



Construction of General Development Model of Learning Analytics--Data Visualization Analysis Based on Citespace

Lingyan Liu¹, Bo Zhao^{1,*}, Yan Li² and Handong Wang¹

¹ School of Information and Science Technology, Yunnan Normal University, Chenggong, Kunming, China

² National Key Laboratory, Yunnan Normal University, Kunming, China

{Lingyan Liur}3059234430@qq.com, {Bo Zhao} ykzb63@162.com, {Yan Li} 2630799151@qq.com

Abstract:

With the development of educational informatization, a lot of data has become an important basis for researchers to discover the learning law of learners. Therefore, Learning Analytics (LA) emerged. It has become an important tool and starting point for researchers to know the students' learning process in education. However, researchers have not conducted in-depth research on the development and evolution law of LA. The study makes a visual analysis of the literature about LA from 2011 to 2022 by using Citespace software. Firstly, according to the cluster map and co-occurrence map of key words, the research hot spots are summarized in LA. According to the time zone map and the number of articles published, four development stages of LA are summarized. Secondly, according to the research hotspots and development stages, the internal development logic of LA is deduced. Thirdly, the general model of LA development is constructed. Finally, the author summarized and looked forward to the development direction of LA in the future.

Keywords: Learning Analytics, Citespace, Visual analysis, Knowledge map, Development model

1 INTRODUCTION

With the development of technology, students' learning behavior and learning process in the network are recorded and stored in real time. Thus, a large number of learning behavior data were generated. It has become an important support for researchers to explore the learning law of learners. LA enables researchers to mine the characteristics and law of learning process from learning behavior data, which supports learners' personalized learning. At present, the development direction and process of LA have been described by literature analysis method [11] in some studies. In addition, some studies have sorted out the development of LA and existing problems from the perspective of social history and culture [6]. Some studies start from similar fields to sort out the context of LA by analyzing the differences among concepts [8]. However, there are no scholars who have conducted deep exploration on the development and evolution of LA. They have not established a general development model. Based on this, the research sorts out the research topics and hot spots in recent 11 years with Citespace5.8.R3, and analyzes and summarizes the

development stages of LA. Combining hotspots change and development stages of research, the internal development logic of LA is deduced. Finally, the general model of LA development is constructed.

2 DATA AND METHODS

2.1 Data Source

In order to objectively analyze the research status and hot spots of LA. In the study, citespace5.8.R3 was used to search journals and dissertations in CNKI with the development of LA and LA technology as keywords. The author set the search span from June 2011 to June 2022. A total of 282 literatures were retrieved, and 193 literatures were selected to meet the research topic. Take this as the research sample of this study.

2.2 Research methods and tools

The author uses Citespace to make visual analysis and bibliometric analysis of the literature in LA. Firstly, the co-occurrence map and cluster map of keywords are

analyzed, and the research hot spots and topics in this field are extracted. According to the time zone map of keywords and the statistics of published articles, the stages of the development of LA are summarized. Secondly, according to the analysis of hot spots and development stages, the internal logic of the development of LA is summarized. Finally, a general development model of LA is constructed.

3 DEVELOPMENT OF LEARNING ANALYTICS

Researchers are able to read the hot spots in the field by understanding the direction and topic of research. Although keywords do not take up much space in the article, they are the distillation of the core and essence of the article, and are a highly generalized and concentrated description of the theme of the article [1].

3.1 Several highlights of LA can also be found according to these picture.

Co-word analysis is one of the content analysis methods. Its basic principle is to reflect the correlation strength of keywords by counting the co-occurrence of concentrated words or noun phrases in sample literature [7], so as to determine the research hotspot, composition and paradigm of the discipline or field they represent. Through co-occurrence analysis of samples, 224 nodes and 388 connecting lines were obtained, as shown in Figure 1.

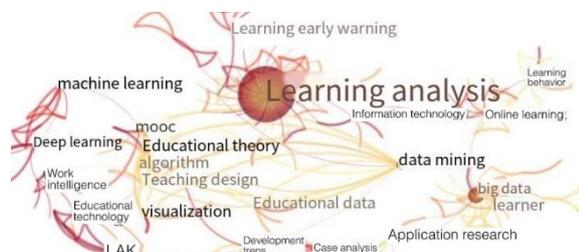


Figure 1: Keywords co-occurrence.

It can be observed from the above figure that LA is closely related to data mining, educational theory, online learning, machine learning, etc. This shows that LA can combine technology with theory to promote students' learning, especially online learning. Words such as "applied research" and "case analysis" also appear in the picture, which also shows that LA is constantly being practiced and applied in the process of development. Just in 2022, the International Conference on Learning Analysis and Knowledge (LAK) was successfully held in the United States, and the "integration of numbers and intelligence" connected with "LAK" in Figure 1 also showed the theme of the conference, that is, the transformation of LA.

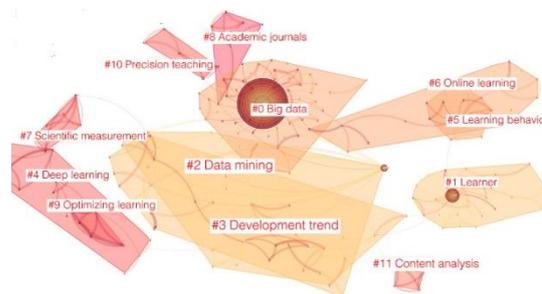


Figure 2: Keyword clustering.

Through the cluster analysis of key words, the author got 12 cluster groups, as shown in Figure 2. The observed clustering groups include big data, online learning, learning behavior, learners, development trends, deep learning, data mining, scientific measurement, optimization learning and so on. Combined with Figure 1 and Figure 2, it can be found that several emphases in LA include the application of LA technology (such as machine learning, data mining, etc.), personalized learning (especially the exploration of learners' personalized characteristics in online learning), visual analysis (such as LA dashboard [9]), multi-modality, ethical issues, etc.

3.2 Some phased performances of LA can be summarized according to this table.

Although LA is formally referred to in LAK11. However, it can be observed from the figure that the Chinese research community began to pay attention to LA in 2012. Individual researchers have started earlier. Based on the time zone map, some stages of LA development can be seen. From 2011 to 2015, LA carried out theoretical discussion and exploration of available technologies, and has been widely spreaded in 2014. From 2015 to 2018, researchers began to pay attention to practical analysis of LA. In practice, they found that LA was facing challenges from new technologies and ethical issues. From 2018 to 2022, researchers focus on the combination of LA and big data to analyze the characteristics of learners.

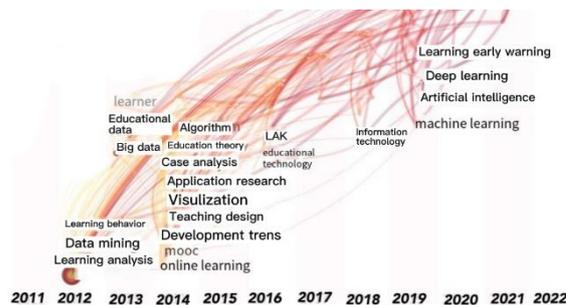


Figure 3: Time zone map.

It can be inferred from Figure 4 that the development of LA in 2015 encountered challenges and opportunities, resulting in a rapid increase in publications. In 2018, the development of LA may also encounter new

opportunities, resulting in a certain increase in the number of articles. In 2022, LA should have a good development foundation, but the number of articles published declined rapidly, which may be due to transformation.



Figure 4: The number of articles published per year.

After 2018, articles published tend to be more about individual learners, showing a learner-centered trend. In 2022, there were more discussions on the future development direction of LA. This indicates that LA has established a certain foundation so far. Researchers began to think about the development direction of LA.

Table 1: Top 10 institutions or authors with publications

Count	Centrality	Author Institutions
12	0	Wei Zhang
9	0	Zhu Xiaofeng
6	0	Zhongjun Wang
3	0	East China Normal University
4	0	Xiaoqing Gu
5	0	Yonghe Wu
7	0	Northeast Normal University
3	0	Wei Zhao
3	0	Central China Normal University
3	0	East China Normal University

According to the study, although there are a certain number of research institutions and researchers in LA, there are few connections between researchers and research institutions, which is not conducive to the long-term development of LA.

3.3 Analysis of development stage.

The development stages of LA are systematically summarized in this paper by combining the phased performances and highlights in LA, as shown in Figure 5.

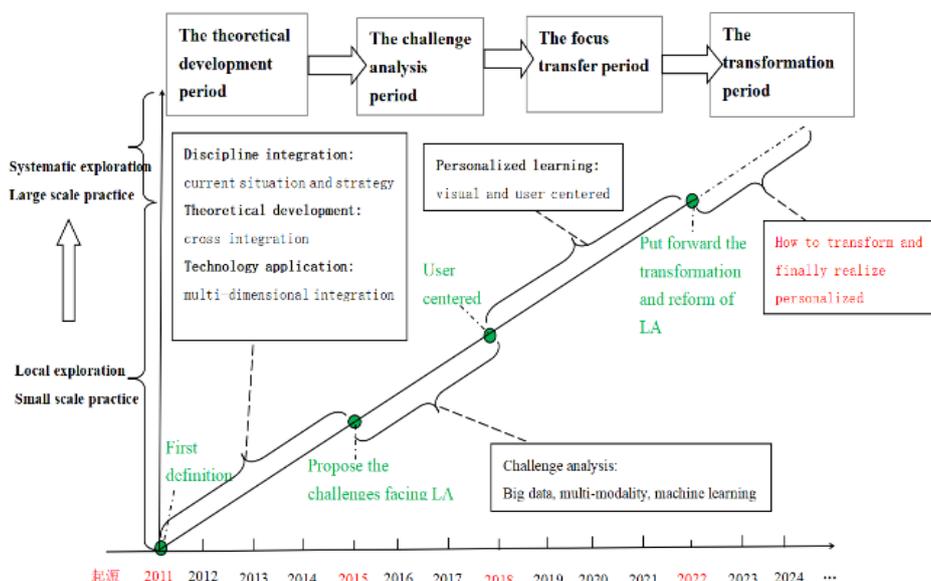


Figure 5: Division of LA development stages.

Horizontally, the development of LA has gone through four stages, including theoretical development (2011-2015), challenge analysis (2015-2018), focus transfer (2018-2022) and transformation (after 2022). Each stage shows different characteristics and emphases.

- The theoretical development period.

The LA concept has been formally proposed in this period. Experts put forward plans for the development of LA from three aspects, including discipline integration, theoretical development and technology application. Discipline integration aims to summarize the current situation and development strategy of LA technology, modeling, representation, knowledge work and analysis.

Theoretical development is related to the cross - integration of multidisciplinary theories. Technical applications require the integration of LA from different dimensions using multiple technologies.

But the essential difference between LA and other disciplines remains unclear. As a result, some common problems need to be concerned, such as how to develop LA with multidisciplinary historical roots into a truly independent discipline? What is LA? What technical and theories support LA?

- The challenge analysis period.

Due to the rapid development of educational big data, technical challenges and many ethical issues have arisen in LA. The emergence of new technologies (such as machine learning) has brought benefits as well as challenges to LA. But these challenges also encourage people to think differently about the development direction of LA. Therefore, LA has entered a stage of more dialectical analysis from blind exploration at this time.

- The focus transfer period.

With the rapid increase of students' online learning behavior data, LA researchers have great interest in students' individual learning. The shift of emphasis mainly refers to the change of the focus object of LA in this period, that is, from the original focus on the learning group to the student as the center. Personalized learning believes that the learning process should be based on students' personality characteristics. In addition, visualization also provides technical support for better personalized learning. Therefore, this transformation of LA will lay a foundation for the subsequent development of personalized learning.

- The transformation period.

After ten years of research and practice, LA has ushered in a critical period. In this period, researchers need to explore the reform path and strategy of LA. While avoiding risks, LA is promoted to keep pace with the times and adapt to the changes in education.

Vertically, LA has experienced a development period of local exploration and small-scale practice. This is also the common characteristics of the first three stages. Up to now, it has been experienced a period of systematic exploration and large-scale practice.

It is not difficult to discover that the four stages of LA can realize iterative cycle. Once the transformation and reform would be completed, new theoretical concepts, new challenges and new focus point would be generated. Then it will reach the turning point of transformation and reform again. If this cycle continues, LA will steadily update, enter new application fields or become a more advanced educational analysis technology.

3.4 Internal development logic.

Based on the research hot spots and development stages of LA, internal development logic of LA can be discovered, as shown in Figure 6. The development of LA is a process from multidisciplinary combination to independent discipline, from data to information to knowledge, from theory to practice, from macro to micro, from small-scale practice to large-scale practice, from community groups to individual users, from the exploration of fragmented communities to the exploration of systematic users.

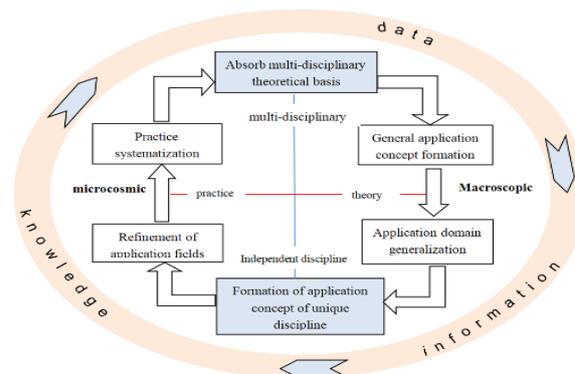


Figure 6: internal development logic of LA.

Wenping Zhao pointed out that “the development of contemporary disciplines presents a vertical and horizontal and hierarchical differentiation trend [13].” The development of LA is a regular process.

Vertically, LA shows the law from macro to micro, from multidisciplinary to independent discipline. Horizontally, LA shows the internal development law from theory to practice. Circularly, an internal development logical chain can be found by analyzing.

Just as "natural selection, survival of the fittest" in Darwin's theory of evolution [5], the internal development logic of LA also applies. LA is constantly evolving under different environmental backgrounds through the internal development logic. Therefore, it can adapt to the changing educational environment.

LA can be achieved a qualitative leap through the internal development logic. It will be combined with emerging technologies such as AI to study at the individual micro level, which ultimately discover the essential law of human learning.

4 GENERAL DEVELOPMENT MODEL OF LEARNING ANALYTICS

Based on this research, a general development model of LA was constructed in this paper, as shown in Figure 7.

- From the hierarchical perspective, the development of LA follows the law from theory to demand to discipline is followed.

LA is an important way to realize personalized learning in education. A remarkable feature of the development of LA is the introduction of theories from other disciplines into education. Based on this multidisciplinary rationale, LA plays a unique role in supporting personalized learning for students.

- From the horizontal perspective, the development of LA follows the law from multi-

disciplinary practice to cycle of development stages and then to discipline innovation.

LA is bred from multidisciplinary practice and it can meet various needs. After four stages of sustainable development, it has formed unique advantages in the field. And LA is also expected to realize innovation in the big data environment which realize systematic practice in specific learning stages and discover the unique learning law of learners.

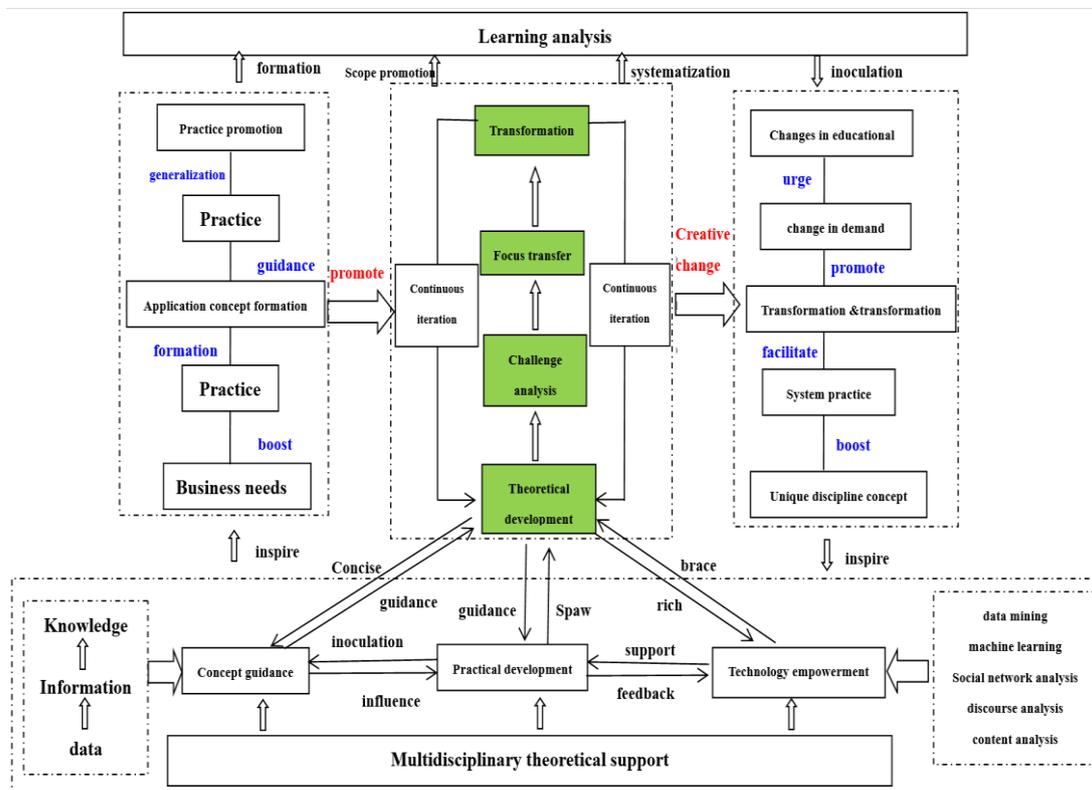


Figure 7: General development model of LA.

- From the vertically perspective, the development of LA follows the law from fragmented practice to discipline development and then to systematic practice.

It is an important development aspect in LA to promote the integration of multidisciplinary theory and experience. It aims to make LA an independent discipline with richer contents. Therefore, researchers from various countries have conducted a lot of practice and discussion [10]. In the process of continuous practice, LA has been separated from multi-disciplines and formed a unique practice mechanism.

- From the circulation perspective, the development of LA is the organic integration of the first three laws.

The development of LA is centered on four stages of iteration, which follows the law from multidisciplinary theoretical basis to fragmented practice, then to systematic practice, then to independent discipline innovation, and then to the extension of multidisciplinary

fields. It is also a profound reflection of the general development of LA.

5 FUTURE DEVELOPMENT PROSPECT OF LEARNING ANALYTICS

5.1 Conclusion

Based on the whole research, some conclusions can be drawn.

Firstly, LA is a set of technical means or tools to study learners based on different material media under the background of educational big data [2].

Secondly, the development of LA follows a cycle of four stages from theoretical development to challenge analysis to focus transfer to transformation.

Thirdly, LA follows internal development logic in the process of development.

Fourth, the development of LA is moving in a systematic and practical direction. It is driven by environmental requirements and centered on iterations of development stages.

Fifth, LA is viewed as an opportunity for researchers to master the law of learning. It may be able to point out the shortcomings of traditional education and promote the reform of traditional education.

5.2 Future development direction of learning analytics

To sum up, the author has the following opinions on the future development direction of LA.

- The combination of LA and machine learning [12] meets the accurately predicted needs of big data analysis.

- The combination of LA and brain science reveals the occurrence mechanism of deep learning [3] and provides a scientific basis for the study of deep learning.

- The combination of LA and education big data [4] promotes the study of personalized learning for learners.

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