

# GAMES AND LEARNING – A BIBLIOMETRIC ANALYSIS OF THE SCIENTIFIC PRODUCTION

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## Abstract

In this paper we present a bibliometric analysis of the scientific production concerning games and education. Our purpose with this study is to provide a macro overview of the history, trends and focus of the research conducted since 1952 in the intersection of these two knowledge fields, recurring to Thomson Reuters Web of Science's database.

We analyse the quantitative effort dedicated to research in games and education, compared with the overall production in the scientific area of Education, and we discern the major focus of the scientific production in this field by identifying the most frequent words used.

We conduct an investigation with the aim of understanding if researchers have been using the key terms considered relevant in education and training by the European Centre for the Development of Vocational Training, and we summarize the main publishers in this multidisciplinary area.

Keywords: Education, game, bibliometric analysis

## 1 INTRODUCTION

The connection between games and education is not new. For centuries games have been used for learning social, physical, and psychological skills, and traditional board games and role-play games have been used for formal learning long before the arrival of digital games [1].

In the mid twentieth century the association between games and learning began to capture the public attention with Johan Huizinga's study "Homo Ludens" [3], which posited play as a primary, necessary activity in the generation of cultures, and with Jean Piaget connecting the development of moral judgement in children to their ability to understand rules in a game [2].

With the advent of personal computing, in the 1980s, we witnessed the evolution and commercialization of a new kind of learning games, digital games. The attention towards games and its applications in Education has then highly increased, accompanying the augmented possibilities provided by technology. In 2003 James Gee, in his book "What Videogames Are Teaching Our Children", highlighted the many benefits of video games for learning, which contributed to generating attention and support for the use of games as a powerful medium for teaching and learning [4][5].

Game-based learning is establishing itself as a new research area within Education and Educational Research, with dedicated journals, conferences, courses and networks [1][6][7].

There is an increasing number of researchers, teachers, parents and even politics recognizing that games can be useful platforms for learning, particularly through its potential to engage and motivate, and that games can promote a number of valuable skills like strategic thinking, group decision-making and communication [6][8][9][10]. However the relationship between games and learning (through educational games, serious games, Commercial off the Shelf / COTS games, among others) is all but linear. There is still a lot of research that needs to be done concerning crucial aspects of education and learning (such as motivation, impact or assessment) and its interconnection with games, if we are ever to witness game-based learning massively implemented in education [10][11][12].

Understanding what have been the tendencies and the range of research conducted internationally in this field is vital to guide researchers, decision-makers and research initiatives, and that is one of our main contributions with this paper.

On the other hand since this is a multidisciplinary topic arising from different research areas, it is also essential to define and create a common vocabulary within games and education. In order to do that it is important to know if the existing vocabulary valued within the education area is being used in the

scientific literature on the topic games and education. The European Centre for the Development of Vocational Training (Cedefop) was established in 1975 and is the European Union's reference centre for vocational education and training. It has published a glossary that defines key terms used in European education and training, mirroring the priorities of European Union policies, mainly in skills and competence needs analysis [14]. We decided to evaluate to what extent the words and expressions presented in this glossary have been used so far by researchers in the field of games and education.

Bibliometrics, a term coined by Alan Pritchard as the application of mathematics and statistical methods to books and other media of communication, consists of quantitative and statistical techniques to measure indexes of knowledge production and dissemination, as well as to track the development of scientific areas and patterns of authorship, publication and usage of research results [15][16].

With this paper we intend to add to the discussion about the area of games and education by conducting a bibliometric analysis to bring to light new data related with the scientific production within this field of research.

## **2 METHODOLOGY**

### **2.1 Data collection**

In order to conduct a bibliometric analysis of the publications within the thematic of games and education, we used Thomson Reuters Web of Science database. We choose this database for three main reasons: 1. its scope and quality of publications' coverage of research journals in sciences (coverage back to 1900) and social sciences (coverage back to 1956) [17]; 2. its proceedings section, covering papers delivered at the top international conferences, symposia, seminars, colloquia, workshops and conventions (coverage from 1990) [17]; 3. its tagging system by subject area, allowing to narrow our search to specific fields of study.

Using the advanced search by subject area (SU) we limited our data universe to the field "Education and Educational Research". Within this SU we then searched for all the results confined to the Topic (TS) Game, using the lemmatization option. Lemmatization in a TS query includes synonyms, plurals, and singulars of the topic terms, in this case of the word game. The search for topic terms retrieves results in the fields Title, Abstract, Author Keyword and Keywords Plus.

With this search query, conducted on 15 July 2015, we obtained 8497 results, from which we excluded the results from 2015. The data analysed in the present paper consists in 8297 results, categorized by Web of Science as follows: 6849 journals, 979 books and 469 books in series; containing results as early as 1952 to the end of 2014.

### **2.2 Analysis of the most frequent words**

In order to understand the main focus of the research conducted within this SU and TS, we performed an analysis to identify the most frequent words in the titles of the publications. For that, we developed a routine for Microsoft Excel in Visual Basic that creates a frequency table with the existing words from selected fields, in this case from the field Title.

From the frequency table, we excluded the following groups of words: 1. Groups of alphanumeric characters with no understandable meaning; 2. Function words (articles, pronouns, adpositions, conjunctions, interjections, particles, auxiliary verbs, expletives and pro-sentences), whenever it was possible to clearly identify them; 3. The word "game" and respective lemmatization results; 4. The write out of numbers. We considered these to be aseptic words for our analysis since they appear in all papers. We then combined plurals and singular words. Finally, we have also removed words that only appeared once, since we do not considered them representative as they do not show any collective use.

We then decided to analyse only the time period of 1994 to 2014, and to obtain a visual representation of the most relevant terms used both in titles and abstracts in that period. For that we used VOSviewer (version 1.6.2), a software tool for constructing and visualizing bibliometric networks that also offers text mining functionalities that allow to construct and visualize co-occurrence networks of important terms extracted from a body of text [18]. We performed an analysis using Title and Abstract fields, using the binary counting method and excluding terms with less than 10 occurrences. Based on the

relevance index of VOSviewer [18], we then included the 60% most relevant terms in those conditions, in a total of 1652 terms.

### 2.3 Analysis of the occurrence of key terms from the education glossary

In order to understand if the research conducted within the chosen SU and TS takes into account what the European Union considers priorities in education and training policy, we analysed the occurrence of the key terms defined in the glossary "Terminology of European education and training policy - A selection of 130 key terms" in the fields Title and Abstract. Since some of the key terms are expressions and not words, whenever felt necessary and appropriate, long expressions were decomposed into smaller expressions.

The search for the key terms was conducted in Microsoft Excel and the results were used to create a frequency table, showing how many titles and how many abstracts contained a specific key term from the glossary.

## 3 RESULTS AND DISCUSSION

### 3.1 Comparison of Topic publication results with Subject Area results

To obtain an outline of the quantitative effort dedicated to scientific research related to games, within the field of Education, we compared the TS Game results with the overall production in the SU "Education and Educational Research" (see Fig. 1).

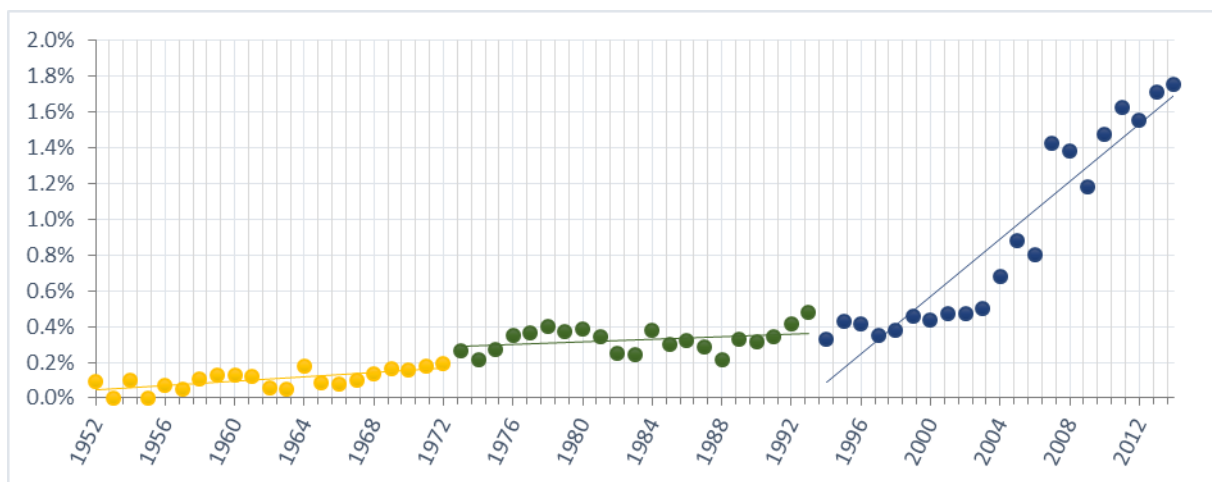


Fig. 1 – Percentage of TS Game publications in relation to SU publications, by year of publication.

If we divide the 63 years of results, from 1952 to 2014, in three periods, and we plot trend lines for each period, it becomes clear that the evolution of publications in the intersection between games and education has not been constant. In Fig. 1 we can see that there has been a great increase in the number of publications within the TS Game in relation to the overall publication results of the SU Education and Educational Research in the last 19 to 21 years, from 1994/1996 to recent days.

This increasing percentage of Educational Research around the Topic Game can be associated with the path paved by technological developments, in particular the advent of personal computing in the 1980s and then the arrival of World Wide Web with the first browsers and search engines available in the mid-1990s. We believe that some seminal works in this field were also important for this evolution, like Seymour Papert's "Mindstorms: Children, Computers, and Powerful Ideas", published in 1980 [13]. Another recent relevant work is James Gee's "What Videogames Are Teaching Our Children", published in 2003 [5], underlining the benefits of video games for learning, which may have influenced subsequent publications on this topic, with the highest increase in TS Game publications taking place from 2004 onwards.

### 3.2 Most frequent words used in titles

To uncover the main emphasis of research conducted within games (TS) and education (SU), we performed an analysis to identify the most frequent words used in titles of publications (see Table 1).

Table 1 – Top 25 percentile of most frequent words used in titles from 1952 to 2014.

Words	Occurrences	%	Cum. %	Words	Occurrences	%	Cum. %
learning	1559	2.82%	2.82%	play	292	0.53%	18.32%
education	934	1.69%	4.50%	skill	281	0.51%	18.83%
student	771	1.39%	5.90%	environment	270	0.49%	19.32%
children	651	1.18%	7.07%	social	246	0.44%	19.76%
school	602	1.09%	8.16%	virtual	245	0.44%	20.20%
teaching	576	1.04%	9.20%	based	229	0.41%	20.62%
study	525	0.95%	10.15%	video	226	0.41%	21.03%
educational	499	0.90%	11.05%	serious	217	0.39%	21.42%
using	484	0.87%	11.92%	approach	216	0.39%	21.81%
computer	474	0.86%	12.78%	digital	209	0.38%	22.19%
effect	406	0.73%	13.51%	performance	204	0.37%	22.55%
simulation	394	0.71%	14.23%	language	200	0.36%	22.92%
training	371	0.67%	14.90%	classroom	199	0.36%	23.27%
development	358	0.65%	15.54%	science	191	0.35%	23.62%
design	323	0.58%	16.13%	research	189	0.34%	23.96%
analysis	315	0.57%	16.70%	new	188	0.34%	24.30%
activity	304	0.55%	17.24%	online	186	0.34%	24.64%
physical	304	0.55%	17.79%	playing	181	0.33%	24.96%

From the results we can see that a higher focus is given to learning than to teaching or training, which is aligned with a recent shift of paradigm in the educational sciences, with an increasing emphasis given to the perspective of the learner. The most common verbs are learn, teach, study, use, train, design, play and research, which are all action verbs (though play and design might also been used as nouns in some of the cases). It is also apparent that there is a major focus on children, which occupy the fourth place in terms of frequency of occurrences in titles. It is interesting to note that the word simulation appears in the top 25 percentile, with a great number of studies concentrating in researching the use of environments that imitate real-world processes or systems and that provide safe spaces for trial and error, which is essential to the learning process.

Giving that we concluded from Fig. 1 that the period from 1994 to 2014 was a more prolific one in terms of publications in games and education, we decided to analyse the key terms most relevant in this period both in titles and abstracts (see Fig. 2).

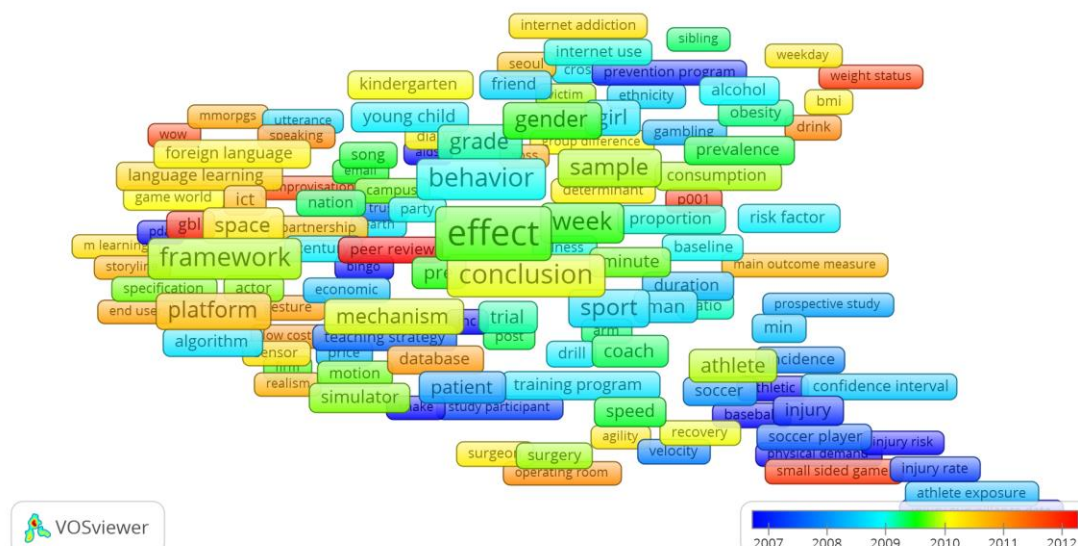


Figure 2 – Most relevant terms present in titles and abstracts, from 1994 to 2014, with a colour scale indicating the average year of publication.

The terms with more occurrences in this time period were effect, framework, conclusion, behavior, platform and sample. We can see that in 2008 many of the terms are related to sports, in 2010 the

most frequent terms include effect, platform, mechanism, language learning and simulator, and in 2012 emphasis comes to terms as gbl (game-based learning) and peer review.

### 3.3 Frequency of expressions from the education glossary

To understand if research conducted within the chosen SU and TS takes into account what the European Union (EU) considers priorities in education and training policy, we analysed the occurrence of the key terms defined in the glossary “Terminology of European education and training policy - A selection of 130 key terms” in the fields Title and Abstract. From our analysis we determined that 57% of the key terms of the glossary do not appear in any title, while 41% of them do not appear in any abstract. The top 25 percentile key term occurrences can be seen in Table 2.

Table 2 – Frequency of key terms from the education glossary in titles and abstracts, top 25 percentile

Words / expressions	Conjunction of words / expressions	Occurrences in Titles		Occurrences in Abstracts		Sum Titles + Abstracts		
		No. Titles	% of the Occurrences	No. Abstracts	% of the Occurrences	No. Titles + No. Abstracts	% of the Occurrences	Cum. % of the Occurrences
learning	NA	1309	53.28%	1963	23.81%	3272	30.57%	30.57%
skill	skill + skills	278	11.31%	1292	15.67%	1570	14.67%	45.24%
teacher	teacher + teachers	243	9.89%	1231	14.93%	1474	13.77%	59.02%
knowledge	knowledge + knowledges	132	5.37%	1164	14.12%	1296	12.11%	71.13%
curriculum	curriculum + CV + curricula	97	3.95%	558	6.77%	655	6.12%	77.25%
e-learning	NA	54	2.20%	166	2.01%	220	2.06%	79.30%
competence	competence + competences	30	1.22%	187	2.27%	217	2.03%	81.33%
learning outcomes / learning attainments	learning outcome + learning outcomes	20	0.81%	168	2.04%	188	1.76%	83.09%
information and communication technology (icT)	information and communication technology(ies) + ICT	33	1.34%	152	1.84%	185	1.73%	84.82%
standard	NA	5	0.20%	180	2.18%	185	1.73%	86.54%
guidance and counselling / information, advice and guidance (iag)	guidance + counselling + advice	14	0.57%	122	1.48%	136	1.27%	87.82%
tutoring	tutoring + tutor	24	0.98%	79	0.96%	103	0.96%	88.78%
mentoring	mentoring + mentor	65	2.65%	34	0.41%	99	0.93%	89.70%
sector	sector + sectors	3	0.12%	68	0.82%	71	0.66%	90.37%
trainer	trainer + trainers	5	0.20%	66	0.80%	71	0.66%	91.03%
learning content	learning content + learning contents	7	0.28%	63	0.76%	70	0.65%	91.68%
job	job + jobs	6	0.24%	56	0.68%	62	0.58%	92.26%
certificate / diploma / title	certificate(s) + diploma(s) + title(s)	4	0.16%	49	0.59%	53	0.50%	92.76%
professional development	NA	4	0.16%	46	0.56%	50	0.47%	93.23%
iSced level 1 – Primary education	primary education	12	0.49%	33	0.40%	45	0.42%	93.65%
programme of education or training	programme(s) of education + education programme(s) + training programme(s)	3	0.12%	36	0.44%	39	0.36%	94.01%
informal learning	NA	3	0.12%	35	0.42%	38	0.36%	94.37%
lifelong learning	NA	7	0.28%	25	0.30%	32	0.30%	94.66%
vocational education and training (VeT)	vocational education and training + VeT	7	0.28%	25	0.30%	32	0.30%	94.96%

**Legend:** Words/expressions – key terms as they appear in the glossary; Conjunction of words/expressions - whenever felt necessary and appropriate, long expressions were decomposed into smaller ones, here we present the conjunction of the smaller expressions that are responsible for the number of occurrences.

The glossary published by the European Centre for the Development of Vocational Training is an extended and updated version of “Terminology of European education and training policy”, published in 2008, and “Terminology of vocational training policy”, published in 2004, and gives emphasis to EU priorities in education and training policy, more than to the vocabulary used in research in the field of education, and that needs to be taken into account when interpreting these results. From our results we can see that much of the key terms are not being used (52% do not appear in any title or abstract). This may be for several reasons: terms considered relevant in education and training policy are not considered relevant in this SU and TS research area or the key terms may be used in the research in terms of meaning and subject without the application of the exact expressions.

Our results are relevant to rethink the utility of this glossary in shaping the vocabulary used in the research done in games and education, since research and policies should have a common ground language.

### 3.4 Sources of publications

To acquire an overview of the main publishers in games and education, we examined the number of results occurring by publisher. For the top 25 percentile (see Table 3) we examined if the publisher was a conference or a journal and determined which of those were indexed with an impact factor evaluation, using the 2015 Journal Citation Report [19].

For the total of results not classified as books, we determined which percentage was published in conferences and which percentage was published in journals, and we came to the conclusion that approximately 28% of papers were published in conferences.

Table 3 – Top 25 percentile of Publishers in games and education.

Publication Name	Type	Results	%	IF
Proceedings of the European Conference on Games Based Learning (ECGBL)	Conference	582	7.01%	NA
Computers & Education	Journal	235	2.83%	2.556
International Conference on Education and New Learning Technologies (EDULEARN)	Conference	173	2.08%	NA
International Technology, Education and Development Conference (INTED)	Conference	122	1.47%	NA
International Conference of Education, Research and Innovation (ICERI)	Conference	115	1.39%	NA
British Journal of Educational Technology	Journal	110	1.33%	1.318
Journal of Chemical Education	Journal	95	1.14%	1.106
Journal of Economic Education	Journal	86	1.04%	0.612
IEEE Frontiers in Education Conference (FIE)	Conference	64	0.77%	NA
Educational Technology & Society	Journal	60	0.72%	1.018
International Conference on Education and Sports Education (ESE)	Conference	57	0.69%	NA
Reading Teacher	Journal	55	0.66%	0.748
International Journal of Engineering Education	Journal	54	0.65%	0.582
World Conference on Educational Sciences (WCES)	Conference	52	0.63%	NA
Journal of Strength and Conditioning Research	Journal	51	0.61%	2.075
Etr&D-Educational Technology Research and Development	Journal	50	0.60%	1.420
Journal of Teaching in Physical Education	Journal	50	0.60%	0.740
Sport Education and Society	Journal	47	0.57%	1.288
Journal of Educational Computing Research	Journal	46	0.55%	0.670

**Legend:** Results – number of papers; % - percentage of papers in relation to the total results; IF – impact factor of the publication; NA - Non applicable, the publication does not have impact factor; Type - Type of publication, i.e. if it is a journal, conference, report or other.

From the analysis of the publications and publishers we conclude that there is already a high percentage of publications in journals (72%). In absolute value the number of papers presented in conferences is still quite high. It is important to increase the number of publications in journals with higher impact factors, to augment the credibility of the studies conducted in this field.

#### 4 FUTURE WORK

It is important to state that this is an exploratory paper that will serve as a starting point to further investigations. Understanding the limitations of the study and providing suggestions for improvement is as important as describing and presenting results. In order to do so, we herein present a few comments to our own paper and propose some directions for future work.

In our search conducted in Web of Science we limited the results by SU “Education and Educational Research” which could have eliminated some relevant results for games and education that might have not been tagged as belonging to this SU, though we believe this would be residual. On the other hand our search methodology includes results concerning sports games which may be seen by some researchers as irrelevant content for this analysis; we should note though that they are still under the SU “Education and Educational Research” which makes them viable for our analysis. Nevertheless the bibliometric analysis conducted within this study can be enriched by considering other search methodologies and even other databases.

Our analysis of the most frequent words has the associated problem of lacking context since we extract isolated words from the text, which can bring difficulties in terms of attribution of meaning. In the future we intend to perform a categorization of the extracted words, complementing the methodology of the study with a qualitative approach. We also intend to analyse the yearly frequency of the most common words to better understand the trends in the vocabulary used in this field of

research, both in titles and abstracts. To complement this exploration we intend to conduct a similar one focusing only on papers' keywords, which we believe will be an interesting approach to enrich our study.

In relation to the key terms of the glossary, we intend to use other reference works in the future, with smaller key terms and with less emphasis on policy, to complement our analysis. We also intend to use international reference works to perform this analysis instead of a European one, since the research papers here analysed have worldwide origin.

We find it extremely important to conduct further bibliometric analysis on this subject in order to better understand the development of the recent research field of games and education.

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