

# The Analysis of Hotspots and Frontiers of Holistic Instructional Design from the Perspective of Knowledge Map

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**Abstract:** This research searched the documents of holistic instructional design from Web of Science in the past twenty years (1999 to 2019). The biblio-metric analysis by Citespace provides the cluster of hotspots based on co-citation of references and authors. The frontiers of research mainly focus on information technology fields, e.g. e-learning environment, mobile learning systems and flipped classroom etc. The research basis of different clusters mainly lie in First Principles of Instruction, Complex learning design and Cognitive load Theory.

## 1. Introduction

Since 1990s, with the formation of complex science and the rise of constructivism, in order to get rid of the fine segmentation dominated by atomism, the holism originated from system theory has come forward, providing programmatic methodology for the reconstruction of instructional design. “Holistic instructional design” is not an instructional model, but an instructional theory. It is a study of “instructional design” under the framework of holism. Based on the whole task, it points to the orderly instructional design of comprehensive skills training in real life and vocational fields, that is, after training, learners use these skills to solve the problems encountered in real life or work.

The research on holistic instructional design is the vane of reflecting the international development trend and research status of instructional design. In this paper, the literature on holistic instructional design from 1999 to 2019 is taken as the research object, and the knowledge map is drawn by CiteSpace software to show the key hotspots and research frontiers of holistic instructional design abroad. On the basis of summarizing the research focus, this study also makes a reflection and discussion, in order to find a logical starting point for the follow-up research practice.

## 2. Knowledge Map of International Research

The author searched for the subject headings “holistic instructional design” or “whole task” in WOS (Web of Science Core Collection), and obtained 116 valid records related to English documents. However, it is impossible to obtain clear keyword clustering by using the existing English literature collected. It may be that the matching of English subject words leads to insufficient literature, or the foreign research is indeed scattered. Therefore, this study further expands the scope of literature analysis to include citation analysis.

### (1) Citation clustering analysis

In this study, Citespace is used to extract noun terms from the titles of citing documents and cited documents to name clusters<sup>1</sup> and LLR (Log Likelihood Algorithm) algorithm is used to obtain visual knowledge maps. Figure 1 shows a hotspot clustering information map based on the joint analysis of cited documents and cited authors. The results are divided into five major clusters (that is, five blocks in the figure): the first type “#0instructional design”, the second type “#1teaching causal reasoning”, the third type “#2context-aware mobile learning system”, and the fourth type “#3complex skill”, The fifth category “#4secondary school mathematica”. Under each cluster, we

<sup>1</sup> The citing documents here refer to 116 collected documents. The citation of other documents in this paper represents the convergence of various research topics to the current research trend, and the citation of published articles is the continuation of this trend.

can find that the nodes are annual rings. The bigger the nodes are, the bigger the fonts of co-cited are, indicating that the overall frequency of co-cited is higher. In the ring, blue indicates the earlier year, red indicates the latest year, and the thickness of the ring is directly proportional to the co-citation frequency of the year. Some annual rings have purple outer rings, which means that the co-citation has greater centrality. For example, in the literature of the first type of “instructional design” clustering, Van Merriënboer. J's research led the whole cluster No.0. In the literature of the second type of “teaching causal reasoning” clustering, Merrill.M.D's research leads the whole cluster No.1.

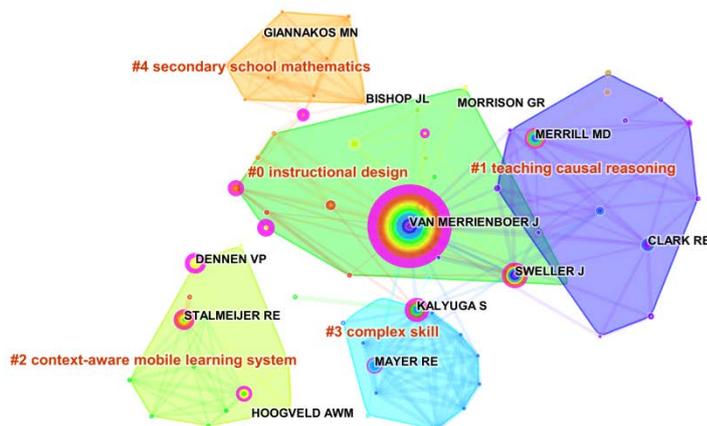


Fig.1 Analysis of Clustering Information of Co-Cited Hotspots by Authors

Then, this study inquired the detailed result interface of each cluster, and obtained the important information of citing documents and cited documents (the first four categories were introduced due to the limited space). The most active citing literature represents the research frontier of this cluster, and the most frequently cited literature represents the research foundation of this cluster. In the No.0 “Instructional Design” cluster, a total of 17 documents were captured, and the silhouette value was 0.814. The most active Citing Articles in this category is Mario's statement in 2018 on how to create digital learning environment by using comprehensive learning design pattern in physics teaching [1]. The most frequently cited reference in this cluster is Van Merriënboer's book on complex cognitive skills training published in 1997 [2], which created a comprehensive learning design model for professional and technical training. Van Merriënboer absorbed the research results of instructional mode by Charles M.Reigeluth and Tennyson, and put forward his own cognitive theory by summarizing the important theories of cognitive psychology and connecting it with the analysis and design stages of instructional design. Based on the debate between constructivism and instructionism, the role of learning theory is re-examined.

In the No.1 “Teaching Causal Reasoning” cluster, 15 papers were captured, and the silhouette value was 0.803. The most active citing literature in this category is Nadolski's research on how to optimize the training steps in competency-based multimedia teaching [3]. This paper cited 4 of the 15 papers in Cluster No.1, and this paper mainly provided a complete task optimization step model for the non-renewable skills causal reasoning ability, which was put into practice in the legal discipline. The most frequently cited article in this cluster reference is the paper “First Principles of Instruction” submitted by Merrill at the AECT Annual Meeting in 2000 [4].The half-life of literature is 9 years, the citation frequency is 9 times, and the centrality is 0.12. Then, in 2002, Merrill published this article in the Journal of Educational Technology Research and Development, which is also an active citing document in Cluster 1. Merrill put forward five basic teaching principles, focusing on problems and serving four stages of effective teaching, and summed up three concrete inferences under each principle. The primary teaching principle is not limited by the form of teaching practice, and has been presented in many instructional design theories, especially in the research of instructional design aiming at causal reasoning ability.

In the No.2 “Context-Aware Mobile Learning System” cluster, 14 papers (size) were captured,

and the silhouette value was 0.98. The most active citing literature in this category is Wu Pohan's paper published in 2012 on promoting the operation of cognitive apprenticeship mode by using context-aware mobile learning system in nursing skills training [5]. In this study, the students will wear a mobile device, which can detect whether the students are in the correct position on the simulated patient model for physical evaluation of specific diseases, and can provide immediate feedback and suggestions for wrong operations. The skills test, learning attitude evaluation and cognitive load measurement, show that learners' learning achievements have been significantly improved. From the detailed results of clustering, it can be seen that the research frontier of clustering mainly focuses on the application of cognitive apprenticeship. The most frequently cited paper in this cluster is Stalmeijer's research on practical feedback of cognitive apprenticeship in clinical practice [6]. The half-life of this paper is 9 years, the citation frequency is 9 times, and the centrality is 0.17. In this study, 24 6-year medical students were interviewed in the form of focus group. The driving force of cognitive apprenticeship on learning process was analysed and summarized. At the same time, some important suggestions on modelling, scaffolding and counselling were put forward. The study also shows that cognitive apprenticeship model is a model of situational awareness based teaching.

In the detailed results of No.3 “Comprehensive Skills” cluster, 14 papers were captured, and the silhouette value was 0.869. The most active citing literature in this category is Nadolski's paper on how to optimize the number of training steps for comprehensive skills. Taking the sophomores majoring in law as subjects, taking training how to prepare a case defense as an example, combining with many factors such as task completion time and psychological effort, the results show that a moderate number of training steps can help improve learners' performance in routine tasks, but have no effect on their performance in transfer tasks. The most frequently cited paper in this cluster is Kalyuga's paper on instructional design and learner expertise published in 1998 [8]. The half-life of this paper is 14 years, the cited frequency is 8 times and the centrality is 0.28. From the long half-life and high centrality, this study has a far-reaching pioneer role in the clustering.

### (2) Research emergence analysis

Through citespace analysis, the emergent information about cited references is obtained, which shows that a large number of studies in this field have cited this literature in a specific period of time. As shown in Figure 2, the emergent information of the top 25 references is listed. The book on complex cognitive skills training published by Van Merriënboer in 1997 has the highest emergent intensity, with an intensity coefficient of 4.1853. From the perspective of mutation duration, Merrill's *First Principles of Instruction* published in 2002 has the longest influence: 6 years from 2005 to 2010. In the second place, Hwang GwoJen published an experimental paper on the promotion of complex science by context-aware ubiquitous learning environment, which lasted for 5 years from 2012 to 2016. Context-aware ubiquitous learning (U-learning) combines wireless, mobile and context-aware technologies to detect learners' situations in the real world and provide adaptive support, which is systematic, authentic and economical.

In addition, the emergent information of the top 25 cited journals shows that the three journals with longer mutation durations are “Cognitive Science”, “Situated Learning” and “Cognition Instruction”. It can be seen that related research on holistic instructional design mainly focuses on the learning of cognitive skills.

### (3) Author co-occurrence analysis

Fig. 3 shows the co-occurrence knowledge map of English authors. The nodes are annual rings. The bigger the nodes are, the bigger the fonts of the authors are, indicating that the overall frequency of the authors is higher. The connection between authors means that two authors have cooperation. The thicker the connection is, the higher the co-occurrence frequency is. We can find that the font of the author “van Merriënboer” is the largest, and the thickness of the central radiation circle is higher, showing higher centrality. Combined with the English co-occurrence information table in Table 1, the frequency represents the frequency of the author's cooperation with others, and the cooperation between the two is only recorded once. For example, the frequency corresponding to the author “van Merriënboer” in the table is “30”. In the collected literature, the author “van

Merrienboer” and 30 different scholars have co authored related papers. The longer the cited half-life is, the more far-reaching influence and timeliness of the representative articles are. Articles published 15 years ago are still being cited many times.

Top 25 references highlight information



Fig.2 Emerging Information from English References

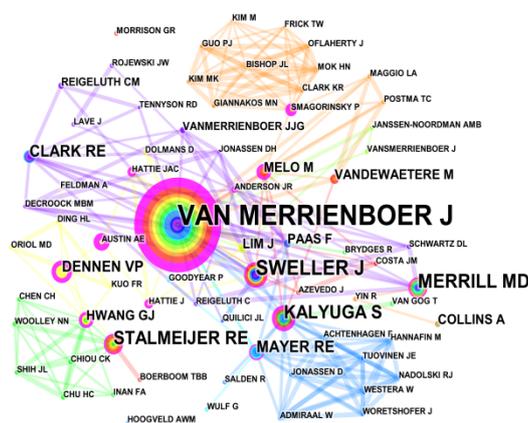


Fig.3 Co-Occurrence Knowledge Map of English Authors

Table 1 Co-Occurrence Information of English Authors

Co-occurrence frequency	Centrality	Author	Earliest time to post	Maximum cited half-life (years)
30	1.07	van Merrienboer. J	1997	15
11	0.19	Sweller. J	1998	8
9	0.12	Merrill MD	2000	9

As a matter of fact, the three foreign scholars in Table 1 represent the three mainstays in the research of holistic instructional design, and they are closely related to each other. Van Merriënboer, J., who ranks first, is the director of the Education Development Research Center of Maastricht University in the Netherlands. He has multiple academic backgrounds such as experimental psychology, psychophysiology and educational technology, so he interprets the implication of instructional design from a multidisciplinary perspective. In the book *Training Complex Learning Skills* written by him in 1997, the training blueprint of comprehensive learning design was comprehensively and thoroughly displayed. In 2007, van Merriënboer, J. and Professor Kirschner cooperated to develop ten operation steps of the comprehensive learning design model. In 2013 and 2018, these two scholars revised and refined the “Ten Steps” twice. van Merriënboer, J. takes complex cognitive skills as the starting point, and focuses on the professional skills training required for social jobs. In the past 20 years, van Merriënboer, J. has cooperated with many scholars to study how to develop adaptive instructional design according to learners' specialty, and combine the advantages of problem teaching and direct instruction teaching to realize the integrated development of knowledge, skills and attitude.

Professor Sweller, J., an honorary professor at the University of New South Wales in Australia, as an internationally renowned expert in educational psychology, founded the cognitive load theory in 1988 according to the characteristics of human cognitive structure. Since 1990s, van Merriënboer, J. has cooperated with Professor Sweller, J. in the study of learning tasks. In 1998, they cooperated to develop a new version of cognitive load theory, which included the concept of “related cognitive load” [9]. In 2019, van Merriënboer, J., Sweller, J. and Pass jointly issued a document to commemorate the 20th anniversary of the birth of cognitive load theory [10], reviewed the types, measurement and teaching effects of cognitive load theory, and discussed the future development trend of this theory. Sweller, J. explored the necessity of overall task design from the perspective of element interaction. His research on cognitive load theory provides guiding principles for optimizing teaching design for the promotion of learning transfer effects.

Merrill is an emeritus professor at Utah State University in the United States. As a leader in the second generation of teaching technology and design, during his 50-year career, he tirelessly explored how to achieve effective teaching with good effect, high efficiency and great participation. The primary teaching principle put forward by him and van Merriënboer, J.'s comprehensive learning design theory have achieved a great agreement in guiding program and operation level. Among the 116 English documents<sup>2</sup>, the two most frequently cited documents are Merrill's *First Principles of Instruction* (483 times) and van Merriënboer, J.'s *Blueprints for Complex Learning: 4C/ID Model* (204 times), which were published in the journal *Educational Technology Research and Development* in 2002 [12]. This is enough to prove the typicality of the above two theoretical models in the history of educational technology research and the close relationship between them.

### 3. Evaluation and Reflection

From the results of literature analysis, it can be seen that the researchers of holistic instructional design have reached consensus in the following aspects. On the basis of summarizing these common characteristics, the author puts forward some tentative suggestions for follow-up research.

Researchers agree that cognitive load theory is the theoretical support of holistic instructional design. The development of cognitive load theory is closely related to the development of instructional design research. The early development of cognitive load theory focuses on how to adjust teaching strategies to reduce external cognitive load. Sweller, J. et al. Summarized some instructional design principles that can help novice learners reduce the external cognitive load. However, with more and more holistic instructional design theories regarding rich and real-life learning tasks as the basis of complex learning, such tasks undoubtedly increase a lot of internal cognitive load for novice learners and hinder their learning process. Only by the six principles of

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<sup>2</sup>The cited frequency here refers to the cited times of the paper in the whole Web of Science, and also includes the cited times of articles in other disciplines.

reducing the external cognitive load can the total load in working memory be controlled within an acceptable range. Therefore, the study of cognitive load theory turns to how to provide teaching support to change the internal cognitive load. Holistic instructional design regards the process of complex learning as the process from the construction of cognitive schema to proficiency, and fully respects the evolution and development law of psychological mode in task sequencing and presentation. With the increase of project training duration, specialty reversal effect will also be involved in instructional design. This is the interaction between various basic cognitive load effects and the level of expertise. This is also the guiding foundation of “teaching according to needs, from support to release” in holistic instructional design.

Holistic teaching itself pays more attention to comprehensive quality, which is not only a general teaching design theory, but also a training design theory. The application practice in the literature mainly focuses on the fields of information technology and medical education. For example, multimedia technology teaching and nursing skills teaching. Because the training objectives of technical disciplines or vocational education courses point to procedural skills, their output tasks are highly similar to those in real life. It is easy for researchers to use objective yardstick to measure the merits and demerits of task completion, and quantitative research is mostly done. These holistic instructional design researches focus on analysing the teaching strategies based on the discipline starting point, rather than constructing the teaching mode, and pay attention to the bottom-up micro process, rather than the top-down macro design. Evidence-based research is adopted in most applied research, and the most representative one is to compare the effects of the whole task and local task teaching methods on learning transfer and acquisition of comprehensive skills through experimental research [13]. The implementation of holistic instructional design is inseparable from the learning environment supported by technology. An important feature of the whole task is authentic learning, which includes two meanings: authentic learning content and authentic learning style. The real learning content includes realistic situation representation and task variant representation. The real learning mode points to the representation of expert thinking mode and personalized guidance. The learning environment integrated with cutting-edge technology is the combination of virtual network space and real physical space. It can visualize the tacit knowledge of experts and practical wisdom of teachers anytime and anywhere, and generate new teaching cognition. Using artificial intelligence to develop training resource database, accurately respond to learners' diverse personalized needs and various potential needs. Monitoring and information statistical analysis technology is used to realize the real-time recording of learning process, and learning portfolio is used to realize adaptive learning trajectory. The development of information technology creates feasible conditions for the holistic learning to break the boundaries of disciplines.

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