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Research trend and development process in learning analytics: a review of publications in selected journals from 2008 to 2019

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Abstract: We employed a Co-citation analysis by the Citespace software for the trend and development process in learning analytics. Through the clustering term time-zone view, it is clearly shown that 15 research clustering terms occurred from 2008 to 2019. Moreover, this paper proposed a clear review when these terms emerged and how they grew.

Keywords: Co-citation, Learning Analytics, Literature review

1. Introduction

With the development of technology, learning analytics (LA) have been improved (Yin & Hwang, 2018; Yin, Yamada, & Shimada, 2019). To better understand the development line of learning analytics, many researchers proposed literature reviews with different perspectives. For example, states, trends (Dawson, Gašević, & Siemens, et al., 2014), factors, nature, fundaments, applications (Peña-Ayala, 2018), limitations, methods, and key stakeholders (Leitner, Khallil, & Ebner, 2017). Although there was evidence of how many research terms occurred, it is not a clear outline of when they emerged and how they grew.

2. Method

2.1 data

14,035 records were gained on the Web of Science, by keywords: “learning analytics” or “education data mining” and timespan: 2008 to 2019. Then, from 14,035 records, selecting papers published in the top 20 publications by Google Scholar Metrics, and finally we got 496.

2.2 Analysis Method

Clustering in data mining is a process of aggregating and classifying data in complex networks based on similarities. In keyword clustering analysis, clustering reflects the similarity of nodes in a network (Chen, C. et al., 2010), which is helpful for identifying and detecting representative knowledge subgroups in a research field, i.e., hot topics in the research field. By setting the network nodes as “Keyword” in the Citespace software, and clustering them on the basis of keyword co-citation network. Finally, a keyword clustering network by time-zone is obtained, as shown in figure 1. The figure body is the historical development lines, which represent the trend of each clustered term. The label on the left is each clustering term name. The number on each line represents the order of each node.

3. Results

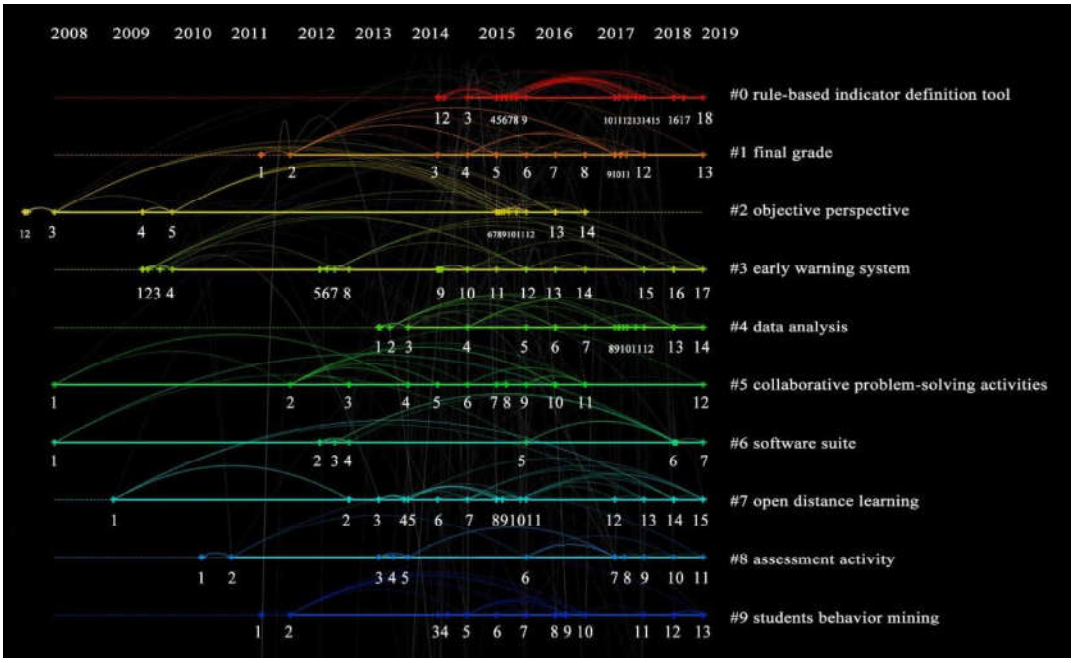

Figure 1. Keyword co-citation network clustering time-zone (Top 10).

In the past decade, the clustering term of LA includes 15 clustered terms, rule-based indicator definition tool, final grade, objective perspective, early warning system, data analysis, collaborative problem-solving activities, software suite, open distance learning, assessment activity, students' behavior mining, institutional strategical plan, managing cognitive load, emerging educational technologies, understanding social interaction, practical application. I selected the top 10 clustering terms for analysis

3.1 Rule-based indicator definition tool

"Actionable insights" merged in 2014. There have been two concentrated development stages. The first one consisted of "data collection" "learning context" and "self-regulated learning" within 2015. The second one included "multimodal data" "machine learning" and "student performance" within 2017. "Neural network" "case study" and "digital learning environment" are the latest research nodes.

3.2 Final grade

It has an even development line, starting with "combing education data mining" in 2011. "Considerable variability" "learning management system" "adult learners time management" "previous research" "learning analytics technique" "data source" "educational research" "5-year development" "open educational resources" and "google analytics" sequentially emerged from 2011 to 2016. Concentrated research has been formed by "applying learning analytics" and "undergraduate students" in 2017. "Course structure" became the latest research node in 2019.

3.3 Objective perspective

It started from 2008 to 2016. A concentrated development stage exited in 2015, including "learning behaviors" "educational technology" and "learning environment". It ended with "3D virtual laboratory" (2016) and "preliminary finding" (2016).

3.4 Early warning system

The initial point of this term concentrated with the "early warning system" "3at-risk students" and

"education institutions". After that, the second concentrated development stages followed by "earning analytics tool" "teacher inquiry" and "learning design". Since 2014, this term has begun to enter an even stage, the "knowledge gap" "educational institutions" "pedagogical model" "social network" "early identification" and "course materials" have emerged and developed in succession until 2017. From then, "blended learning" has been gained attention by 2019.

3.5 Data analysis

"Social learning" and "social network analysis" became the initial nodes in 2013. In the next three years, "massive open online course" "learning performance" "early detection" "foreign language" and "online environment" sequentially entered into the field of data analysis. The concentrated development stage occurred within 2017, focusing on "learning strategy" "online learning" "learning analytics dashboards" and "student engagement". In the past two years, it shifted to "demographic characteristic" "effective strategy" and "decision tree".

3.6 Collaborative problem-solving activities

It has been persistent from 2008 to 2019. Since the initial research node "educational data mining" merged in 2008, there has been limited attention to it until 2011. However, the next six years have seen the rapid development at an increasingly shorter interval. The development sequence is "learning analytics" (2011) "concept comprehension" (2012) "adaptive learning" (2013) "chronological framework" (2014) "student learning" (2014) "completion rates" (2015) "natural language processing" (2015) "collaborative learning" (2015) "guest editorial" (2016) "sequential analysis" (2016). "Artificial intelligence" became the recent research node in 2019.

3.7 Software suite

There were 7 research nodes in it, which presented in a way that is widely spaced over time. The first node was "educational context" in 2008. The second concentrated development stage consisted of "competence acquisition" "blended courses" and "course design" in 2012. The fifth node was "educational data". Both "students' behavior" and "empirical evidence" together constituted a research node in 2018. It followed that the predictive model became the latest research node in 2019.

3.8 Open distance learning

"Content analysis" was the starting point in 2009. After that, some research nodes continued to emerge until 2015, such as "authoring system subject" "critical reflection" "blog content" "analyzing large dataflows" "conceptual framework" "student data" "analytic approach" and "big data". There were two concentrated development stages before 2015, including "ethical considerations" "emerging field" and "learning analytics system". From 2017 to 2019, "classroom settings" "systematic review" "entire course" and "data science" sequentially emerged and formed the fourth concentrated development stage.

3.9 Assessment activity

There were 4 obvious development stages. The first one was composed of "complex chemical system" "conceptual understanding" and "complex system" in 2010. "Assessment activity" "supporting teachers" and "clustering analysis" sequentially emerged and constituted to be the second one in 2013. Compare with the former two stages, "learning experience" was the third one. From 2017 to 2019, "process mining" "course completion" "massive open online course" "available tool" and "theoretical framework" formed the fourth one.

3.10 Students behavior mining

The earliest emergence of this term was "communication technology", following by "learning activity"

in 2011. From 2014 to 2016, the increasing number has been accelerated. For example, “90th percentile” “final course grades” “learning outcome “disciplinary factor” “learning designs” “virtual learning environment” “student-facing learning analytics” and “control group”. The latest research nodes were “learning approach” “students’ engagement” and “e-learning environment” since 2017.

4. Conclusion

This study found that some terms have been persistent from 2008 to 2019, in which some nodes merged in a concentrated or separated way. For example, “collaborative problem-solving activities” and “software suite”. In addition, the majority of terms presented a shorter development line, and grown from a certain time to the present. Such as “rule-based indicator definition tool” “final grade” “early warning system” “data analysis” “open distance learning” “assessment activity” and “students behavior mining”. It is worth noting that “objective perspective” have continued to develop since they appeared, but they have not received attention in recent years.

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Co-Creation of Structure Visualization with Virtual Reality in On-Line Communities: An Analysis of Student Engagement

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Abstract: This study investigated student engagement in paper-based, digital 2D, and VR co-creation environments. The study utilized a quasi-experimental research design with 66 tenth-grade students in two EFL classes in northern Taiwan. The results showed insignificance of co-creation platforms for behavioral and cognitive engagement. However, VR co-creativity resulted in significance in emotional engagement, due to its novel and immersive nature. The study suggested that co-creation be a long-term project for thorough idea synthesis lest the essence and strength of co-creation be under-estimated.

Keywords: Co-Creation, Virtual Reality, Student Engagement

1. Introduction

Virtual reality (VR), with presence, interactivity, and immersion (Ryan, 2015), has proved value in conceptualizing abstract environments (Lamb, 2014), activating cognitive attributes (Lamb, 2014), and improving retention and efficacy for novel information (Freina & Ott, 2015). For social constructivists, VR creation could further turn traditional drill-driven instruction into contextualized inquiry learning where authentic contexts stimulate situativity in knowledge development.

VR co-creation, distinguished from collaboration in high equity and shared leadership for collective wisdom, has shown positive outcomes in subject-matter comprehension (Bertolini et al., 2018), increased self-awareness (Lubicz-Nawrocka, 2018), and improved collaborative skills (Blau & Shamir-Inbal, 2017). Moreover, it has sparked a reading pedagogical shift where student engagement is featured (Rapp et al., 2007).

Student engagement, referring to learners' physical or mental participation for expected academic outcomes (Sun & Rueda, 2012), is specified as behavioral, emotional, and cognitive, each encompassing diversified activity involvement, emotional responses, and psychological efforts in learning (Fredricks, Blumenfeld, & Paris, 2004).

Student engagement helps learners to be goal-oriented, which in turn increases their chance for learning success (Bakker et al., 2015). However, to date, little research has investigated student engagement in VR co-creativity. To fill in the gap, this study explored the effects of on-line real-time VR co-creation on student engagement for creative structure visualization in EFL classrooms. The research model of this study is shown in Figure 1.

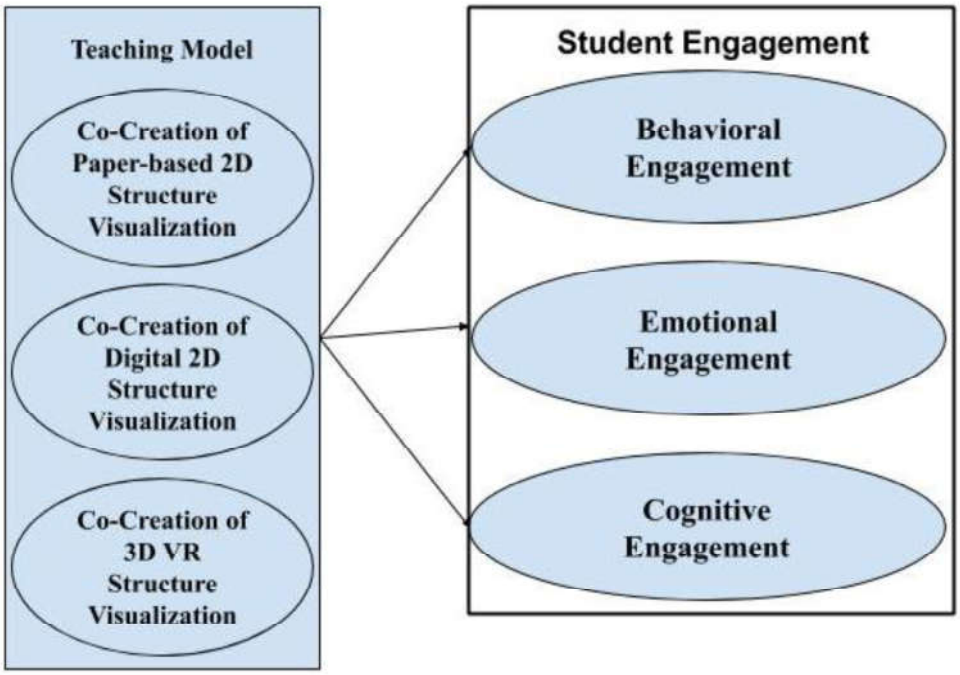


Figure 1. Research Model.

2 Materials and Methods

2.1 Participants

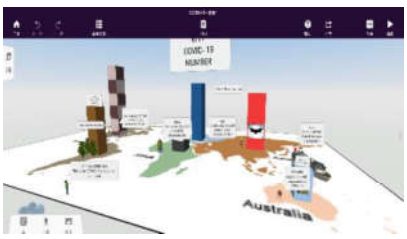
This quasi-experimental research was conducted in 2020 and involved one teacher and 66 tenth-grade students in two English classes from a public senior high school in northern Taiwan. To assess the effects of the paper-based, digital 2D, and VR platforms, the classes were divided into Control Group, Experimental Group A, and Experimental Group B, with a valid sample of N= 22 for each.

2.2 Methods and Instructional Design

The experimental process is shown in Figure 3. Session 1 involved the pre-test on student engagement and reading strategy training. Session 2 involved genre reading instruction: text-based and numerical reports. To visualize the global reading structure, Control Group performed paper-based co-creation, while Experimental Group A and B respectively used Google Jamboard and CoSpaces for digital 2D and VR co-creation (See Figure 2). The experiment ended in Session 3 with the post-test on student engagement.

Control Group

Experimental Group A



Experimental Group B

Figure 2. Co-Creation Interfaces of the Various Groups.

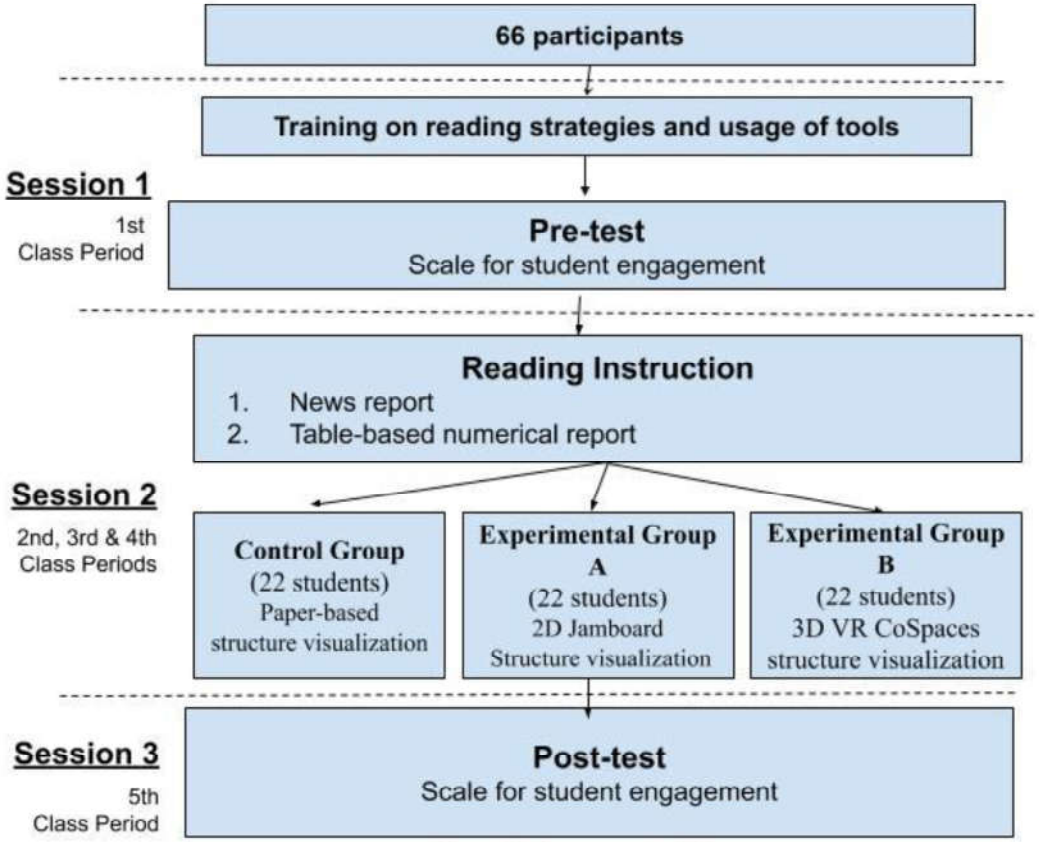


Figure 3. The Experimental Flow.

2.3 Instruments

The student engagement scale, based on Fredricks, Blumenfeld, Friedel, and Paris (2005), with reference to that of Sun (2014), was a 6-point Likert scale with five questions for behavioral, six for emotional, and eight for cognitive engagement. In terms of reliability of the post-test scores, the Cronbach's alpha value for the scale was .91, while the reliability of the constructs had scores of .55–.93, indicating an acceptable to excellent overall internal consistency (George & Mallery, 2003).

2.4 Digital Co-Creation Platforms: Google Jamboard and CoSpaces

In this study, Google Jamboard presented digital 2D structure visualization, whereas CoSpaces enabled learners to co-create immersive scenarios that could be explored virtually using cardboard headsets. Both allow real-time co-creation. Coding within CoSpaces stimulates creativity for turning abstract to concrete by programming objects to follow instructions.

3 Results and Discussion

Analysis of covariance (ANCOVA) in SPSS 20 was performed on the post-test for student engagement to identify between-group differences, with the pre-test as the covariant, the post-test as the dependent variable, and the co-creation mode as the fixed factor. For student engagement, the effect of interaction between the covariates and variables was not significant (F=2.57, p= .086), nor was the homogeneity hypothesis test result for intra-group variance.

Table 1. *Summary of Covariance Analysis for Student Engagement*

Source of variance	SS	*df*	MS	*F*	*p*	Partial η^2
Covariates	.899	1	.899	2.74	.10	4.5%
Inter-group	1.54	2	.77	2.35	.11	7.5%
Intra-group	19.01	58	.33			
Overall	21.60	61				

As shown in Table 1, the overall student engagement revealed no significant differences among the co-creation platforms. Specifically, the covariate failed to significantly predict the dependent variable (F=2.74, p= .10), suggesting the post-test on student engagement was not influenced by the pre-test. Moreover, with the pre-test effect removed, the effect of the co-creation mode was not significant (F=2.35, p= .11), connoting the insignificance of the co-creation platforms on the post-test.

Further ANCOVA results on the three constructs were reported in Table 2. The effect of the co-creation mode was insignificant in behavioral engagement (F=1.01, p= .32) and in cognitive engagement (F= .29, p= .75); the post-tests on the two constructs were not influenced by the co-creation platforms. However, emotional engagement was greatly affected by the co-creation mode (F=6.25, p= .003). Specifically, VR CoSpaces was the most influential, followed by the Jamboard and paper-based co-creation environments respectively.

Table 2. *Summary of Covariance Analysis for the Constructs of Student Engagement*

Constructs	*F*	*p*	Post-hoc
Behavioral engagement	1.01	.32	
Emotional engagement	6.25	.003	(3) > (2) (2) > (1)
Cognitive engagement	.29	.75	

Note. (1) = Control Group; (2) = Experimental Group A; (3) = Experimental Group B

Insufficient co-creation time might account for insignificance in the behavioral and cognitive constructs. As Jensen (2008) proposed in brain-based learning, the development of cognitive attributes and preferred learning modality takes considerable time. Contrarily, emotional responses would be more easily aroused especially in VR owing to its novel, immersive, and experiential nature.

4 Conclusion and Implications

The study investigated student engagement in online real-time VR co-creativity in EFL classrooms. Based on the ANCOVA results, the effect of the co-creation platforms was not significant on behavioral and cognitive engagement. However, emotional engagement was significantly influenced by the co-creation spaces, among which VR CoSpaces was most emotionally engaging.

The study suggested that VR co-creation for collective intelligence be a semester-long project, instead of a short-term activity for transient effects, lest co-creators fail to reach consensus and the strength of co-creation tools be under-estimated.

In conclusion, co-creation evaluation shall include both quantitative and qualitative data. Open-ended interviews and interaction logs are recommended to complement empirical analysis for comprehensive insights towards co-creation essence.

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