A Visualized Analysis of Game-Based Learning Research from 2013 to 2017

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***Abstract*—This study aims to make a visualized analysis of game-based learning (GBL) research so as to provide more insights into the research quantity, categories, regions, the most influential scholars and the research hotspots. This paper analyzed the articles and proceeding papers derived from Web of Science (WOS) in the field of game-based learning from 2013 to 2017. A total of 1818 publications were selected and analyzed by the CiteSpace, which was a freely java application to analyze and visualize the trends of scientific publications. The results indicated that the quantity of game-based learning research presents a growth tendency from 2013 to 2017. The category of Education & Educational Research were the most common category in this field. Mozelius P was the most influential researchers. Furthermore, it was found that serious game, motivation, education and gamification were the most frequently used words in the field of game-based learning. Serious game, environment, motivation, gamification, mathematic and Intelligent tutoring system were the research hotspots in this domain. The implications and limitations were also discussed in detail.**

Keywords—game-based learning, visualized analysis, research hotspots

I. INTRODUCTION

Game-based learning (GBL) is an innovative learning approach based on the use of games (including video games and non-video games) that possess educational value or various software applications that use games for learning and education purposes, it has been used at all levels of education including primary, secondary and higher education. It has been widely acknowledged that game-based learning as a potentially engaging form of supplementary learning developed a reputation with educationalists and became an effective way in enhancing the educational process. So far, a great number of studies about content analysis of game-based learning have been reported. For example, Gwo-Jen Hwang and Po-Han Wu examines the digital game-based learning (DGBL) articles published in seven major SSCI journals from 2001 to 2010 to analyze the research status and trend of DGBL [1]. Chia-Wen Tsai and Ya-Ting Fan analyzed the GBL studies published in SSCI-indexed journals from 2003 to 2012, focusing on sample groups, subject domains, and research methods used in the studies [2]. Thomas Hainey and his colleagues adopted content analysis method to make a systematic literature review of quality empirical studies associated with the application of GBL in Primary Education [3].

To sum up, previous contributions have provided the major ideas underlying the GBL from the qualitative or quantitative perspectives. However, only a few studies examined the intellectual structure of game-based learning in a visualization way. Xueying Bao and Yuxiang Zhao adopted methods of bibliometrics and knowledge mapping to analyze the whole research progress of GBL from 1907 to 2014 [4].

Nevertheless, it was not clear to illuminate the current status of game-based learning in the literature. The latest publications needed to be included in the study. In addition, there were limited studies analyzed the papers of game-based learning by CiteSpace. Actually, more methods and information need to be enriched in the visual study of GBL. As a result, this study endeavored to examine the visual knowledge network maps of game-based learning to analyze the categories, regions, scholars, keywords, and the collaborative relationships of game-based learning through CiteSpace. In this study, we aim to analyze the research status and trend of game-based learning in the recent 5 years (from 2013 to 2017) and investigate the following five research questions:

(1) What was the change in the number of the GBL researches from 2013 to 2017?

(2) What were the relevant categories of GBL over the span of 2013-2017?

(3) What were the major regions in the field of GBL from 2013 to 2017?

(4) Who were the most influential scholars in the field of GBL from 2013 to 2017?

(5) What were the current research status, hotspots and emerging trends of GBL over the span of 2013-2017?

II. METHODS

A. Data Source

This study used the term "game-based learning'' as the subject to search publications from the database of Web of Science (WOS) from 2013 to 2017. Initially there were 1921 papers. After scanning the titles, 103 papers that were not closely related to GBL were excluded. Finally, 1818 publications, including articles and proceeding papers, were retained for further analysis.

B. Research Tool

In this study, CiteSpace, an information visualization software, which was developed by Dr. Chaomei Chen, a scholar at the College of Information Science and Technology of Drexel University, was selected as the analysis tool. It was a freely java application to analyze and visualize the trends and changes of scientific publications [5]. CiteSpace can analyze a variety of knowledge networks, including document co-citation network, keywords network, institutions network, regions network, and so on.

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C. Parameter Setting

Before running the data of publications by CiteSpace, the parameter should be properly set in accordance with the research objectives. In this study, when analyzing categories, regions and authors, the duration was set from 2013 to 2017 and the value of years per slice was set to 1. The style of pruning was set as "Pathfinder". Then we selected the top 50 most cited or occurred items from each slice. The style of visualization was set to be "Cluster View-Static" and "Show Merged Network". With respect to keywords, the operating steps were the same as categories, regions and authors. However, the pruning sector was set as the style of "Minimum Spanning Tree" to simplify the co-occurrence network.

III. Results

A. Number of Publications

Using the function of "Remove duplicates" in CiteSpace, we can remove the duplicate literature data in addition to know the number of publications per year. Fig. 1 depicts the annual quantity of publications published and the trend of game-based learning research from 2013 to 2017. In general, the quantity of GBL research literature presents a growth tendency in the last 5 years. As shown in Fig. 1, the number of related research increased dramatically in 2015 and 2016, and rose to 444 papers in 2015 from 221 in 2013, showing scholars strong research interest in game-based learning. Although research publications of GBL declined slightly in 2017, the quantity remains high as a whole.

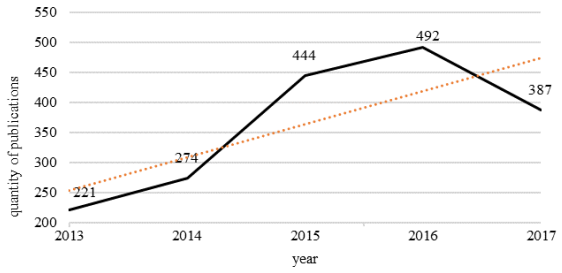

Fig. 1. Quantity of publications about game-based learning (2013-2017)

B. Analysis of Categories and Regions

CiteSpace can display the distribution of categories of publications. As shown in Fig. 2, the visual knowledge network map of different categories, presented with 81 nodes and 255 links. It was found that Education & Educational Research was the leading one in this domain. The second one was Computer Science.

A collaboration map of the productive regions consisted of 64 nodes and 215 links between 2013 and 2017 (see Fig.3). It was noticed that the diameter of the circle represented the amount of papers of the regions. For example, the circle of USA was the biggest, which meant USA was the most productive region. Taiwan ranked the second.

The links in the Fig. 3 represented the relationships in different regions. As the most productive region, USA had 27 regions as collaborators in the past five years, which can be explained with another term, centrality. Centrality represented the level of importance of terms. If the centrality was high, it represented that this region was very important in this domain. Therefore, the USA was the most important country with centrality of 0.38. In addition, there are 215 links in the knowledge network map of regions, and the overall density of the network is relatively high (0.1066), which reflects that there were much international cooperation between researchers from different countries during 2013 to 2017.

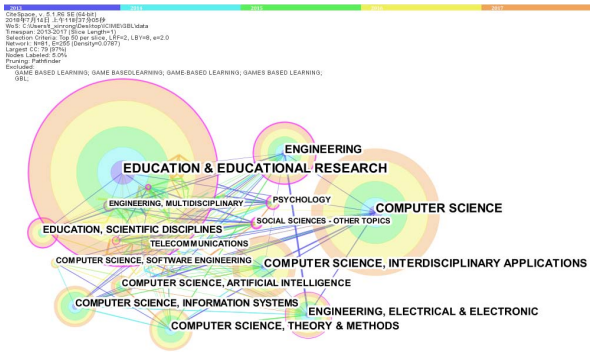

Fig. 2. The knowledge network map of different categories

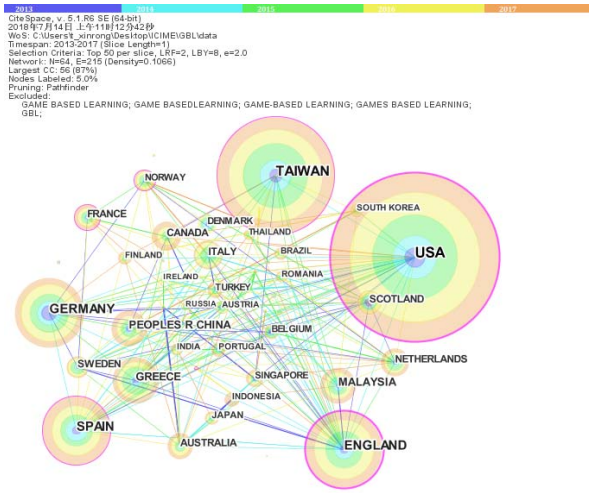

Fig. 3. The knowledge network map of regions

C. Major Contributing Authors

The knowledge network map, which shows the collaboration pattern of authors contributing to the study of game-based learning, contains 431 nodes and 561 links. As shown in Fig. 4, the size of circles implied the amount of publications, the distance and lines between different circles represented the collaboration among individual authors, shorter distances represented more collaboration [6].

Mozelius P was the scholar with the highest number (20) of publications in the last five years, Hainey T ranked the second (16). What's more, there were some small clusters representing the collaboration of the scholars in Fig. 4. Nonetheless, there were no many lines between clusters and the network density is very low (0.0061), suggesting that the collaboration among different authors was not very strong. In other words, researchers in different academic groups need to collaborate more in the future.

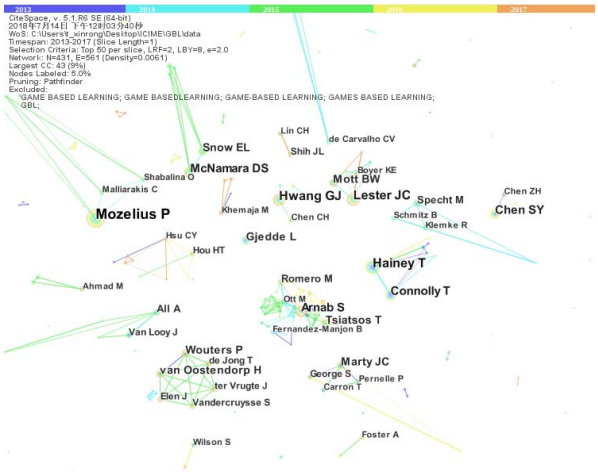

Fig. 4. The knowledge network map of authors

D. Analysis of Research Hotspots

Exclude the similar search keywords including "game-based learning", "game based learning", "game basedlearning", "games based learning" and "GBL", we got a knowledge network map of co-occurring keywords with 117 nodes and 512 links as Fig. 5. Through the network map of keywords, we could know the research status and hotspots. In the knowledge map, one node represents one keyword; the frequency of keywords determines the size of node circle. As shown in Fig. 5, the node of "serious game" is the largest, which represents the occurrence frequency of "serious game" was highest in the recent five years' research. Beside the top frequency, the second one and the third one were "motivation" and "education" according to Fig.5. However, the forth one and fifth one were "gamification" and "game", respectively.

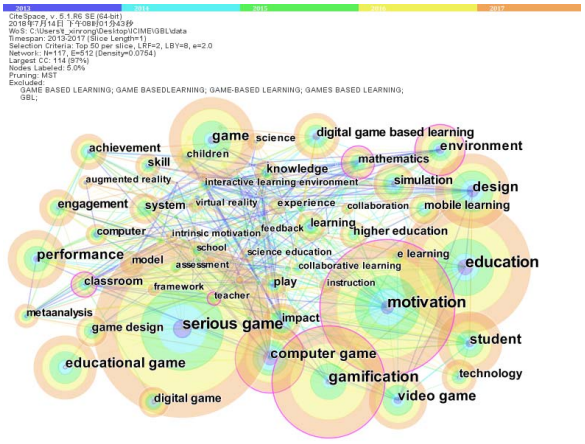

Fig. 5. The knowledge network map of keywords

According to the summary of CiteSpace analysis results, we obtained the information about the top 20 keywords of high frequency (see TABLE □). These keywords are important research contents in the current study field of game-based learning and reflect the research hotspots in the field to some extent. The centrality of the node can measure the power of the node, reflecting the core position of a keyword in the network and the importance of a keyword in the network. The higher the centrality, the more important the node is. According to the centrality, the important keywords could be found: "environment" (0.18), "computer game" (0.13), "motivation" (0.11), "gamification" (0.11) and "mathematics" (0.10). Although some of these keywords have low frequency, they are very important in the entire research network.

TABLE I. LIST OF TOP 20 HIGH-FREQUENCY KEYWORDS OF RESEARCH ON GAME-BASED LEARNING FROM 2013 TO 2017

Ranking	Keywords	Frequency	Centrality
1	serious game	274	0.04
2	motivation	207	0.11
3	education	204	0.09
4	gamification	174	0.11
5	game	133	0.02
6	design	116	0.05
7	computer games	106	0.13
8	student	103	0.08
9	educational game	101	0.02
10	video game	93	0.06
11	performance	91	0.05
12	environment	77	0.18
13	digital game based learning	73	0.07
14	simulation	65	0.02
15	engagement	61	0.05
16	impact	60	0.06
17	technology	58	0.05
18	achievement	58	0.04
19	mathematics	52	0.10
20	mobile learning	52	0.00

In addition, the hot topic could be discussed according to Fig. 6, which listed the top six keywords with the strongest citation burst of game-based learning from 2013 to 2017: "virtual world", "flow", "assessment", "educational technology", "evaluation" and "intelligent tutoring system". For example, "educational technology" was the strongest citation word starting at 2014 and ending at 2015, which meant that "educational technology" was suddenly been studied by many scholars within the two years. Nowadays, "evaluation" and "intelligent tutoring system" were the hot topics of game-based learning and will be the research trends.

Keywords	Year	Strength	Begin	End	2013 - 2017
virtual world	2013	3.621	**2013**	2015	
flow	2013	2.3422	**2013**	2014	
assessment	2013	3.2305	**2014**	2015	
educational technology	2013	3.5206	**2014**	2015	
evaluation	2013	2.8794	**2015**	2017	
intelligent tutoring system	2013	2.6569	**2015**	2017	

Fig. 6. The top six keywords with the strongest citation bursts

Combined with the co-occurrence frequency and centrality of keywords plus the strongest citation bursts, several hotspots of game-based learning from 2013 to 2017 can be found, respectively as follows:

1) Serious game: The majority of computer games are for the purposes of player entertainment, but serious games refers to applications developed using computer game technologies that serve purposes other than pure entertainment. The term has been used to describe a variety of game types, particularly those associated with e-learning, military simulation and medical training [7]. Serious games, as one of the main tools of game-based learning, have always been a hotspot in the field of GBL.

2) Gamification: Gamification (be used as a synonym of Game-Based Learning) is the use of game design elements and game mechanisms in non-gaming environments. In recent years, gamification has become a catchword throughout the fields of education and training, thanks to its perceived potential to make learning more motivating and engaging [8]. Some researchers found that gamification in e-learning platforms seems to have potential to increase student motivation, but it's not trivial to achieve that effect, and a big effort is required in the design and implementation of the experience for it to be fully motivating for participants [9]. However, gamification will be the development trend of game-based learning.

3) Motivation: A motivational approach to game-based learning emphasizes that games are able to engage and motivate players by providing experiences that they enjoy and want to continue [10]. It is assumed that game-based learning could influence learning by improving learning motivation. Some scholars researched motivational effects of game-based learning and the way to improve intrinsic motivation through GBL.

4) Environment: In game-based learning, serious games and game-based learning applications or platforms are applied as learning environments. Many scholars discuss why games are effective learning environments and how these game-based learning environments are designed. It differs from the design of traditional learning environments in a number of ways. Nowadays, various technologies are adopted to design GBL environments, such as augmented reality, virtual reality, and mobile technology. Some researchers devised an augmented reality game using a design-based research approach then tested it in a real classroom, their results show that children do display greater motivation and interest in the activity and the activity is enriched as it promotes problem solving, exploration, and socialization behavior [11].

5) Mathematic: Mathematics is a fundamental skill in our daily life. Nevertheless, many students possess low confidence toward learning mathematics, which, in turn, may lead them to give up pursuing more mathematics knowledge. Some studies indicated that game-based learning was an effective means in improving students' confidence toward mathematics and low-ability students in the GBL group attained better mathematics performance than those in the paper-based setting [12]. The researches about mathematics education by the use of GBL have increased from 2013 to 2017.

6) Intelligent tutoring system (ITS): An ITS is a software agent who can provide adaptive feedback according to learners' ability or behavior then adjust the difficulty of learning task timely. However, one of the main challenges of the educational games is to provide a game design enabling players/learners to face tasks and steps according to their real ability. The main idea in Game-based Learning is to always guarantee a game level a bit greater than the ability she demonstrated by considering a zone of proximal development. This aspect can be sustained by the behavior of an ITS [13].

IV. Research Conclusions

Through the visualized analysis of 1818 publications of game-based learning research in nearly 5 years, this study discussed time distribution of the citations, research categories and regions, major contributing authors and research hotspots. Specifically, the main conclusions of this study include:

1) International game-based learning research presented an overall increasing trend from 2013 to 2017, and there are plenty of publications in the recent 5 years.

2) Education & Educational Research was the biggest category with the largest number of papers about game-based learning. The second one was Computer Science.

3) USA was the most productive region and the most important and influential country in the research network. Taiwan ranked the second in quantity of publications. Besides, there were much international cooperation between researchers from different countries during 2013 to 2017.

4) Mozelius P at Mid Sweden University was the scholar with the highest quantity of publications about game-based learning in the last five years. Hainey T at University of West Scotland ranked the second . However, the collaboration among different authors was not very strong. Researchers in different academic groups need to collaborate more in the future.

5) High-frequency keywords included serious game, motivation, education, gamification, game, design, computer games, etc., and the research hotspots were reflection on the design and application of serious games and learning environments, the use of gamification in learning, the approach and effects about improving learning motivation, research on mathematic education, and the combination of GBL and ITS.

With the development of technology, education field has emerged a variety of learning tools and teaching methods. We need to explore what kind of teaching content and what kind of students are suitable for game-based learning, and what strategies are better for use together. Several previous studies have reported that without properly integrating instructional strategies or learning strategies into gaming scenarios, the effectiveness of game-based learning could be limited, or may be even worse than that of the conventional technology-enhanced learning approach [14]. Therefore, in order to achieve the effect of GBL, the instructional designers, game designers and educational stakeholders need to collaborate [15]. As the traditional learning paradigm gives way to the new learning and then on to the future learning approaches, game-based learning will become more embedded into practices, be personalised and hide the curriculum in more seamless ways [16]. We think that game-based learning or gamification learning will have further development.

In addition, this study was constraint by the following limitations. First, this research only took the examples of

WOS literature database, the sample data may have some limitations. Second, only articles and conference papers were included in this study. Some book chapters, reports, and editorial were excluded. Future studies should enlarge the publications and extend the data sources from other databases. Third, this study only analyzed keywords, authors, categories, and regions, maybe future research could analyze the clusters of research terms. Moreover, there remains further in-depth analysis.

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