Authorship/Authoring Possibilities in Three-Dimensional Virtual Worlds in Education:

The State of Art from a Systematic Review

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***Abstract* — Three-dimensional virtual worlds have been studied by many researchers around the world, including in educational contexts. A range of possibilities have emerged from this type of environment, such as improvements in distance education and other educational technologies. But there are some problems related to the use of this environment, such as complex authorship tools, which need to be discussed and considered to create situations that encourage use. The goal of this study was to find, analyze, and discuss the studies that focused on these environments, with authorship as the main theme. With this in mind, we conducted a systematic review of published articles in six repositories to extract studies for subsequent analysis using text mining and graph analysis software.**

Keywords: Virtual World; Authorship; Systematic Review

I. INTRODUCTION

In recent years, researchers have turned their attention to learning environments, presentation of content, and educational media, looking for electronic learning (e-learning) models with not only two-dimensional (2D) but also three-dimensional parameters (3D). Although virtual learning environments (VLE) are well-known in the current educational context, authorship tools for virtual worlds (VW) are not as intuitive or simple as their 2D equivalents.

As a result, in this paper we describe a profound systematic review intended to provide understanding of the entire scenario and indicate concerns researchers might have about Educational VW research. Consequently, this paper identifies studies on this theme, quantifies the publications in different contexts, and presents them not only according to their theoretical approaches but also geographically. We also present a taxonomy matrix concerning aspects of the authorship, development, use, and applications of three-dimensional VLE. The goal is to understand multiple users as authors of these environments, instead of only regular users. Our study uses quantitative and qualitative analysis; papers were retrieved from six repositories (Brazilian and international), and we applied text mining and graph analysis to the results of these surveys. The study was conducted as follows: (i) the criteria were defined and 61 papers were selected for analysis; (ii) the papers were organized and processed using text mining software; (iii) information such as university, country, year of publication, and paper category was inserted and manipulated using graph editing software; (iv) four categories were created to classify the papers (development, tool, theoretical, and authorship); (v) results were presented and debated.

This paper is subdivided as follows: the second section presents some theoretical concepts related to VW and its educational and pedagogical perspectives. The third section presents the definitions and concepts adopted in the systematic review, as well as the methodological approach used to conduct the study. The fourth section presents the results found in the systematic review. The fifth section presents some discussion of the results, and the sixth section closes with final considerations.

This study presents results and statistic data that can help to understand the current panorama of approaches, tools, and methodologies pertaining to the development of these learning environments. It consequently also helps other researchers interested in 3D environments by providing an important document that can serve as a guide and reference for related studies. Additionally, the model for this systematic review can be reproduced, since the entire process is clearly presented. In summary, this research aims to present, disseminate, and encourage authorship of virtual worlds in educational contexts in order to promote innovation in educational processes.

II. THREE-DIMENSIONAL VIRTUAL WORLDS

Virtual worlds, also known as metaverses, can be understood as the convergence of different concepts, such as the 3D virtual world, which is the three-dimensional digital environment created to simulate the real world. To interact with this environment, users need to create avatars that represent them digitally inside the virtual world. This generates a situation in which users recognize natural behaviors in the environment, creating a sensation of immersion, once they have the physical notion of their body modified through a virtual environment.

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A. Educational perspective

When applied from an educational perspective, virtual worlds can fulfill different purposes and fit into different pedagogical theories, since they permit recreations of our reality.

The constructivist theory describes a change in educational approaches when related to the traditional instructional perspective. In constructivism, students have an important and active role in educational processes while interacting with other students, teachers, environments, and other mediator artifacts that may be involved. Here, the teacher is understood to be a mediator and has the important role of considering the educational process while respecting the individuality of each student [60]. Through project development, construction of learning can be focused by tasks that stimulate student interactions with situations, where action and reflection lead to mastery and achievement of the concept and competence.

This perspective can be debated in the scope of virtual worlds. In general terms, these theories emphasize, explain, and encourage placing the creation/authoring/authorship of the environments where the educational process will occur (or is already occurring) into the hands of multiple users (students, teachers, and others).

Considering the constant use of the terms authoring and authorship, it is important to describe the position of the author in the context of this study. From the perspective of progressive pedagogical debate, it is important to not place the teacher at the center of the discussion, which would consider the teacher to be the main author or owner of the knowledge. The teaching and learning process takes place in a social space mediated by this figure, so the objective of this investigation was to survey the authoring/authorship process while considering the author as a figure not limited to teachers, but also including students, tutors, or anyone else involved in the educational process.

III. Literature Review

A systematic literature review can be used to identify and analyze research on the topic under study, and leads to consistent understanding of the topic [29]. The systematic review described in this article was developed in order to obtain broader comprehension of the studies that have been conducted on the topic of educational virtual worlds.

A. Definitions and selections

In a systematic review, [29] indicates definitions of the following points: (i) the research questions; (ii) the method used for the review; (iii) the keywords and the criteria for including and excluding articles. Thus, this systematic review aims:

i. To obtain deeper knowledge of studies conducted using educational virtual worlds;

ii. To find works addressing issues related to authorship in educational virtual worlds.

Four Brazilian and two international repositories of articles were selected. These repositories are listed in Table I.

TABLE I. Repositories

Acronym	Repository	Link
RBIE	Revista Brasileira de Informática na Escola	http://www.br-ie.org/pub/index.php/rbie
RENOTE	Revista Novas Tecnologias na Educação	http://seer.ufrgs.br/renote/
SBIE	Anais do Simpósio Brasileiro de Informática na Educação	http://www.br-ie.org/pub/index.php/sbie
WIE	Anais do Workshop de Informática na Escola	http://www.br-ie.org/pub/index.php/wie
C&E	Journal of Computers & Education	http://www.sciencedirect.com/science/journal/03601315
IEEE	Institute of Electrical and Electronics Engineers	http://ieeexplore.ieee.org/Xplore/home.jsp

The RBIE, SBIE and WIE repositories were chosen because they are part of the Special Commission on Computing in Education (CEIE) of the Brazilian Computer Society (SBC) and are related to the Brazilian Conference on Computers in Education (CBIE), one of the leading conferences in the area of education technologies in the region. RENOTE is a Brazilian journal that contains studies related to educational virtual worlds. The IEEE repository was selected considering its wide coverage of conference proceedings, journals, and training courses. Elsevier's C&E is known for its high-quality publications in the area of educational technology.

The period of time defined for selecting the publications was defined as 2008–2014. The following search terms were used, using the English terms in the international repositories and the Portuguese terms in the Brazilian repositories: virtual environments (*ambiente virtual*), immersive environments (*ambientes imersivos*), authorship (*autoria*), avatar (*avatar*), metaverses (*metaversos*), virtual worlds (*mundos virtuais*).

After the search, the articles were initially reviewed by reading their abstracts, keywords, and dates of publication to identify their relevance to the outlines and the research topic.

The articles were analyzed further through text mining and graph analysis tools. Text mining uses computational software to process texts and identify useful implicit information therein [40]. This approach is useful for systematic reviews because analysis of a text file produces terms that can be considered important since they appear several times in the text and have a meaningful relation constructed through connections of these terms.

The text mining tool used in this analysis, Sobek, permits frequently occurring terms to be found and related through extraction of relevant information in unstructured databases [30]. The algorithm defined by Schenker (2003, cited in [30]) uses extraction of information from documents via a graphic representation called n-simple distance. Schenker [50] explains the n-simple distance method as an extension of n-distance representation as follows: n-distance deals with the n terms ahead of what is being analyzed, and connects following terms using a line labeled with the distance between them (except when words are separated by punctuation marks); n-simple distance uses the same analysis method but without labeled lines, only showing that the distance between two connected terms does not exceed n. In this way the software conducts a

statistical analysis of texts and presents the extraction of information through a non-directed graph (simple graph).

The other tool used for analysis of the articles was Gephi, a tool for creating and manipulating graphs. In the approach presented here, the database used to generate the graphs was created by manually inserting the information found in the PDF collected for analysis.

The Gephi tool was used in a systematic review by [8]. This approach used several tools to conduct an analysis starting from a root article and its related articles. Among these tools, Gephi was used to display and view the results. This work presents a different review because a root article was not used for the research, but instead a selection of repositories and keywords that produced the data base of articles. As in [8], the results are presented with graphs produced by Gephi.

IV. Results of The Systematic Review

This section presents the results of the systematic review, considering the aspects and definitions presented above.

It is important to point out that this study focuses specifically on finding papers on issues related to authorship in educational VW. However, we did not discard other information that can be related to these environments, since one of the purposes is to obtain deeper knowledge of studies using educational VW, such as the content of these studies, where they originate, and the concerns in their communities.

A. Step 1 – Where do the studies originate?

Considering the definitions above, the articles selected from Brazilian repositories for analysis are presented in Table II.

TABLE II. Papers selected from brazilian repositories

Repository	Paper	Ref
RENOTE	Ávila et al. (2014)	[4]
	Falcade et al. (2014)	[15]
	Ferri and Montovani (2011)	[17]
	Greis and Reategui (2010)	[23]
	Maria et al. (2010)	[34]
	Martins and Montovani (2011)	[35]
	Massaro et al. (2011)	[36]
	Nunes et al. (2013)	[42]
	Rafalski et al. (2014)	[45]
	Santos (2008)	[46]
	Santos (2011)	[47]
	Santos (2012)	[48]
	Schmitt and Tarouco (2008)	[53]
	Sousa Filho (2008)	[56]
	Tarouco et al. (2012)	[58]
	Wagner et al. (2012)	[65]
SBIE	Amaral et al. (2012)	[1]
	Schlemmer et al. (2008)	[52]
	Voss et al. (2013)	[64]
WIE	Falcão and Machado (2010)	[16]
	Silva et. al. (2009)	[55]

As can be seen, 16 articles were selected from RENOTE, 3 from SBIE, and 2 from WIE; no articles were chosen from RBIE.

International repositories and their papers are shown in Table III.

TABLE III. Papers selected from international repositories

Repository	Paper	Ref
C&E	Andreas et al. (2010)	[2]
	Berns et al. (2013)	[5]
	Bulu (2012)	[6]
	Chen et al. (2011)	[9]
	Cheng (2014)	[10]
	Cheong (2010)	[11]
	Cheryan et al. (2011)	[12]
	Choi and Baek (2011)	[13]
	Chow et al. (2012)	[14]
	Gamage et al. (2011)	[19]
	Girvan and Savage (2010)	[21]
	Girvan et al. (2013)	[22]
	Herold (2010)	[24]
	Huang et al. (2010)	[26]
	Jamaludin et al. (2009)	[27]
	Jarmon et al. (2009)	[28]
	Lorenzo et al. (2012)	[32]
	Lucia et al. (2009)	[33]
	Merchant et al. (2014)	[38]
	Merchant et al. (2012)	[39]
	Okutsu et al. (2013)	[43]
	Petrakou (2010);	[44]
	Traphagan et al. (2010)	[61]
IEEE	Ariyadewa et al. (2010)	[3]
	Carpeño et al. (2014)	[7]
	Gallego et al. (2010)	[18]
	Getchell et al. (2010)	[20]
	Herpich et al. (2014)	[25]
	López et al. (2014)	[31]
	Mavridis and Tsiatsos (2014)	[37]
	Mørch et al. (2014)	[67]
	Nisiotis et al. (2014)	[41]
	Schaf et al. (2012)	[49]
	Schlemmer and Marson (2013)	[51]
	Sébastien et al. (2009)	[54]
	Tamai et al. (2011)	[57]
	Tarouco et al. (2013)	[59]
	Vernaza et al. (2012)	[62]
	Vosinakis et al. (2014)	[63]
	Wagner et al. (2013)	[66]

As the table shows, C&E produced 23 papers and IEEE 17 papers. In total, 61 papers were selected from the combination of Brazilian and international repositories.

The universities involved in the research on our topic of study are presented in Figure 1.

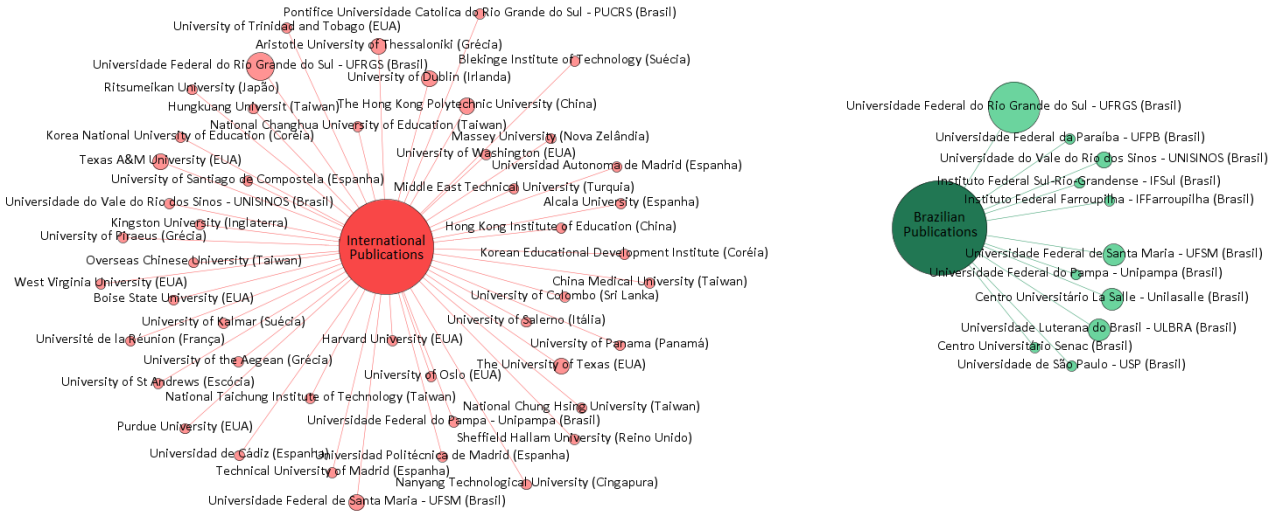

Fig. 1. Universities with research in the area under study

Figure 1 shows that 58 universities published studies about educational virtual worlds: 47 papers were published in international repositories and 11 in Brazilian repositories. The size of the circle corresponds to the number of papers published at each institution.

The following universities stand out in the graph: the Federal University of Rio Grande do Sul (UFRGS), with a total of 12 items, 8 in Brazilian repositories and 4 in international repositories; the Federal University of Santa Maria (UFSM) with a total of 5 items, 2 in Brazil and 3 in international repositories; the Lutheran University of Brazil (ULBRA) with 3 papers in Brazilian repositories; University Center La Salle (UNILASALLE) with 3 papers in Brazil; the University of Vale dos Sinos (UNISINOS) with a total of 3 items, 2 in Brazil and 1 international.

Considering the total of 53 universities mentioned in the analyzed papers, 12 (or 22.2%) of the total are Brazilian. The graph in Figure 2 shows the countries that have conducted and published research on educational virtual worlds and their respective universities.

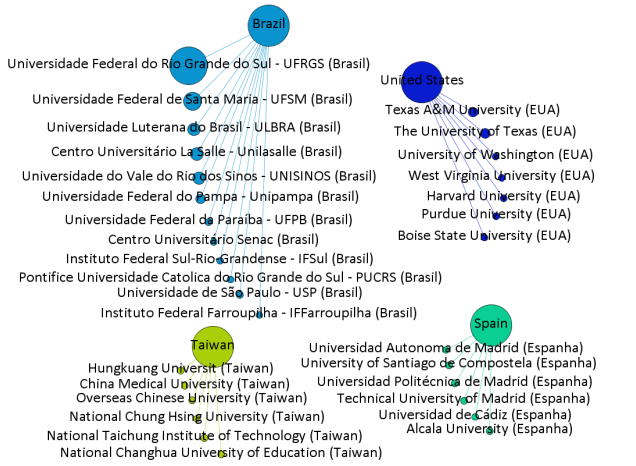

Fig. 2. Graph of the main countries and their universities with publications in the area under study

This graph presents some universities which published articles in the area and their countries. The totals are as follows: Brazil participated in 12 publications, the United States participated in 7 publications, and Taiwan and Spain participated in 6 publications each. Some other countries participated in publications but are not shown in the graph: Greece participated in a total of 3, China, Sweden and Korea participated in two publications each, and other countries (the United Kingdom, Sri Lanka, Japan, Italy, New Zealand, France, Singapore, Ireland, Panama, Turkey, England, Scotland, Norway, and Trinidad and Tobago) participated in one publication each.

Distribution according to the period of time defined for the systematic review (2008–2014) is shown in Figure 3.

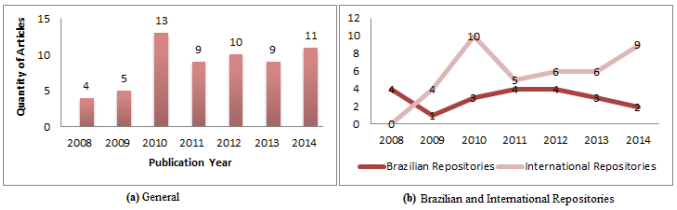

Fig. 3. Publication of papers over defined time period

In this context, we can see in Figure 3a that research on educational VW had the most publications in 2010 with 13 articles, 21.3% of the total. There were 11 publications in 2014 (18% of total). Figure 3b shows that in Brazil, the number of publications has decreased in the last two years and reached its higher numbers in 2008, 2011, and 2012. The international publications followed the trend of the general graph (Figure 3a): 2010 had the most publications (10) followed by 2014 (9).

The analysis above showed where research on the topic of educational VW was conducted. The leaders were Brazil and the United States, followed by Taiwan and Spain. Among the universities, Brazilian institutions were significant for their considerable number of publications. Of the total of 58 universities, twelve were Brazilian, 9 American, 6 Spanish, and

6 Taiwanese. These four countries accounted for 66% of the publications.

B. Step 2 – What are the topics of the studies?

This stage of the analysis used text mining to better understand the general approaches and to confirm that the studies were in agreement with the research questions, resulting in a subsequent classification.

For the content analysis, the 61 items were organized as follows: (i) the text files for each repository containing the title and abstract of each article were sorted; (ii) these files were processed using Sobek; (iii) the output files (graphs and data file obtained from Sobek showing the recurrence of terms) were organized to in order to create graphs in Gephi for the final analysis.

Four categories were created to better understand the approaches of the selected studies and to confirm their content according to their subjects. The categories are described in Table IV.

TABLE IV. CLASSIFICATION CATEGORIES

Category	Description
Development	Studies on the development of educational virtual worlds, learning objects (LOs).
Tool	Generic studies about tools, systems, and software for creating virtual worlds.
Theoretical	Theoretical studies reporting the characteristics, possibilities, and effects related to virtual worlds.
Authorship	Studies that focused on authorship of virtual worlds in educational contexts.

Different features of Gephi were used to organize the graphs. YinfanHu multi-level and the expansion and contraction algorithms were used for node distribution, according to the adjustment required. The modularity statistical calculation algorithm was used to color the nodes, followed by modularity class to color each group/module in order to distinguish them. To define the node size, one column was containing information about the recurrence of terms was inserted in the database, and the node size was adjusted according to the information recorded for each term.

The first repository to be analyzed was the journal *Novas Tecnologias na Educação* (RENOTE); results can be seen in Figure 4.

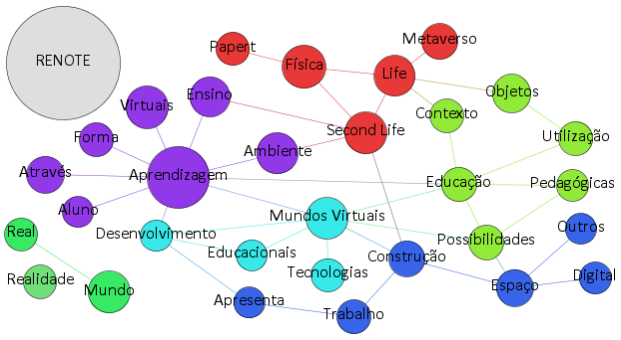

Fig. 4. Graph analysis for RENOTE

The graph shows the recurrent terms (nodes) and the connections between the terms (lines). Six groups of terms with the following key terms can be seen: "learning" (purple) "virtual worlds" (light blue), "education" (light green), "life" (red), and "space" (dark blue).

From this repository, 16 papers on the topic of study were selected [15][45][4][42][65][48][58][36][35][47][17][34][23][53][46][56], focusing on topics such as virtual laboratories for engineering education, geometry, anatomy, simulators for physics teaching, and teacher training environments. We can note that although the papers in this group involve educational virtual worlds, authorship is not present among the terms contained in the graph. The closest term is "construction", describing some studies that discuss the development of environments [4][42][17] but do not consider the teacher or the multiple educational users centered in the processes.

Figure 5 shows the results obtained from *Simpósio Brasileiro de Informática na Educação* (SBIE).

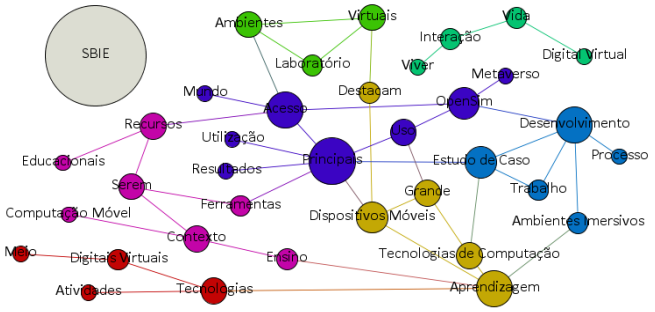

Fig. 5. Graph analysis for SBIE

Seven groups can be seen in the image, surrounding the following key terms: "main" (dark blue), "development" (light blue, "mobile devices" (yellow), "context" and "being" (purple), "technology" (red), "interaction" and "life" (dark green), and "environments", "laboratory" and "virtual" (light green). Three papers from this repository were analyzed [64][1][52]; two are theoretical debates [1][52], and one was related to mobile devices in research [64], which explains some of the terms that appear in the graph. No references to authorship can be seen, and only the term "development" has a slight connection to the concept, but does not necessarily address multiple users as the center of this process.

Figure 6 shows the analysis graph for articles obtained from *Workshop de Informática na Escola* (WIE).

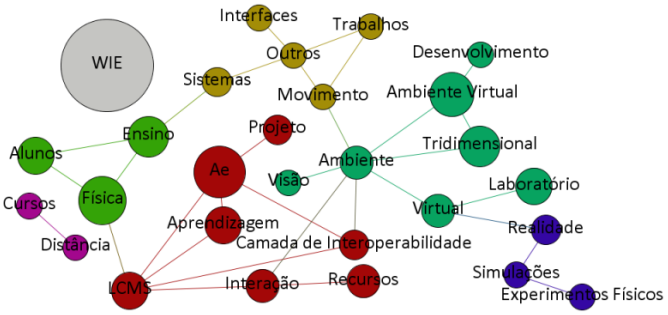

Fig. 6. Graph analysis for WIE

Six groups can be seen in the image: "Ae" and "LCMS" (red), "students", "education", and "physics" (green), "others" (yellow), "environment" (turquoise), "simulations" (blue), and "distance" and "courses" (purple). Two papers were analyzed from this repository [16][55]. One pertains to virtual labs for physics teaching [16], and the other presents a layer of interoperability between VLEs and VWs [55] called TIDIA-Ae, terms which are present in the graph ("interoperability layer", "Ae", and "physics"). Only one node highlights the "development" of environments, and places little emphasis on image. This relation resembles the findings in the analysis of studies from SBIE for the same term. Nothing appears in this graph showing any mention of authorship in these studies.

Figure 7 shows the graph analysis of studies from the *Computers & Education* repository (C&E).

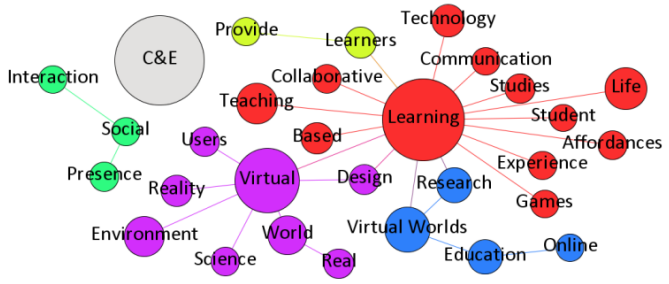

Fig. 7. Graph analysis for C&E

This repository yielded 23 articles for analysis [10][38][22] [43][5][32][14][39][6][13][19][9][12][26][61][11][2][21][24] [44][27][28][33]. The graph shows five groups of nodes containing the following terms: "learning" (red), "virtual worlds" and "education" (blue), "virtual" (purple), "social" (green), and "learners" and "provide" (yellow). No term was found connecting the studies to authorship by teachers or multiple users, and none of terms or their connections relate to the development of environments. Most of the studies published in this repository focus on the effects of the environment on its users. These papers do not necessarily address technologies or processes for developing virtual worlds, unlike what was seen in the other repositories.

Figure 8 shows the analysis graph for papers from the Institute of Electrical Engineers and Electronics (IEEE).

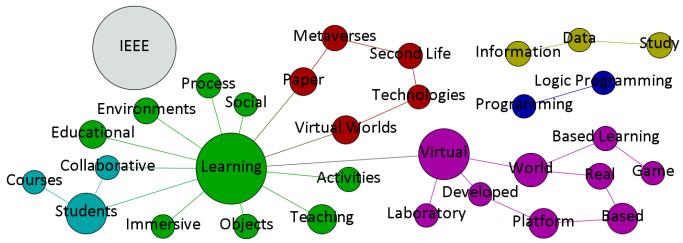

Fig. 8. Graph analysis for IEEE

This repository resulted in the selection of 17 papers [67] [25][41][37][63][31][7][66][51][59][62][49][57][3][18][20] [54]. In the graph, six clusters of nodes can be noted with the following key terms: "learning" (green), "data" (yellow), "virtual" and "world" (purple), "Second Life", "metaverses" and "technologies" (red); "students" (light blue), and "programming" and "logic programming" (dark blue). No nodes or relationships featuring research on authorship and teachers in the development process were found.

C. *Classifying the studies*

Our analysis found no graphs that featured the terms addressing authorship in educational virtual worlds. For better results in this search, the studies were analyzed in more detail and then classified according to the criteria presented in Table IV; Figure 9 shows this classification.

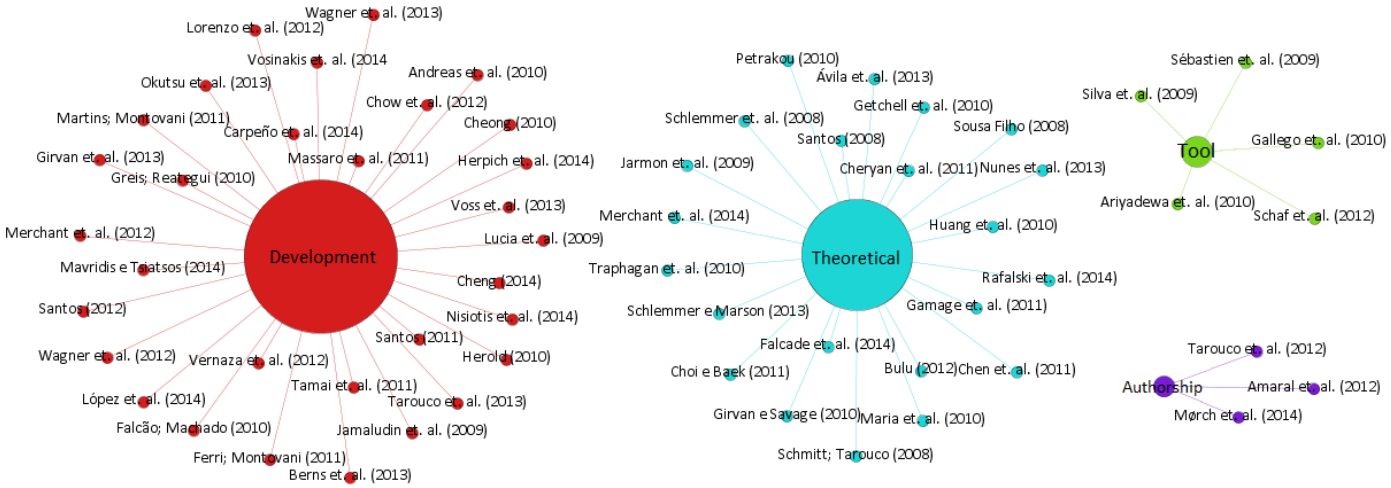

Fig. 9. Classification of papers

The graph in Figure 9 shows that most of the studies (31 papers or 50.81%) were classified under "development" (red), describing the development of virtual worlds, learning objects, and case studies. Another 22 papers (36.06%) were classified as "theoretical" (blue), and referred theoretically to features, effects, and possibilities of the environments. The green group shows the classification "tool", used for papers describing experiments and tools in a generic approach and applicable to other studies. Five articles, 8.19% of the total, were classified in this group. Finally, the purple group shows the classification "authorship", which contains studies that addressed authorship in educational virtual worlds in some manner. Only three studies were classified in this category, 4.91% of the total.

V. Discussion

The main goal of this systematic review was to understand how studies on the Educational VW are addressed in a global context. Brazil was seen to have high levels of participation in this research, particularly in the southern region of the country. Twelve Brazilian universities participated in the selected publications, especially UFRGS and UFSM. The United States also had many universities conducting studies in this area. Nine universities participated in the publications, especially the Texas A&M University and the University of Texas. In Europe, the main country that conducted research in the area is Spain, with six universities participating in publications on this topic. In Asia, Taiwan led with six universities publishing related studies.

The most studies were published in 2010; the number of studies fell in the following years and rose again in 2014. In Brazilian repositories, publications decreased in 2012; nevertheless, studies from Brazilian researchers were found in international repositories in 2013 and 2014, increasing the number of Brazilian studies for these years.

During the second part of the analysis, papers that described development or construction of environments were notable. They featured many different approaches to the disciplines and contents applied to these environments, such as physics [16][23][46][47][48], chemistry [39], geometry [1][58], calculus [59], anatomy [36], archeology [20], electronics [7][31], biodiversity [54], healthcare education [14], logic programming education [63], language learning [5][57], aerospace design [43], and software engineering [25]. A constructivist foundation was seen to be present and cited in some studies in the analyzed group, such as [21][22][26][49] [37][46][34][9].

On the other hand, there were no significant references to authorship or authoring by teachers, students, or other multiple users involved in the educational processes. This can demonstrate an important, negative tendency for the development (especially tools) of educational virtual world to not be considered appropriate for these audiences. One of the graphs that helps us understand this factor is shown in Figure 9. The classification according to the categories described in Table IV demonstrated that most of the papers described general development of virtual worlds or theoretical debates about them. In this case, we can consider development to mean simple demonstrations and descriptions of the construction of environments, learning objects, or case studies, focusing on a specific use. Just three of the 61 studies analyzed contained some kind of debate linking the need to easily turn the authorship process toward the teacher [1][58][67]. Along with the concept of authorship discussed in this paper, we can also consider many aspects of authoring, such as development tools, development processes, methodologies, practices, etc.

VI. Final Considerations

These factors demonstrate that studies on educational virtual worlds are a potential research topic. Virtual worlds have been applied in many different areas, as discussed previously. Additionally, there are various contexts and challenges to be explored, ranging from disciplines and content that have not yet addressed up to the impact on the teaching-learning process, as well as specific and appropriate tools that consider the important approach of authorship. In the meantime, from this point we can ask other questions: How useful and effective can these environments be in the contexts where they are applied? Why did the review show that multiple users have not been involved as authors in any appropriate authorship process or debate?

With regard to our main goal, to find studies addressing authorship in educational VW, none of the three studies found [1][58] [67] specifically addressed teacher-oriented authorship. As a result, we believe that the analysis presented herein can serve as an important base for research involving educational VW, particularly discussions that expose, debate, and complement the need for expanded authorship.

It is important to point that appropriate authorship for multiple users and teachers seems to be the most effective route to broader dissemination of the technologies involved. The debates generated in this paper and many of the findings in the papers analyzed generally focus on the dissemination of information and communication technologies (ICT) in educational contexts. We must think about if these studies are looking for agents that are actively involved in educational processes, autonomous and concerned about their own realities. This takes place in constructivism, where social interaction is a center point in educational processes. This interaction can occur in either two-dimensional or three-dimensional digital environments, or in reality. To think about how these questions can be addressed by the technologies that are discussed for educational processes is an important exercise that needs to be done constantly.

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