.00%
Educational Psychologist	8.209	41	3.37%
Interactive Learning Environments	4.965	37	3.04%
Instructional Science	2.225	33	2.71%
Internet and Higher Education	8.591	32	2.63%
Journal Of Computer-Assisted Learning	3.761	30	2.46%
Educational Psychology	3.117	28	2.30%
Etr&D—Educational Technology Research and Development	5.58	28	2.30%

3.3. Analysis of Published Countries and Institutions in the Field of Global Self-Regulated Learning Research

3.3.1. Country Analysis

The number of articles published by a country reflects its importance, influence, and contribution to the field [23]. Combined with the statistical analysis function of WOS, the top eight published countries were selected, as shown in Table 2. The United States accounted for the greatest proportion, its contribution corresponds to 329 articles, accounting for 27.01% of the total. Although China ranked second in terms of the number of articles published, it was far behind the USA, accounting for 10.84% of the articles published. Australia, Germany, The Netherlands and Canada had a similar number of publications (90~110). Compared with the above countries, the numbers of publications from Chinese Taiwan and Spain are relatively small, with Spain at the bottom of the list having only 60 publications. In general, the research gap between countries regarding self-regulated learning is still large, with most studies being mainly concentrated in the USA, China, and other countries. This is related to the developmental history of self-regulated learning. Self-regulated learning was originally proposed by the American educational psychologist George Zimmerman, who played a leading role in the field, making the United States the main field of self-regulated learning research. The research on self-regulated learning in China is relatively late. Tang SYF [24] (2007) initially studied self-regulated

learning. Through efforts, the research on self-regulated learning in China has also strongly influenced the world.

Table 2. Study the top eight published statistics of countries.

Serial No.	Countries	Article Number	Percentage
1	USA	329	27.01%
2	China	132	10.84%
3	Australia	107	8.78%
4	Germany	106	8.70%
5	The Netherlands	102	8.37%
6	Canada	92	7.55%
7	Chinese Taiwan	74	6.08%
8	Spain	60	4.93%

To explore the degree of cooperation between countries and the intensity of cooperation, CiteSpace was used to conduct a co-occurrence analysis of the published countries, and the time slice was set to three. The results are shown in Figure 2. Each node (N = 59) represents an institution, and the larger the annual ring, the greater the number of publications. The connections between nodes (E = 187) reflect the connections and cooperation between countries. In terms of national distribution, the United States has the highest number of articles published (329 articles), followed by China (132 articles) and Australia (107 articles). These countries are closely connected, with the United States forming the center. Among them, the three countries with the greatest abruptness are the USA (0.40), Australia (0.24), and The Netherlands (0.21), indicating that they play a prominent role in the fundamental direction of research.
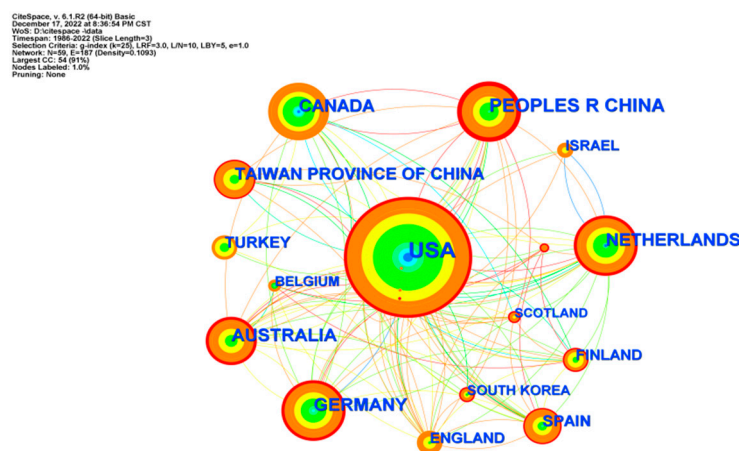

Figure 2. National Cooperation Network of self-regulated learning research from 1986 to 2022.

3.3.2. Institutional Analysis

Institutional analysis can be used to obtain the distribution of research power in each research field, as shown in Table 3, which shows the top eight research institutions in the field of self-regulated learning from 1986 to 2022. The University of North Carolina in the United States is the institution with the largest number of articles published, with 38 articles published, accounting for 3.12% of the total research volume. It shows that the United States still occupies an absolute position with respect to the study of self-regulated learning. McGill University in Canada published 35 articles, accounting for 2.87% of the total research. Maastricht University and Open University Netherlands also have outstanding performance and now occupy important positions in the field of self-regulated learning. Among the top eight research institutions with respect to the number of published articles, there are two American institutions, specifically, the University of North Carolina and the State University System of Florida; there are three universities in The Netherlands,

namely, Maastricht University, Open University Netherlands, and Utrecht University. McGill University, the Chinese University of Hong Kong, and the University of Oulu are located in Canada, China, and Finland, respectively.

Table 3. Statistics published by research institutions.

Serial No.	Institutions	Countries	Number of Articles	Percentage
1	University of North Carolina	USA	38	3.12%
2	McGill University	Canada	35	2.87%
3	Maastricht University	The Netherlands	29	2.38%
4	Open University Netherlands	The Netherlands	29	2.38%
5	State University System of Florida	USA	28	2.29%
6	University of Oulu	Finland	26	2.13%
7	Chinese University of Hong Kong	China	24	1.97%
8	Utrecht University	The Netherlands	22	1.81%

To explore the distribution of cooperative research fields and the cooperation intensity among institutions, CiteSpace was used to conduct an institutional cooperation map analysis, as shown in Figure 3. The results show that the number of nodes (N) is 392, the number of connections (E) is 342, and the network density (D) is 0.0045. Although McGill University, the largest node, published more articles, it had fewer network connections centered on it and formed a cooperative sub-group with the University of North Carolina, the University of Florida, and the University of British Columbia. Monash University, Maastricht University, the University of Utrecht, the University of Edinburgh, and the Open University of The Netherlands occupy the core position of the atlas. Together, these universities form a condensed subgroup, with Monash University and the University of Utrecht as the core.
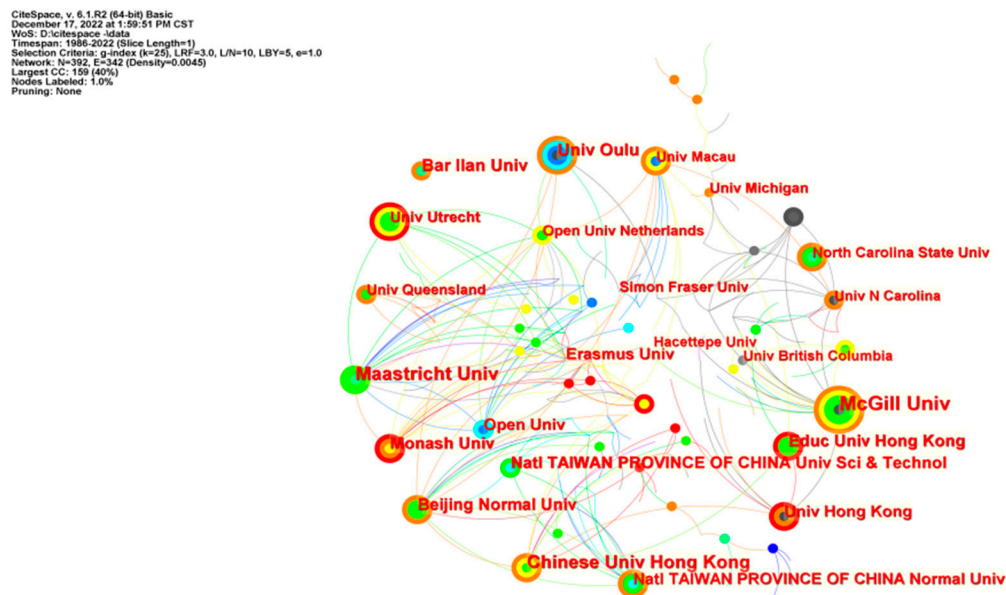

Figure 3. Cooperation map of self-regulated learning research institutions from 1986 to 2022.

3.4. Keyword Network Graph Analysis

Keywords are highly abbreviated terms that summarize the core of an article, and frequent keywords are used to identify the main themes of a research field [25]. A co-occurrence analysis of keywords in self-regulated learning research was carried out. The circle in the figure represents nodes, and the larger the annual ring, the higher the frequency of keywords, thus revealing the currently trending research topics and general research trends over the years. As shown in Figure 4, the keywords with more than 100 occurrences

included Self-Regulated Learning, Motivation, Strategy, Student, Performance, Achievement, Efficacy, Metacognition, Classroom, Feedback, Education, Knowledge, etc., thereby representing the popular research topics in this field. From the perspective of keyword centrality, the top five keywords are Performance, Strategy, Student, Achievement, and Classroom, which indicates that they are the key nodes with which to connect different research topics and cluster topics in self-regulated learning.

Figure 4. Self-regulated learning studies keyword co-occurrence network graph.

Regarding the history of the keywords' co-occurrence, Self-Regulated Learning (Barry et al., 1986) and Strategy [26] (Sin, 1991) appeared earlier, starting from 1986 to 1991. This is the initial development period of the field of self-regulated learning. This period was based on the research into using self-regulated learning behaviors and strategies to improve learners' efficacy and achievement and provided preliminary discussion on the constitution of self-regulated learning. From 1992 to 1997, Motivation [27] (Ridley, 1992), Performance, and Achievement [28] (Butler, 1995), and the emergence of research topics such as Efficacy and Knowledge, showed that with the gradual deepening of research, Efficacy provided support to the self-regulation learning model and emphasized monitoring as the center of cognitive operation with respect to self-regulation and cognitive reference. In recent years, the co-occurrence of keywords such as motivation, hypermedia, emotion, cognition, metacognition, feedback, and social collaboration is significant, indicating that self-regulated learning has been applied in technology-supported learning environments, and that related research has begun to be carried out according to different aspects.

3.5. Analysis of Important Authors

The number of articles published by authors can reflect the level of scientific research to a certain extent. The statistical function of the WOS database is used to analyze and screen the top ten authors with the most articles published, as shown in Table 4. The results show no significant difference in the number of articles published by different scholars. Azevedo and Lajoie are the authors with the most articles published, with 18 and 15, respectively. The rest of the top 10 authors had similar numbers of publications, ranging from 10 to 13. According to Price's theory, $M = 0.748\sqrt{N_{max}}$ (M represents the minimum number of papers that the core author should publish, and N_{max} represents the highest output of the author); after calculation, M = 3.17, and the integer is 3, so the author who publishes at least 3 papers is called a high-producing core author, since a paper with at least 3 publications has a large number of core authors (up to 97). To better select the number

of representative core authors, no fewer than 10 papers were selected as the high-yielding core authors of this self-regulated learning study. According to statistics, there were 10 core authors of no fewer than 10 articles (as shown in Table 4), with an average number of articles published equal to 9.59, accounting for 10.59% of the total articles published. On the whole, there are fewer productive authors, indicating that relatively few researchers specialize in self-regulated learning.

Table 4. Statistics of the number of publications from the top ten authors.

Author	Number of Articles	Percentage
Azevedo, Roger	18	1.48%
Lajoie, Susanne P.	15	1.23%
Winne, Philip H.	13	1.23%
Greene, Jeffrey A.	13	1.23%
Jarvela, Sanna	13	1.23%
Malmberg, Jonna	12	0.99%
Zheng, Juan	11	0.91%
Kramarski, Bracha	11	0.91%
Barry, Bai	10	0.82%
Muis, Krista R.	10	0.82%

At the same time, in order to obtain the authors' collaborative relationships in recent decades more accurately, CiteSpace was used to conduct an author collaboration network analysis. The period of analysis was set to 1986–2022 (the earliest study retrieved was from 1986), the time slice was 3 years, and CiteSpace was run to obtain a co-occurring knowledge graph of self-regulated learning research authors, with the number of nodes N = 583, the number of connections E = 542, and the density value D = 0.0032. As shown in Figure 5, the network map is more scattered, forming fewer core author teams, and Dragan Gasevic, who is highly active, closely cooperates with other researchers, with whom it can be seen that only a few authors are closely connected, indicating that the core author team in the field of self-regulated learning is not yet fully established, and while the team-building characteristics of the research force are less obvious, a large core team will eventually be formed. Thus, if cooperation can be strengthened, a large core team of authors will eventually be formed.
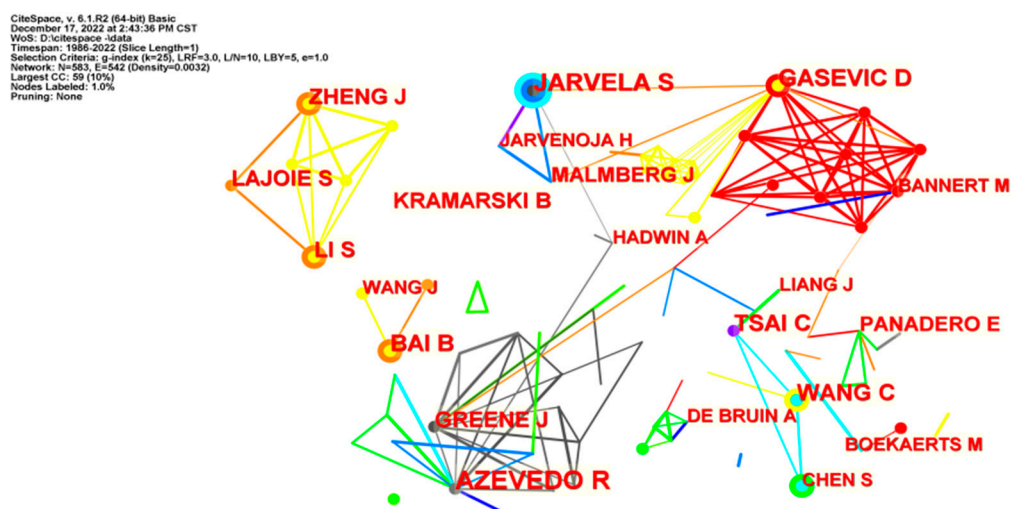

Figure 5. Research author collaboration network map.

3.6. Analysis of Highly Cited Literature

The highly cited literature plays a key role in the knowledge flow network and is the basis of discipline-specific research knowledge [29]. In bibliometric analysis, the highly

cited literature in a research field is usually regarded as the source of the knowledge base in this field. Accordingly, the top 30 highly cited studies in the field of global self-regulated learning research constitutes the knowledge base of this field. As shown in Table 5 below. Based on the analysis of these highly cited studies, it can be found that the publication period for the most highly cited literature spans from 1986 to 2016, and the most frequently cited study is Formative Assessment and Self-Regulated Learning: a Model and Seven Principles of Good Feedback Practice, which was published by Nicol et al. [30] in the journal Studies In Higher Education in 2006. Among them, 2005 and 2008 were important nodes, and the sum of publications in these two years reached 6, accounting for about 21% of the total publications. This shows that, on the one hand, global pioneers in self-regulated learning have laid a solid foundation for research in this field, such as Azevedo [31], who used hypermedia as a metacognitive tool for optimizing student learning. The nature of self-regulated learning illustrates how self-regulated learning can be used as a guiding theoretical framework to examine learning using hypermedia. On the other hand, few influential research results have appeared since 2018 that are worthy of vigilance and reflection. These documents are mainly from the perspectives of goal setting and self-efficacy, formative assessment, academic emotions, feedback, academic achievement, personal learning environments and social media, hypermedia, gender, cognitive interaction and network, the relationship between faith and network teaching, etc., which mainly focus on the self-regulated learning of basic content.

Table 5. Top 30 cited studies of self-regulated learning from 1986 to 2022.

Author/Year	Title	Citation Frequency
Nicol, D.J./2006	Formative assessment and self-regulated learning: a model and seven principles of good feedback practice [30]	2070
Pekrun, R./2002	Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research [32]	1718
Butler, D.L./1995	Feedback and Self-Regulated Learning: A Theoretical Synthesis [28]	1440
Zimmerman, B.J./2008	Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects [33]	1418
Zimmerman, B.J./1990	Self-Regulated Learning and Academic Achievement: An Overview [34]	1321
Zimmerman, B.J./1986	Development of a Structured Interview for Assessing Student Use of Self-Regulated Learning Strategies [1]	756
Dabbagh, Nada/2012	Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning [35]	708
Paris, S.G./2001	Classroom applications of research on self-regulated learning [18]	573
Schraw, G./2006	Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning [19]	524
Boekaerts, M./1997	Self-regulated learning: A new concept embraced by researchers, policymakers, educators, teachers, and students [17]	507
Broadbent, J./2015	Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review [36]	489
Wolters, C.A./2003	Regulation of motivation: Evaluating an underemphasized aspect of self-regulated learning [37]	415
Dignath, C./2008	Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level [38]	403
Azevedo, R./2005	Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning [31]	402
Dignath, C./2008	How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes [39]	387
Schunk, D.H./1990	Goal Setting and Self-Efficacy During Self-Regulated Learning [40]	384
McLoughlin, C./2010	Personalised and self regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software [41]	378

Table 5. *Cont.*

Author/Year	Title	Citation Frequency
Efklides, A./2011	Interactions of Metacognition with Motivation and Affect in Self-Regulated Learning: The MASRL Model [42]	362
Kizilcec, R.F./2017	Self-regulated learning strategies predict learner behavior and goal attainment in Massive Open Online Courses [43]	325
Pajares, F./2002	Gender and perceived self-efficacy in self-regulated learning [44]	293
Kuo, Y.C./2014	Interaction, Internet self-efficacy, and self-regulated learning as predictors of student satisfaction in online education courses [45]	285
Winne, P.H./1995	Inherent details in self-regulated learning [46]	285
Littlejohn, A./2016	Learning in MOOCs: Motivations and self-regulated learning in MOOCs [47]	276
Wolters, C.A./1998	Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms [48]	273
Azevedo, R./2005	Scaffolding self-regulated learning and metacognition–Implications for the design of computer-based scaffolds [49]	266
Schunk, D.H./2005	Self-regulated learning: The educational legacy of Paul R. Pintrich [50]	251
Joo, Y.J./2000	Self-efficacy for self-regulated learning, academic self-efficacy, and Internet self-efficacy in Web-based instruction [51]	239
Wang, C.H./2013	Students' characteristics, self-regulated learning, technology self-efficacy, and course outcomes in online learning [52]	228
Muis, K.R./2007	The role of epistemic beliefs in self-regulated learning [53]	227

3.7. Co-Citation Analysis of Authors

Author co-citation refers to the frequency with which two authors are cited together in different documents. CiteSpace software only considers the co-citation of the first author when calculating author co-citation, and multiple citations of the same author in the same literature are also counted as one. This paper conducts statistical analysis on the top ten first authors with respect to the number of co-citations, as shown in Table 6. The three most-cited authors are Zimmerman, B.J. (1986); Pintrich, P.R. (1995) [54]; and Winne, P.H. (1995), with totals of 820, 673, and 408 citations, respectively. Among them, Zimmerman, B.J. has been cited the most, up to 820 times, and this author's intermediary centrality (0.06) is also the highest, indicating that their published articles have greatly influenced subsequent research. It should be noted that high citation frequency does not mean high centrality. For example, the citation frequency of Schunk DH's articles is significantly higher than that of Boekaerts, M.; Bandura, A.; Azevedo, R; and other authors, but his centrality is 0.01. At the same time, the year in the table represents when the author of the related research field published their first article on self-regulated learning.

Table 6. Top ten citations of authors from 1986 to 2022.

Count	Centrality	Year	Cited Authors
820	0.06	1986	Zimmerman, B.J.
673	0.03	1995	Pintrich, P.R.
408	0.06	1995	Winne, P.H.
342	0.01	1990	Schunk, D.H.
340	0.05	1995	Boekaerts, M.
337	0.05	1986	Bandura, A.
268	0.04	2005	Azevedo, R.
207	0.06	1995	Butler, D.L.
186	0.04	2005	Schraw, G.
169	0.04	2002	Wolters, C.A.

By calculating the co-citation relationship between the authors, a co-cited author network diagram was developed, as shown in Figure 6. The number of nodes (N) is 981, and the size of the tree ring represents the number of citations of each author. The larger the tree ring, the more times the author has been co-cited, and vice versa. The number of lines (E) is 6748, and the density of the network is D = 0.014. The lines in the figure reveal

the academic community in the research field of SRL, which is not simply a cooperative relationship but denotes the relationship among authors in the same research field. The cooperative relationships have been detected in the analysis of the important authors in this paper.
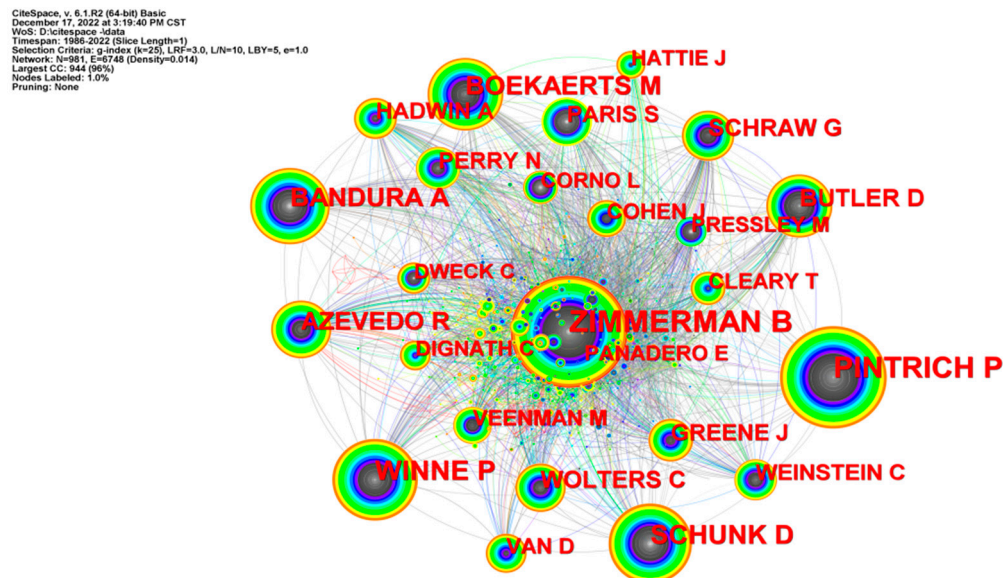

Figure 6. Co-citation analysis map of the authors from 1986 to 2022.

3.8. Keywords Cluster Analysis

Cluster analysis is a method used to summarize similar research topics, obtain representative clusters in related research fields, and analyze the overall state of research fields from different perspectives [55]. The method of word frequency analysis is used to extract the frequency distribution of keywords or subject words that can express the core content of the literature in order to study the developmental trend and research hotspots in this field. The CiteSpace software was used for keyword clustering analysis. In the Selection Criteria dialog box, Top N = 35 and Top N % = 5%, and in the Pruning dialog box, Pathfinder was selected. Obtained as shown in Figure 7. By pruning the sliced networks and the merged network, the co-word graph retains 93 network nodes and 95 lines, with a network density D = 0.0222, and Modularity Q = 0.7991 > 0.3. This shows that co-word network clustering has a significant effect. The Mean Silhouette value was 0.9563 > 0.7, indicating that the clustering results were convincing. Using the log-likelihood LSI algorithm, a total of nine main clusters were derived, and Table 7 shows the nine largest clusters (#0~#8), wherein the size of the clusters corresponds to the number of mentions contained in a study, and the larger the number of the cluster, the fewer the members. The S value is between 0.924~1, which indicates that the clustering results have high credibility.

Cluster #0—technology-enhanced feedback: This cluster of keywords contains latent growth modeling; cluster analysis; and clickstream data. Oinas et al. (2021) [56] analyzed interviews (N = 62) and questionnaires (N = 132) concerning the perceptions and emotions of primary school students toward TEF. TEF is loaded with smiling emoticons to monitor performance and behavior. Janson et al. [57] (2020) proposed a theoretical model based on Adaptive Structuring Theory and Cognitive load Theory to explain how technology-enhanced scaffolds contribute to learning outcomes and tested this model with a completely randomized inter-subject experiment. The results showed that the technology-enhanced scaffolds significantly contribute to the management of cognitive load and the satisfaction of the learning process and the learning outcomes of problem solving. In Cluster #1, the keywords of self-assessment include Metacognitive monitoring, Intelligent accountability, calibration accuracy, and calibration accuracy. The study with the highest clustering activity is Classroom Applications of Research on Self-Regulated Learning published by Paris [18]

in Educational Psychologist in 2001, which plays a key role as a connecting node. He used SRL examples in the classroom to develop three research fields: reading and writing strategies, cognitive participation in tasks, and self-assessment. During this period, he not only developed and improved the theoretical model of self-regulated learning but also began to research self-regulated learning in the technological environment. Regarding the clustering of students, the highest contribution rate comes from a study published in Studies In Higher Education, namely, Formative Assessment and Self-Regulated Learning: a Model and Seven Principles of Good Feedback Practice [30]. This article explains how formative assessment and feedback can help students take control of their learning. This reformulation is used to identify seven principles of good feedback practice that support self-regulation. Recently published in the Asia Pacific Journal Of Education, the study Social Support and Online Self-Regulated Learning During COVID-19 Pandemic [58] collected 2616 Chinese college students quarantined at home and receiving online instruction during the COVID-19 pandemic. Based on social cognitive theory, the mediating effect of online learning-related self-efficacy and the moderating effect of gender were considered to explore the relationship between social support and online self-regulated learning. The results showed that social support was positively correlated with online self-regulated learning, and online learning self-efficacy partially mediated the positive correlation. In addition, the positive associations between social support and online learning-related self-efficacy and online self-regulated learning were stronger in men than in women. Cluster #3: In the task value clustering, Interactions of Metacognition With Motivation and Affect in Self-Regulated Learning: The MASRL Model [42] published in the journal Educational Psychologist has the highest citation rate. In this study, the "metacognition and emotion model of self-regulated learning" (MASRL model) is divided into two functional levels in SRL: an individual level and task X individual level. Cluster #4, self-regulated learning, contains keywords such as self-regulation, online learning, and learning analytics; self-regulated learning related to this cluster study is considered to be the key factor for the success of online learning. In addition, students' senses of academic control and academic emotions are important influencing factors for self-regulated learning [59]. Cluster #5: Keywords in the learning performance cluster include challenge, motivating strategy, belief, etc. Cluster #6: Keywords in the teacher training cluster include framework, technology, inquiry, etc. Cluster#7: Motivation contains keywords such as achievement, behavior, academic performance, etc. Cluster#8: Keywords included in critical pedology clustering include feedback, classroom, instruction, etc.; the keywords included in these clusters have been hot topics in recent years.

3.9. Timeline Analysis

The timeline view mainly focuses on delineating the relationship between clusters and the historical span of the literature in a cluster. According to the timeline diagram of self-regulation learning cluster analysis generated using CiteSpace software, the co-citation of the literature regarding hypermedia, preference, strategy, environment, and auto-regulation clustering is relatively dense overall. As shown in Figure 8. Moreover, some influential and key nodes are concentrated, constituting the main position of self-regulated learning research. The co-citations of the motivation, achievement, and preference clusters are obvious in the early stage and gradually fade afterwards, indicating that they play a fundamental role in defining the conceptual framework, constructing theoretical models, and developing evaluation and measurement methods in the field of self-regulated learning. Recent studies mainly focus on online learning [60], learning time allocation [61], the learning environment [62], and collaborative learning with computer support [63], and their numbers continue to rise. Therefore, the application of self-regulated learning and co-regulated learning in the context of social networks and computer-supported collaborative learning will remain an important research topic in the future.
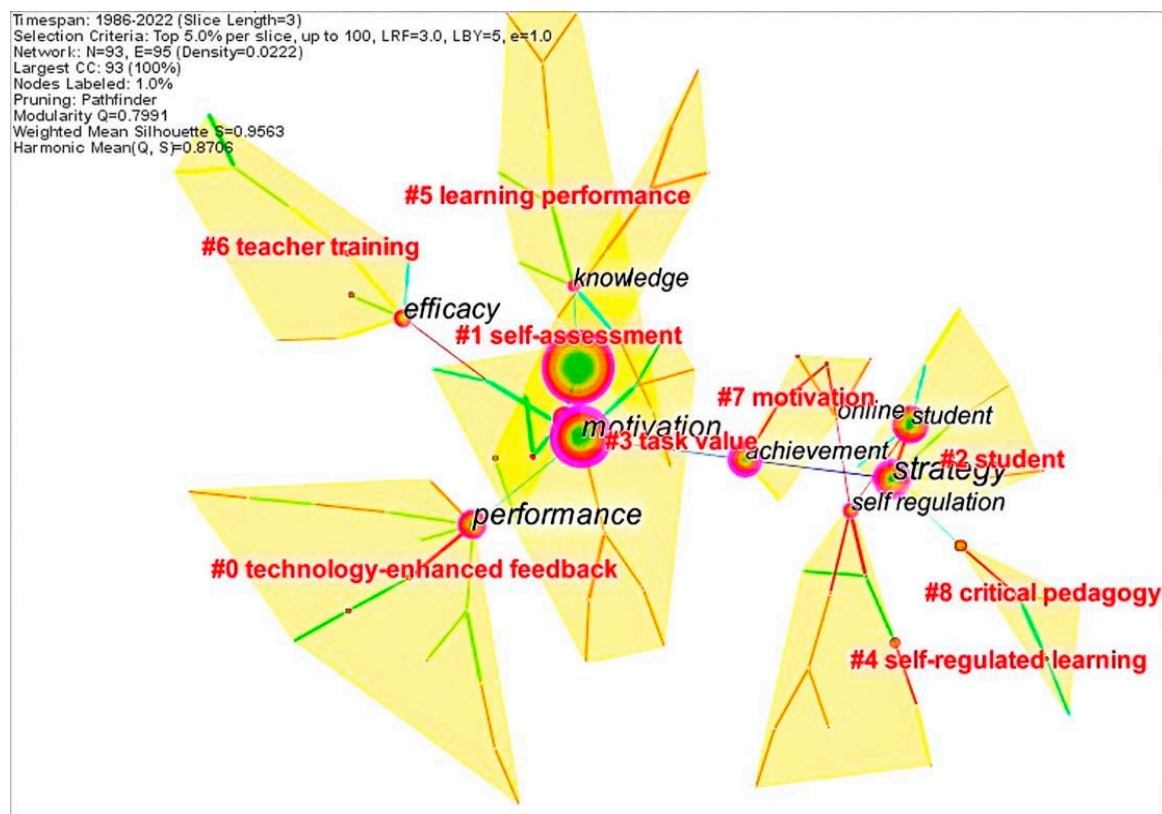
Figure 7. Keyword-clustering knowledge map.

Table 7. Keyword Clustering statistics.

Cluster-ID	Clustering	Silhouette	Cluster Size	Identifying Words (Top 3)
0	technology-enhanced feedback	0.97	15	latent growth modeling; cluster analysis; clickstream data
1	self-assessment	1	12	Metacognitive monitoring; intelligent accountability; calibration accuracy
2	students	0.907	11	internal feedback; self-regulated learning instruction; intervention effects
3	task value	0.909	11	self-efficacy; teaching/learning strategies; regulation of emotions
4	self-regulated learning	0.934	11	learning analytics; task analysis; learning engagement
5	learning performance	0.969	11	learning performance; metacognitive processes; prospective university students
6	teacher training	1	10	student-facing learning analytics; learning analytics dashboard; data science application in education
7	Motivation	0.924	7	at-risk students; group awareness; group collaboration processes
8	critical pedagogy	1	5	authentic tasks; critical educational; Asian Confucian cultural contexts

A textual interpretation of the research literature on the topic of self-regulated learning, which is heavily cited in the clusters in which the timeline appears, yielded research branches in each cluster. We identified the following three key self-regulated learning research paths.
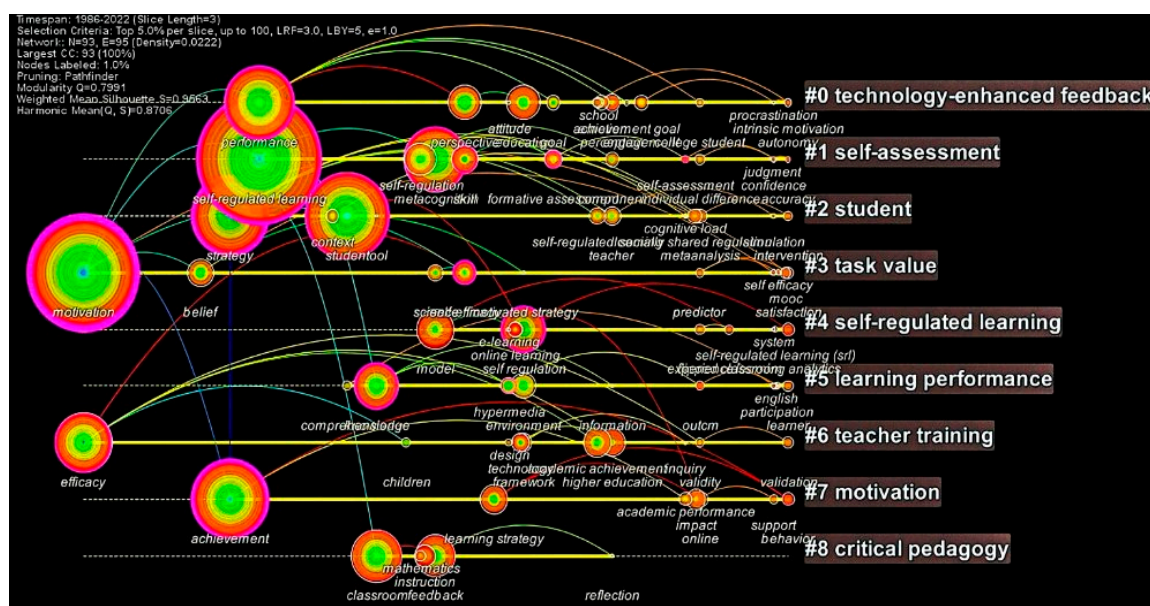
Figure 8. Time chart of self-regulated learning research from 1986 to 2022.

(1)   Combination of Multi-Domain Research

In the context of big data, the combination of multi-domain research has become the focus for what is currently involved in many study procedures, and some researchers have set out to study the application of self-regulated learning in the fields of medicine, education, finance, and media technology [64–68]. For example, in clinical medicine, authors are exploring the behavior of undergraduate students' self-regulated learning models in clinical settings, and research has shown that developing self-regulated learning best supports clinical behavior based on individual student needs; in mathematics, there are authors studying whether students' self-regulated learning and mathematical problem-solving abilities are closely related. Thus, the combination of multiple disciplines has led to the concretization of self-regulated learning in other areas as well; therefore, the field is no longer limited to one-sided research.

(2)   Focus on Student Learning Environment Pathways

As modern educational information technology continues to advance, providing ubiquitous access to a variety of online resources, students' learning paths are no longer traditional, i.e., correspond to a single direction, and changes in teachers' educational philosophy have had a significant impact on students' education. During the COVID-19 pandemic and the advent of the new normal, the combination of online and offline teaching [69–71] has greatly broadened students' learning paths, stimulated learners' needs, made students more creative, and made teachers' division of labor clearer.

(3)   Focus on the Collaborative Learning Process

Collaborative learning is the sum of behaviors associated with learners cooperating and helping each other to accomplish certain goals for a common learning objective. Nowadays, the teacher's responsibility is not only to enable students to learn to self-regulate their learning individually in all subjects, but also to foster students such that they have a sense of community in a mixed environment in order to potentiate the ability of peers to assist in self-regulated learning based on team-learning methods that emphasize the application of knowledge and the mastery of skills in the classroom. More importantly, students can apply the knowledge and skills learned to develop higher-order critical thinking skills and creative abilities [72,73].

3.10. Analysis of Prominent Citation

An emergent citation refers to the phenomenon wherein the citation of a certain study or research topic suddenly increases or decreases at a certain time to reveal the knowledge structure of a certain research field. CreateSpace was used to conduct a burst analysis of the research literature on self-regulated learning, and the results are shown below (Figure 9). It is found that the article written by Zimmerman (2008) has the strongest burst, with a burst intensity of 25.63, ranking first, indicating that this article plays a key role in the direction of this research topic. This article has advanced research on the theory and measurement of self-regulated learning since the beginning of the 21st century. The articles written by Panadero and Kizilcec (2017) ranked second and third in terms of the intensity of outbursts. They mostly began the study of the interaction between Motivation, Metacognition, Emotion, and other factors, indicating that the research on self-regulated learning has begun to mature and deepen in recent years, and they began to pay attention the improvement of learning in technological environments. Of course, for almost a decade between 2005 and 2015, Veenman (2006), Azevedo (2005), Boekaerts (2005), Zimmerman (2012), Winne (2008), Winters (2008), and Greene (2009) have experienced no reduction in the intensity of abruptness [74–78]. Their research on self-regulated learning showed diversification in terms of theoretical perspectives and applications to teaching practice, which improved the theoretical model of self-regulated learning, indicating that the research of scholars in this period began to turn to applications in teaching practice and theoretical knowledge construction.

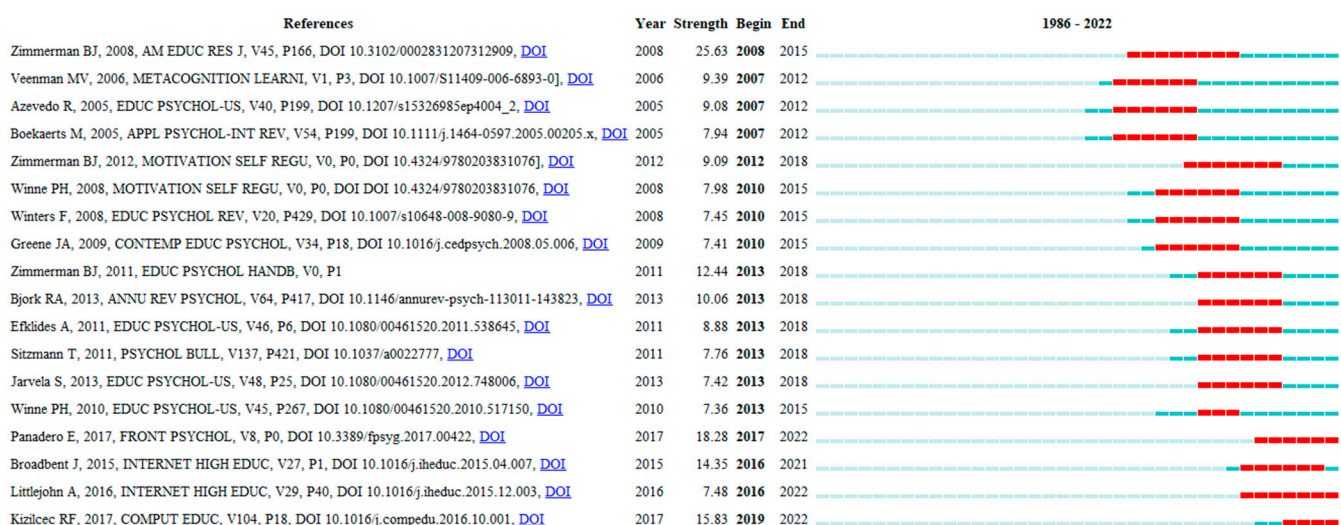**Top 18 References with the Strongest Citation Bursts**

References	Year	Strength	Begin	End	1986 - 2022
Zimmerman BJ, 2008, AM EDUC RES J, V45, P166, DOI 10.3102/0002831207312909, DOI	2008	25.63	**2008**	2015	
Veenman MV, 2006, METACOGNITION LEARNI, V1, P3, DOI 10.1007/S11409-006-6893-0], DOI	2006	9.39	**2007**	2012	
Azevedo R, 2005, EDUC PSYCHOL-US, V40, P199, DOI 10.1207/s15326985ep4004_2, DOI	2005	9.08	**2007**	2012	
Boekaerts M, 2005, APPL PSYCHOL-INT REV, V54, P199, DOI 10.1111/j.1464-0597.2005.00205.x, DOI	2005	7.94	**2007**	2012	
Zimmerman BJ, 2012, MOTIVATION SELF REGU, V0, P0, DOI 10.4324/9780203831076], DOI	2012	9.09	**2012**	2018	
Winne PH, 2008, MOTIVATION SELF REGU, V0, P0, DOI DOI 10.4324/9780203831076, DOI	2008	7.98	**2010**	2015	
Winters F, 2008, EDUC PSYCHOL REV, V20, P429, DOI 10.1007/s10648-008-9080-9, DOI	2008	7.45	**2010**	2015	
Greene JA, 2009, CONTEMP EDUC PSYCHOL, V34, P18, DOI 10.1016/j.cedpsych.2008.05.006, DOI	2009	7.41	**2010**	2015	
Zimmerman BJ, 2011, EDUC PSYCHOL HANDB, V0, P1	2011	12.44	**2013**	2018	
Bjork RA, 2013, ANNU REV PSYCHOL, V64, P417, DOI 10.1146/annurev-psych-113011-143823, DOI	2013	10.06	**2013**	2018	
Efklides A, 2011, EDUC PSYCHOL-US, V46, P6, DOI 10.1080/00461520.2011.538645, DOI	2011	8.88	**2013**	2018	
Sitzmann T, 2011, PSYCHOL BULL, V137, P421, DOI 10.1037/a0022777, DOI	2011	7.76	**2013**	2018	
Jarvela S, 2013, EDUC PSYCHOL-US, V48, P25, DOI 10.1080/00461520.2012.748006, DOI	2013	7.42	**2013**	2018	
Winne PH, 2010, EDUC PSYCHOL-US, V45, P267, DOI 10.1080/00461520.2010.517150, DOI	2010	7.36	**2013**	2015	
Panadero E, 2017, FRONT PSYCHOL, V8, P0, DOI 10.3389/fpsyg.2017.00422, DOI	2017	18.28	**2017**	2022	
Broadbent J, 2015, INTERNET HIGH EDUC, V27, P1, DOI 10.1016/j.iheduc.2015.04.007, DOI	2015	14.35	**2016**	2021	
Littlejohn A, 2016, INTERNET HIGH EDUC, V29, P40, DOI 10.1016/j.iheduc.2015.12.003, DOI	2016	7.48	**2016**	2022	
Kizilcec RF, 2017, COMPUT EDUC, V104, P18, DOI 10.1016/j.compedu.2016.10.001, DOI	2017	15.83	**2019**	2022	

Figure 9. Citation of self-regulated learning outbursts from 1986 to 2022.

4. Discussion

Based on CiteSpace bibliometrics software, this paper conducted a statistical analysis of the research on self-regulated learning, aiming to clarify the research context in this field and grasp the future research trends.

In recent decades, self-regulated learning has been attracting the academic community's attention as a research direction, and its research popularity is on the rise. During the entire SRL research period, the number of published studies in the field of self-regulated learning has shown an increasing trend, which can be divided into three stages (see Section 3.1 for detailed explanation): an embryonic stage of development (1986–2002), a slow stage of development (2003–2009), and a rapid stage of development (2010–2022). European and North American countries are the main impetuses of self-regulated learning research, with China projected to occupy the leading position in the near future; the United States, China, Australia, and Germany are active in self-regulated learning-related

research, with closer cooperation among countries. Self-regulated learning research teams are concentrated overall, and these teams are mainly from Europe and the United States. The communication and collaboration between core authors is not very extensive, the activity is not too high, and the team-building characteristics of the research force are not too obvious; it is hoped that subsequent researchers will strengthen the global partnership in self-regulated learning research. In addition, when we analyzed the literature citations and author co-citations, we found that only 29 papers had more than 220 citations, and the most frequently cited paper was "Formative assessment and self-regulated learning: a model and seven principles of good feedback practice" by Nicol, DJ et al., which was published in Studies In Higher Education in 2006. The most influential co-cited authors were Zimmerman, B.J., and Pintrich, P.R., both with over 600 co-citations, indicating that these authors have made significant contributions to the field of SRL research. In addition, Pinnick and Zimmerman have undertaken extensive research on the measurement of self-regulated learning, designing measurement scales and interview protocols such as the LAS-SI, MSLP, and SRLIS. Second, Winne, Azevedo, Zimmerman, and Schenk conducted empirical studies on the effectiveness of self-regulated learning with respect to promoting learning and improving performance. Finally, research on self-regulated learning in technology-supported learning environments has received attention, and Hardman and Azevedo have begun to explore self-regulated learning in media and digital environments, emphasizing the social aspects of self-regulated learning and proposing concepts such as co-regulation.

In general, the current status of global research on self-regulated learning can be visually comprehended through the use of knowledge mapping, and it has been found that there have been significant developments in the research on self-regulated learning in various fields, with research hotspots focusing on strategy, learning motivation, collaborative learning, self-efficacy, and hypermedia, etc. Research themes focus on teaching design and intervention from the perspective of self-regulated learning, theoretical models of self-regulated learning, factors influencing self-regulated learning in computer environments, self-regulated learning in online courses such as MOOCs, and the development of learning environments that support self-regulation.

A more comprehensive bibliometric study of global self-regulated learning in the context of new technology-supported learning environments has not been found. Therefore, this study systematically analyzed the knowledge structure and developmental history of the field, which can provide relevant information for core authors, institutions, research teams, and countries. In this context, the development of learners' online self-regulated learning capabilities and the research, methodology, and theoretical constructs of online self-regulated learning will become important trends in the future.

5. Future Work

Of course, this article's research has certain limitations; in terms of the present study, our analysis of the literature was limited, as it only employed the SSCI database's Web of Science module on literature in the field of self-regulated learning research. In addition, the selected articles are all in English, which, to some extent, ignores articles in other languages and other databases. Therefore, in the context of the information age, with the wide application of networks, we should also expand the search scope of the database in the field of self-regulated learning to increase the comprehensiveness of the analyzed data in future research. Self-regulated learning is not isolated but should be combined with project-based learning, gamified learning, blended learning, and other specific learning methods.

Author Contributions: All authors acknowledge their contribution to the preparation of this paper. L.H. and J.Z. jointly proposed the structure of the study. L.H. performed the data collection and analysis and completed the paper. D.W., F.W., J.L., D.S., X.C., D.Y. and Q.P. gave some good suggestions. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Zimmerman, B.J.; Martinez-Pons, M. Development of a structured interview for assessing student use of self-regulated learning strategies. *Am. Educ. Res. J.* **1986**, *23*, 614–628. [CrossRef]
2. Zimmerman, B.J. A social cognitive view of self-regulated academic learning. *J. Educ. Psychol.* **1989**, *81*, 329–339. [CrossRef]
3. Brown, R.; Pressley, M. Self-regulated reading and getting meaning from text: The transactional strategies instruction model. In *Self-Regulation of Learning and Performance*; Schunk, D.H., Zimmerman, B.J., Eds.; Lawrence Erlbaum Associates: Hillsdale, NJ, USA, 1994; pp. 155–180.
4. Pintrich, P.R. The role of goal orientation in self-regulated learning. In *Handbook of Self-Regulation*; Bockaerts, M., Pintrich, P.R., Zeidner, M., Eds.; Academic Press: Cambridge, MA, USA, 2000; pp. 452–501.
5. Boekaerts, M. Bringing about change in the classroom: Strengths and weaknesses of the self-regulated learning approach—EARLI Presidential Address, 2001. *Learn. Instr.* **2002**, *12*, 589–604. [CrossRef]
6. Zimmerman, B.J. Becoming a Self-Regulated Learner: An Overview. *Theory Pract.* **2022**, *41*, 64–70. [CrossRef]
7. Panadero, E. A Review of Self-regulated Learning: Six Models and Four Directions for Research. *Front. Psychol.* **2017**, *8*, 422. [CrossRef]
8. Pokay, P.; Blunenfeld, P.C. Predicting Achievement Early and Late in the Semester: The Role of Motivation and Use of Learning Strategies. *J. Educ. Psychol.* **1990**, *82*, 41–50. [CrossRef]
9. Boekaerts, M.; Corno, L. Self-regulation in the classroom: A perspective on assessment and intervention. *Appl. Psychol.* **2005**, *54*, 199–231. [CrossRef]
10. Pintrich, P.R. A conceptual framework for assessing motivation and self-regulated learning in college students. *Educ. Psychol. Rev.* **2004**, *16*, 385–407. [CrossRef]
11. Shih, K.P.; Chen, H.C.; Chang, C.Y.; Kao, T.C. The Development and Implementation of a Scaffolding-Based Self-Regulated Learning System for e/m-Learning. *J. Educ. Technol. Soc.* **2010**, *13*, 80–93.
12. Cheng, G.; Chau, J. Exploring the relationship between students' self-regulated learning ability and their ePortfolio achievement. *Internet High. Educ.* **2013**, *17*, 9–15. [CrossRef]
13. Chen, C. CiteSpace II: Detecting and visualizing emerging trends and transient patterns in the scientific literature. *J. Am. Soc. Inf. Sci. Technol.* **2006**, *57*, 359–377. [CrossRef]
14. Rousseeuw, P.J. Silhouettes: A graphical aid to the interpretation and validation of cluster analysis. *J. Comput. Appl. Math.* **1987**, *20*, 53–65. [CrossRef]
15. Wang, D.; Huangfu, Y.; Dong, Z.; Dong, Y. Research Hotspots and Evolution Trends of Carbon Neutrality—Visual Analysis of Bibliometrics Based on CiteSpace. *Sustainability* **2022**, *14*, 1078. [CrossRef]
16. Zimmerman, B.J. Self-efficacy: An essential motive to learn. *Contemp. Educ. Psychol.* **2000**, *25*, 82–91. [CrossRef]
17. Boekaerts, M. Self-regulated learning: A new concept embraced by researchers, policymakers, educators, teachers, and students. *Learn. Instr.* **1997**, *7*, 161–186. [CrossRef]
18. Paris, S.G.; Paris, A.H. Classroom applications of research on self-regulated learning. *Educ. Psychol.* **2001**, *36*, 89–101. [CrossRef]
19. Schraw, G.; Crippen, K.J.; Hartley, K. Promoting self-regulation in science education: Metacognition as part of a broader perspective on learning. *Res. Sci. Educ.* **2006**, *36*, 111–139. [CrossRef]
20. Whitebread, D.; Coltman, P.; Pasternak, D.P. The development of two observational tools for assessing metacognition and self-regulated learning in young children. *Metacogn. Learn.* **2009**, *4*, 63–85. [CrossRef]
21. Moos, D.C. Setting the stage for metacognition during hypermedia learning: What motivation constructs matter? *Comput. Educ.* **2014**, *70*, 128–137. [CrossRef]
22. Panadero, E.; Jonsson, A.; Botella, J. Effects of self-assessment on self-regulated learning and self-efficacy: Four meta-analyses. *Educ. Res. Rev.* **2017**, *22*, 72–98. [CrossRef]
23. Wang, Z.; Ma, D.; Pang, R.; Xie, F.; Zhang, J.; Sun, D. Research progress and development trend of social media big data (smbd): Knowledge mapping analysis based on cite space. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 632. [CrossRef]

24. Tang, S.Y.F.; Chow, A.W.K. Communicating feedback in teaching practice supervision in a learning-oriented field experience assessment framework. *Teach. Teach. Educ.* **2007**, *23*, 1066–1085. [CrossRef]

25. Wang, X.; Guo, J.; Gu, D.; Yang, Y.; Yang, X.; Zhu, K. Tracking knowledge evolution, hotspots and future directions of emerging technologies in cancers research: A bibliometrics review. *J. Cancer* **2019**, *10*, 2643. [CrossRef]

26. Sink, C.A.; Barnett, J.E.; Hixon, J.E. Self-regulated Learning and Achive Ement by Middle-School Children. *Psychol. Rep.* **1991**, *69*, 979–989. [CrossRef] [PubMed]

27. Ridley, D.S.; Schutz, P.A.; Glanz, R.S.; Weinstein, C.E. Self-Regulated Learning: The Interactive Influence of Metacognitive Awareness and Goal-Setting. *J. Exp. Educ.* **1992**, *60*, 293–306. [CrossRef]

28. Butler, D.L.; Winne, P.H. Feedback and Self-Regulated Learning: A Theoretical Synthesis. *Rev. Educ. Res.* **1995**, *65*, 245–281. [CrossRef]

29. Shi, D.; Zhou, J.; Wang, D.; Wu, X. Research Status, Hotspots, and Evolutionary Trends of Intelligent Education from the Perspective of Knowledge Graph. *Sustainability* **2022**, *14*, 10934. [CrossRef]

30. Nicol, D.J.; Macfarlane-Dick, D.F. Formative assessment, and self-regulated learning: A model and seven principles of good feedback practice. *Stud. High. Educ.* **2006**, *31*, 199–218. [CrossRef]

31. Azevedo, R. Using hypermedia as a metacognitive tool for enhancing student learning? The role of self-regulated learning. *Educ. Psychol.* **2005**, *40*, 199–209. [CrossRef]

32. Pekrun, R.; Goetz, T.; Titz, W.; Perry, R.P. Academic emotions in students' self-regulated learning and achievement: A program of qualitative and quantitative research. *Educ. Psychol.* **2002**, *37*, 91–105. [CrossRef]

33. Zimmerman, B.J. Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *Am. Educ. Res. J.* **2008**, *45*, 166–183. [CrossRef]

34. Zimmerman, B.J. Self-Regulated Learning and Academic Achievement: An Overview. *Educ. Psychol.* **1990**, *25*, 3–17. [CrossRef]

35. Dabbagh, N.; Kitsantas, A. Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *Internet High. Educ.* **2012**, *15*, 3–8. [CrossRef]

36. Broadbent, J.; Poon, W.L. Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. *Internet High. Educ.* **2015**, *27*, 1–13. [CrossRef]

37. Wolters, C.A. Regulation of motivation: Evaluating an underemphasized aspect of self-regulated learning. *Educ. Psychol.* **2003**, *38*, 189–205. [CrossRef]

38. Dignath, C.; Buttner, G. Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacogn. Learn.* **2008**, *3*, 231–264. [CrossRef]

39. Dignath, C.; Buettner, G.; Langfeldt, H.P. How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educ. Res. Rev.* **2008**, *3*, 101–129. [CrossRef]

40. Schunk, D.H. Goal Setting and Self-Efficacy During Self-Regulated Learning. *Educ. Psychol.* **1990**, *25*, 71–86. [CrossRef]

41. McLoughlin, C.; Lee, M.J.W. Personalised and self regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software. *Australas. J. Educ. Technol.* **2010**, *26*, 28–43. [CrossRef]

42. Efklides, A. Interactions of Metacognition With Motivation and Affect in Self-Regulated Learning: The MASRL Model. *Educ. Psychol.* **2011**, *46*, 6–25. [CrossRef]

43. Kizilcec, R.F.; Perez-Sanagustin, M.; Maldonado, J.J. Self-regulated learning strategies predict learner behavior and goal attainment in Massive Open Online Courses. *Comput. Educ.* **2017**, *104*, 18–33. [CrossRef]

44. Pajares, F. Gender and perceived self-efficacy in self-regulated learning. *Theory Pract.* **2002**, *41*, 116–125. [CrossRef]

45. Kuo, Y.C.; Walker, A.E.; Schroder, K.E.E.; Belland, B.R. Interaction, Internet self-efficacy, and self-regulated learning as predictors of student satisfaction in online education courses. *Internet High. Educ.* **2014**, *20*, 35–50. [CrossRef]

46. Winne, P.H. Inherent details in self-regulated learning. *Educ. Psychol.* **1995**, *30*, 173–187. [CrossRef]

47. Littlejohn, A.; Hood, N.; Milligan, C.; Mustain, P. Learning in MOOCs: Motivations and self-regulated learning in MOOCs. *Internet High. Educ.* **2016**, *29*, 40–48. [CrossRef]

48. Wolters, C.A.; Pintrich, P.R. Contextual differences in student motivation and self-regulated learning in mathematics, English, and social studies classrooms. *Instr. Sci.* **1998**, *26*, 27–47. [CrossRef]

49. Azevedo, R.; Hadwin, A.F. Scaffolding self-regulated learning and metacognition—Implications for the design of computer-based scaffolds. *Instr. Sci.* **2005**, *33*, 367–379. [CrossRef]

50. Schunk, D.H. Self-regulated learning: The educational legacy of Paul, R. Pintrich. *Educ. Psychol.* **2005**, *40*, 85–94. [CrossRef]

51. Joo, Y.J.; Bong, M.; Choi, H.J. Self-efficacy for self-regulated learning, academic self-efficacy, and Internet self-efficacy in Web-based instruction. *Educ. Technol. Res. Dev.* **2000**, *48*, 5–17. [CrossRef]

52. Wang, C.H.; Shannon, D.M.; Ross, M.E. Students' characteristics, self-regulated learning, technology self-efficacy, and course outcomes in online learning. *Distance Educ.* **2013**, *34*, 302–323. [CrossRef]

53. Muis, K.R. The role of epistemic beliefs in self-regulated learning. *Educ. Psychol.* **2007**, *42*, 173–190. [CrossRef]

54. Pintrich, P.R. Current issues in research Self-Regulated Learning—A Discussion with commentaries. *Educ. Psychol.* **1995**, *30*, 171–172. [CrossRef]

55. Zhao, Y.; Guo, J.; Bao, C.; Liang, C.; Jain, H.K. Knowledge graph analysis of human health research related to climate change. *Int. J. Environ. Res. Public Health* **2020**, *17*, 7395. [CrossRef]

56. Oinas, S.; Ahtiainen, R.; Vainikainen, M.P. Pupils' Perceptions About Technology-enhanced Feedback: Do Emojis Guide Self-regulated Learning? *Scand. J. Educ. Res.* **2021**, *65*, 1037–1051. [CrossRef]
57. Janson, A.; Sollner, M.; Leimeister, J.M. Ladders for Learning: Is Scaffolding the Key to Teaching Problem-Solving in Technology-Mediated Learning Contexts? *Acad. Manag. Learn. Educ.* **2020**, *19*, 439–468. [CrossRef]
58. Yu, H.Y.; Zhou, J.H. Social support and online self-regulated learning during the COVID-19 pandemic. *Asia Pac. J. Educ.* **2022**, 1–15. [CrossRef]
59. You, J.W.; Kang, M. The role of academic emotions in the relationship between perceived academic control and self-regulated learning in online learning. *Comput. Educ.* **2014**, *77*, 125–133. [CrossRef]
60. Bai, X.M.; Gu, X.Q. Effect of teacher autonomy support on the online self-regulated learning of students during COVID-19 in China: The chain mediating effect of parental autonomy support and students' self-efficacy. *J. Comput. Assist. Learn.* **2022**, *38*, 1173–1184. [CrossRef]
61. Cao, T.H.; Zhang, Z.L.; Chen, W.L.; Shu, J.B. Utilizing clickstream data to reveal the time management of self-regulated learning in higher education online learning environment. *Interact. Learn. Environ.* **2022**, 1–18. [CrossRef]
62. Guo, L. Using metacognitive prompts to enhance self-regulated learning and learning outcomes: A meta-analysis of experimental studies in computer-based learning environments. *J. Comput. Assist. Learn.* **2022**, *38*, 811–832. [CrossRef]
63. Shin, Y.; Song, D.G. The Effects of Self-Regulated Learning Support on Learners' Task Performance and Cognitive Load in Computer Programing. *J. Educ. Comput. Res.* **2022**, *60*, 1490–1513. [CrossRef]
64. Yot-Dominguez, C.; Marcelo, C. University students' self-regulated learning using digital technologies. *Int. J. Educ. Technol. High. Educ.* **2017**, *17*, 38. [CrossRef]
65. Berkhout, J.J.; Teunissen, P.W.; Helmich, E.; van Exel, J.; van der Vleuten, C.P.; Jaarsma, D.A. Patterns in clinical students' self-regulated learning behavior: A Q-methodology study. *Adv. Health Sci. Educ.* **2017**, *22*, 105–121. [CrossRef] [PubMed]
66. Alegria, D.A.H.; Boscardin, C.; Wamsley, M.; Poncelet, A.; Mayfield, C. Using tablets to support self-regulated learning in a longitudinal integrated clerkship. *Med. Educ. Online* **2014**, *19*, 23638. [CrossRef]
67. Marchis, I. Self-Regulated Learning and Mathematical Problem Solving. *New Educ. Rev.* **2012**, 195–208.
68. Littlejohn, A.; Milligan, C.; Fontana, R.P.; Margaryan, A. Professional Learning Through Everyday Work: How Finance Professionals Self-Regulate Their Learning. *Vocat. Learn.* **2016**, *9*, 207–226. [CrossRef]
69. Albelbisi, N.A.; Al-Adwan, A.S.; Habibi, A. Self-regulated learning and satisfaction: A key determinants of MOOC success. *Educ. Inf. Technol.* **2021**, *26*, 3459–3481. [CrossRef]
70. Yoon, M.; Hill, J.; Kim, D. Designing supports for promoting self-regulated learning in the flipped classroom. *J. Comput. High. Educ.* **2021**, *33*, 398–418. [CrossRef]
71. Hensley, L.C.; Iaconelli, R.; Wolters, C.A. This weird time we're in: How a sudden change to remote education impacted college students' self-regulated learning. *J. Res. Technol. Educ.* **2022**, *54*, S203–S218. [CrossRef]
72. Vassallo, S. Critical Pedagogy and Neoliberalism: Concerns with Teaching Self-Regulated Learning. *Stud. Philos. Educ.* **2013**, *32*, 563–580. [CrossRef]
73. Guvenc, H. The Effects of Cooperative Learning and Learning Journals on Teacher Candidates' Self-Regulated Learning. *Educ. Sci. Theory Pract.* **2010**, *10*, 1477–1487.
74. Greene, J.A.; Azevedo, R.A. macro-level analysis of SRL processes and their relations to the acquisition of a sophisticated mental model of a complex system. *Contemp. Educ. Psychol.* **2009**, *34*, 18–29. [CrossRef]
75. Bjork, R.A.; Dunlosky, J.; Kornell, N. Self-Regulated Learning: Beliefs, Techniques, and Illusions. *Annu. Rev. Psychol.* **2013**, *64*, 417. [CrossRef] [PubMed]
76. Winne, P.H. Improving Measurements of Self-Regulated Learning. *Educ. Psychol.* **2010**, *45*, 267–276. [CrossRef]
77. Sitzmann, T.; Ely, K.A. Meta-Analysis of Self-Regulated Learning in Work-Related Training and Educational Attainment: What We Know and Where We Need to Go. *Psychol. Bull.* **2011**, *137*, 421–442. [CrossRef] [PubMed]
78. Winters, F.; Greene, J.; Costich, C. Self-Regulation of Learning within Computer-based Learning Environments: A Critical Analysis. *Educ. Psychol. Rev.* **2008**, *20*, 429–444. [CrossRef]