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IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Date of publication xxxx 00, 0000, date of current version xxxx 00, 0000.

Digital Object Identifier 10.1109/ACCESS.2022.Doi Number

Exploring Gamification Research Trends Using Topic Modeling

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This work was funded by the Researchers Supporting Project Number (RSPD2023R564) King Saud University, Riyadh, Saudi Arabia

ABSTRACT Gamification holds significant importance as an efficacious means to motivate individuals, stimulate their engagement, and foster desired behaviors. There is an increasing interest among researchers in exploring the domain of gamification. Consequently, it becomes crucial to identify specific research trends within this field. This study employs a comprehensive analysis of 4743 articles sourced from the Scopus database, utilizing the topic modeling approach, with the objective of discerning research patterns and trends within the gamification domain. The findings revealed the existence of thirteen distinct topics within the field. Notably, "Health training," "Enhancing learning with technology," and "Game design framework" emerged as the most prominent topics, based on their frequency of research publications and popularity. This study serves as a valuable resource for researchers and practitioners seeking to stay abreast of the latest advancements in gamification. The identified issues through topic modeling can be employed to identify gaps in current research and potential directions for future research endeavors.

INDEX TERMS Gamification, Topic modeling, Machine learning, Trend analysis, Text mining

I. INTRODUCTION

Gamification is the process of applying game design principles, mechanics and elements to non-game contexts to motivate and engage users [1]. Gamification involves the use of game mechanics such as points, badges, levels, leaderboards, and rewards to create an immersive experience that encourages users to participate and achieve specific goals [2]. The field of gamification, which involves using game design principles and mechanics in non-game contexts, has grown and developed significantly in recent years [3], [4]. Moreover, gamification has become an increasingly popular approach in different fields such as driving customer engagement [5], employee productivity [6], and social change [7].

The current state of gamification research is quite extensive, with numerous studies investigating various aspects of gamification in different fields. Studies in the field of gamification first examined the impact of gamification on motivation and engagement [8], [9]. Researches have shown that gamification can increase motivation by providing users with a sense of autonomy, competence, and relatedness, which are key components of self-determination theory. Second, it has focused on identifying which game design elements in gamification are most effective in motivating users [10], [11]. Research has shown that providing users with feedback, points, badges, and leaderboards can be effective in increasing motivation and engagement. Third, they investigated the user experience of gamification [12]. Research includes examining factors such as usability [13], enjoyment [14] and satisfaction [15]. It has shown that gamification can enhance the user experience by providing users with a sense of challenge, mastery, and fun. Fourth, it examined the effectiveness of gamification in different application domains such as education [16], health [17] and sustainability [18].

Despite the many potential benefits of gamification, there are some criticisms of the approach. Kim & Papers [19]

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argue that gamification can be manipulative and may not lead to long-term behavior change. Overall, the literature suggests that gamification can be an effective approach to motivate users and drive behavior change in a variety of contexts. Gamification is a relatively new and emerging field and there is much to learn about its effects and potential applications. The frequent use of the gamification approach in many fields necessitates descriptive studies to provide a holistic understanding of the field. Several studies have used content analysis, systematic review, meta-analysis and bibliometric analysis to examine the literature on gamification.

A. REVIEW OF THE LITERATURE

There is a wide range of studies on gamification in the literature. Numerous content analyzes can be mentioned about gamification. Park & Kim [20] conducted a content analysis of 754 different gamification studies to identify patterns that can be used in the gamification development process. The results of the analysis revealed game mechanics, reward systems and interactive learning elements commonly used in gamification applications. Ozcinar et al. [21] conducted a content analysis study on teachers' use of gamification with 47 articles published between 2008 and 2021. The findings of the study revealed that teachers used gamification to increase students' motivation to learn, encourage engagement, and enhance the educational experience, and that gamification improves students' self-management skills and encourages social interaction. Zhang et al. [22] examined the effects of a gamification platform called Classcraft on gamification learning experiences in terms of learning achievement and motivation. The researchers systematically analyzed relevant studies in the literature and brought together the findings using meta-analysis. The results show that the use of Classcraft has positive effects on learning achievement and motivation.

When systematic review studies on gamification are examined, it is determined that there are studies in many fields from education to health. Subhash & Cudney [23] examined the use of gamification in higher education through a systematic literature review. The researchers collected and analyzed 42 articles in their 2017 study. The results show that gamification in higher education yields positive results in terms of enhancing learning, increasing students' motivation and engagement, enhancing learning experiences, and improving learning outcomes. Zainuddin et al. [24] is a study that examines the impact of gamification on learning and education through a systematic literature review. Through a search query in 2015, the researchers collected and analyzed 46 articles. The results show that gamification has positive effects on learning and education. Specifically, gamification was found to increase motivation to learn, improve learning outcomes, enrich the learning experience and make the learning process more effective. Johnson et al. [25] examined the use of gamification for health and well-being using a systematic literature review. Through a search query conducted in 2016, the researchers collected and analyzed 66 articles. The results show that gamification has several benefits for health and well-being. In particular, gamification was found to be effective in increasing physical activity, obesity management, chronic disease management, and smoking cessation. In addition, gamification is also beneficial in terms of providing education, motivation, information and social support on health and well-being issues. Sardi et al. [26] examined the use of gamification in eHealth using a systematic literature review. Through a search query in 2017, the researchers collected and analyzed 33 articles. The results show that gamification has several benefits in eHealth. In particular, gamification was found to be effective in increasing education, motivation, treatment adherence, and healthcare utilization in health and well-being. Edwards et al. [27] examined the use of gamification in health promotion through a systematic literature review in terms of behavior change techniques in smartphone applications. Through a search query in 2019, the researchers collected and analyzed 28 articles. The results suggest that gamification can be used in health promotion and can be effective when combined with behavior modification techniques.

When meta-analyses related to gamification are examined, studies related to the field of education have attracted attention in general. Sailer & Homner [28] examined the effect of gamification on learning by meta-analysis method. The researchers analyzed 70 studies to calculate the average effect size of studies conducted between 2005 and 2015. The results showed that gamification had a small but statistically significant positive effect on learning, increasing motivation to learn, improving learning outcomes and making the learning process more effective. Bai et al. [29] examined whether student learning outcomes can be improved through gamification using meta-analysis and qualitative data synthesis. The researchers meta-analyzed 43 studies and also synthesized 21 qualitative studies to examine the impact of gamification on student learning outcomes. The results show that gamification improves student learning outcomes and increases students' motivation. Huang et al. [30] is a study that examines the impact of gamification on student learning outcomes in educational settings through meta-analysis. The researchers examined the impact of gamification on student learning outcomes by combining 54 studies with meta-analysis method. The results suggest that gamification improves students' learning outcomes and increases motivation and interest in learning.

When bibliometric studies on gamification are examined, they are generally focused on the field of education. Martí-Parreño et al. [31] presented a bibliometric and text mining analysis examining the use of gamification in education. The researchers collected 187 articles from the Web of Science (WoS) database and used them for text mining and bibliometric analysis. The results show that gamification is becoming increasingly popular in education and is especially used in higher education. It has also been found to have a

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number of benefits, such as increasing students' motivation, improving their learning experience and enhancing the quality of learning. Swacha [32] presented a bibliometric survey examining the current state of research on gamification in education. The researchers collected and analyzed 532 articles published in the WoS database since 2000. The results revealed that the use of gamification in education is increasing and has become especially popular in higher education, with many benefits such as increasing students' motivation, enhancing learning experiences and improving the quality of learning. Behl et al. [33] presented a systematic literature review, bibliometric analysis and future research agenda of research on gamification and e-learning for young learners. The researchers collected and analyzed 45 articles from the WoS database. The results showed that gamification is an effective method in e-learning environments for young learners and increases learning motivation. Moreover, the researchers noted that gamification makes learning materials more engaging, learning becomes more effective and more enjoyable. However, the researchers noted that more research needs to be done on gamification and address the limitations of existing research.

B. IMPORTANCE OF THE CURRENT STUDY AND THE PROBLEM STATEMENT

As can be seen from the literature review, gamification has attracted considerable attention as a research topic in various fields including education, health, banking, engineering and social sciences since the last decade [34]–[38]. Although there are various analysis studies that evaluate the studies on gamification approach in different fields, there is a lack of a comprehensive study that addresses the gamification approach as a whole. Gamification has been developing rapidly in recent years [39] and continues to offer new research opportunities [40], [41]. Ozyurt & Ayaz [39] reported that gamification is a trending topic in the field of educational technology, despite its relatively low volume, and there has been a recent increase in interest. In this context, it is important to conduct a research paper that identifies the current trends, interests and tendencies of the field. Reviewing gamification-related articles will provide a broader perspective on the field by describing in detail all gamification-related studies from the past to the present. As a result, this study will provide valuable information about the current state of the field and guide future research. From all these perspectives, the current study is necessary and important.

Traditional analysis methods such as content analysis, systematic reviews, meta-analysis and bibliometric studies face challenges when dealing with large datasets, such as the number of articles and the need for manual analysis [42]. Topic modeling based on data/text mining is a frequently employed approach to address the challenges of clustering and conducting in-depth analysis on big data. This method proves valuable as it allows for a comprehensive exploration of themes and trends across various fields of study [39], [43]–[45].

The main contributions of this paper are given below:

Identifying Trends and Topic Intensity: This study excels in identifying the dominant trends in the gamification field and the level of focus on specific topics. By doing so, it provides researchers with valuable insights and highlights areas that require further attention and exploration.

Presenting Different Perspectives: Using topic modeling, this article effectively brings together different disciplinary approaches to gamification. This synthesis of diverse perspectives provides a unique opportunity for a more comprehensive and holistic understanding of the field.

Identification of Research Gaps: One of the highlights of this paper is its ability to identify gaps and under-researched aspects in the field of gamification. By identifying these research gaps, it will not only raise awareness but also serve as a catalyst to formulate research questions and methodologies for future research.

Expanding Application Areas: Through topic modeling, this paper systematically uncovers both existing and potential application areas for gamification. This comprehensive overview will lead the way to understanding how gamification can be used in a variety of sectors, including education, health, business, entertainment and beyond.

This study employs a semantic analysis approach using topic modeling to uncover the primary themes and trends within articles utilizing the gamification approach throughout history. By analyzing a dataset of 4743 articles, this study stands as the most comprehensive research endeavor within the gamification field, being the first to specifically focus on semantic analysis based on topic modeling. This study holds significance in its ability to offer a comprehensive outlook on the field, providing a detailed account of all studies related to the gamification approach. The research questions addressed in this study are as follows:

RQ1: What are the research topics related to gamification from past to present?
RQ2: How have gamification topics changed over time?
RQ3: What is the relationship between gamification and related topics? Which topics are most similar or most different?

II. METHODS

Latent Dirichlet Allocation (LDA) based topic modeling analysis was used in this study. Topic modeling is a semi-automatic probabilistic method for extracting hidden and implicit information from data sets [46]. In recent years, topic

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modeling has been widely used as a semi-automated text mining method to extract hidden semantic patterns from large text data sets [39], [47], [48]. In the topic modeling approach, large chunks of text contain implicit semantic patterns called "topics". Each topic is described as a probability distribution defined by a fixed set of terms [47]. Numerous topic modeling algorithms are available for text mining and natural language processing research, including Latent Dirichlet Allocation (LDA), Hierarchical Latent Dirichlet Allocation (HLDA), Hierarchical Dirichlet Process (HDP), Non-Negative Matrix Factorization (NMF), Dirichlet Multinomial Regression (DMR), Dynamic Topic Model (DTM), and Correlated Topic Model (CTM) [49]. Some of these algorithms (NMF, CTM, and DMR) have limitations in estimating the optimal number of topics using commonly accepted consistency scores. Recently proposed topic models, such as HDP and HLDA, automatically identify the optimal number of topics [49]. On the contrary, the LDA model offers the flexibility of manually adjusting the number of topics based on an iterative examination of the topics uncovered in previous analyses. This iterative process has proven to be effective in achieving an optimal estimation of both the number of topics and their semantic consistency [50]. Furthermore, the LDA algorithm provides a plethora of efficient methods for calculating coherence scores, which aid in estimating the ideal number of topics. This feature makes LDA a widely adopted technique across various fields [51], [52]. Due to these advantages, LDA stands as a highly favored and widely accepted algorithm for conducting semantic content analysis on extensive textual corpora. Its systematic approach and versatility have made it a staple choice in numerous research endeavors [53], [54].

In this study, topic modeling analysis was conducted utilizing the LDA algorithm, which is a generative approach [46]. LDA-based topic modeling has been widely used in information extraction from large datasets, job postings, identification of literature search topics and trends, and semantic content analysis [47], [55].

A. SELECTION CRITERIAS, SEARCH STRATEGIES AND DATA COLLECTION

In order to create the data set in the study, it was first aimed to access the studies in the literature on "gamification". Such studies in the literature were examined and it was seen that it was sufficient to use the Scopus database for this purpose [42], [55]. Scopus is the largest abstract and citation database in the world, containing more than 7,000 publishers such as Wiley Blackwell, Sage, Elsevier, Springer, Taylor & Francis, Emerald and others and more than 240 disciplines [56], [57]. Both these features and the fact that it is frequently preferred in such studies in the literature were seen as evidence that Scopus is sufficient to reach the most studies.

In order to reach the most articles on "gamification" on Scopus, key terms were determined by considering the studies in the literature [58]–[60]. A query was created to search for these terms in title, abstract and keywords on Scopus. Only journal articles (research and review) were included in the query. In the search query, the year 2023 was excluded and all journal articles published in English from the past to the present (until the end of 2022) were selected. According to these criteria, the final query is as follows:

TITLE-ABS-KEY ("gamification" OR "gamified" OR "gamify" OR "gamifying") AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (EXCLUDE (PUBYEAR, 2023)) AND (LIMIT-TO (LANGUAGE , "English")

This query was run on April 6, 2023. The search returned a total of 4743 articles over a twelve-year period from past to present. While 4372 of these articles are research articles, 371 of them are review articles. The title, abstract and author keyword information of these articles were added to the dataset and a corpus of "gamification" literature was created.

B. DATA PREPROCESSING, IMPLEMENTATION OF TOPIC MODELING AND DATA ANALYSIS

As the topic modeling analysis process involves text mining, several preprocessing stages need to be performed prior to the analysis. The purpose of these preprocessing steps is to transform the raw data into a clean dataset and make it ready for analysis [61], [62]. These steps can be listed as follows:

The next step is cleaning and tokenization. In this stage, the texts are converted to lowercase, and all words are standardized to lowercase as well. Special characters and punctuation marks within the words are removed.

Another preprocessing step is lemmatization, which involves reducing words to their base or root form and removing any affixes attached to them.

The first step is to create a list of stop words and eliminate them from the text. Stop words are commonly used words such as "a," "an," "is," "the," "of," "for," and so on, which do not carry significant meaning in the context. These stop words are identified and removed from the text.

After all these preprocessing steps, the title, abstract and keywords were combined and the corpus was ready for topic modeling analysis. First, a pilot LDA analysis was conducted. In the pilot analysis, "gamification" and the terms used in the query were seen in almost all of the topics. Since the corpus is directly related to this field, the terms used in the query were added to the stop word list. In this way, the terms in the query were prevented from appearing repeatedly in the topics.

The topic modeling analysis was performed with the "ldaMulticore" model of the Python language Gensim library [63]. To apply the LDA-based topic model to the empirical corpus, the parameter values enabling model optimization were chosen. The initial values for the parameters α, which

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govern the topic distribution in the documents, and β (also referred to as eta), which govern the word distribution in the topics, were set as ['symmetric', 'asymmetric'] for α and ['symmetric'] for β (these variables can have related values). In addition, the hyperparameters of the model are set to "workers=3, random_state=42, passes=20". In the literature, an iterative and heuristic process is commonly recommended for model fitting [64]. To determine the optimal number of topics (K) in the LDA-based topic modeling analysis, models were created for K values ranging from 5 to 35. The suitability of different topic numbers was assessed using the "c_v coherence measure." The coherence value (c_v) was calculated for each K value, with a target value of 0.7 often considered optimal [46]. For each model, the coherence value was computed, and the number of topics that yielded the closest result to 0.7 was considered ideal [46]. The analysis indicated that the model with 13 topics (K=13) achieved the highest c_v coherence value for the α and β values of ['asymmetric', 'symmetric']. Therefore, the topic distributions effectively represented the corpus, and the ideal number of topics was determined as 13 (K=13; c_v=0.4101).

PyLDAvis, a visualization tool used in topic modeling, was used to visualize the topics [63], [65]. The λ value indicating the priority order of the words within the topics was taken as 0.6 as recommended and accepted in the literature [66]. The meaningfulness and consistency of these thirteen topics formed by the terms representing each topic were evaluated together by the researchers. After examining the consistency of the topics, the topics were named based on the terms defining the topics. Furthermore, the study calculated the percentage of each topic per document, the distribution of terms within each topic, and the distribution of topics across all articles. These distributions were utilized to determine the trends of the topics over time by calculating the slope. As a result of this process, the top fifteen terms with the highest frequency representing each of the thirteen topics were listed.

III. FINDINGS

First, the number of publications of articles in the field of "gamification" by years was calculated. The number of publications by year is presented in Figure 1, with the first studies indexed by the Scopus database dating back to 2011.

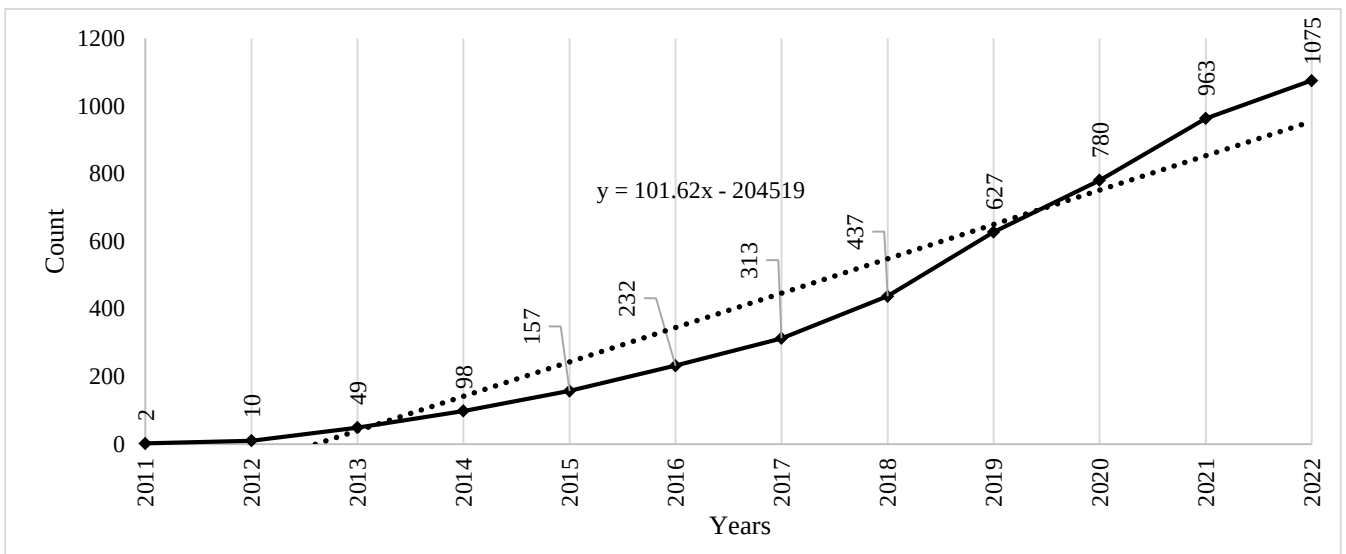


FIGURE 1. **Number of publications by year and slope graph**

As can be seen in Figure 1, the number of publications in this field has been increasing rapidly and steadily over the years. Secondly, LDA-based analysis to explore research topics in gamification (to answer RQ1) identified thirteen topics from the corpus of 4743 articles. Each topic was named according to the keywords associated with it. A full list of the topic names and associated keywords, as well as their volume ratios and acceleration values, ordered by volume ratio, is provided in Appendix A. In addition, the distribution of the number of publications of the topics by year is presented in Appendix B.

A. FINDINGS ACCORDING TO THE VOLUME AND ACCELERATION OF THE TOPICS

The volume ratio and acceleration values of topics related to gamification are given in figure 2 in order according to the volume ratio. The highest volume topic is "Health training" (29.88%), followed by "Enhancing learning with technology" (24.31%) and "Game design framework" (23.42%). These are the most studied topics related to gamifacition. On the other hand, "Mobile apps and user engagement" is the least studied topic and only 0.53% of the publications are under this topic.

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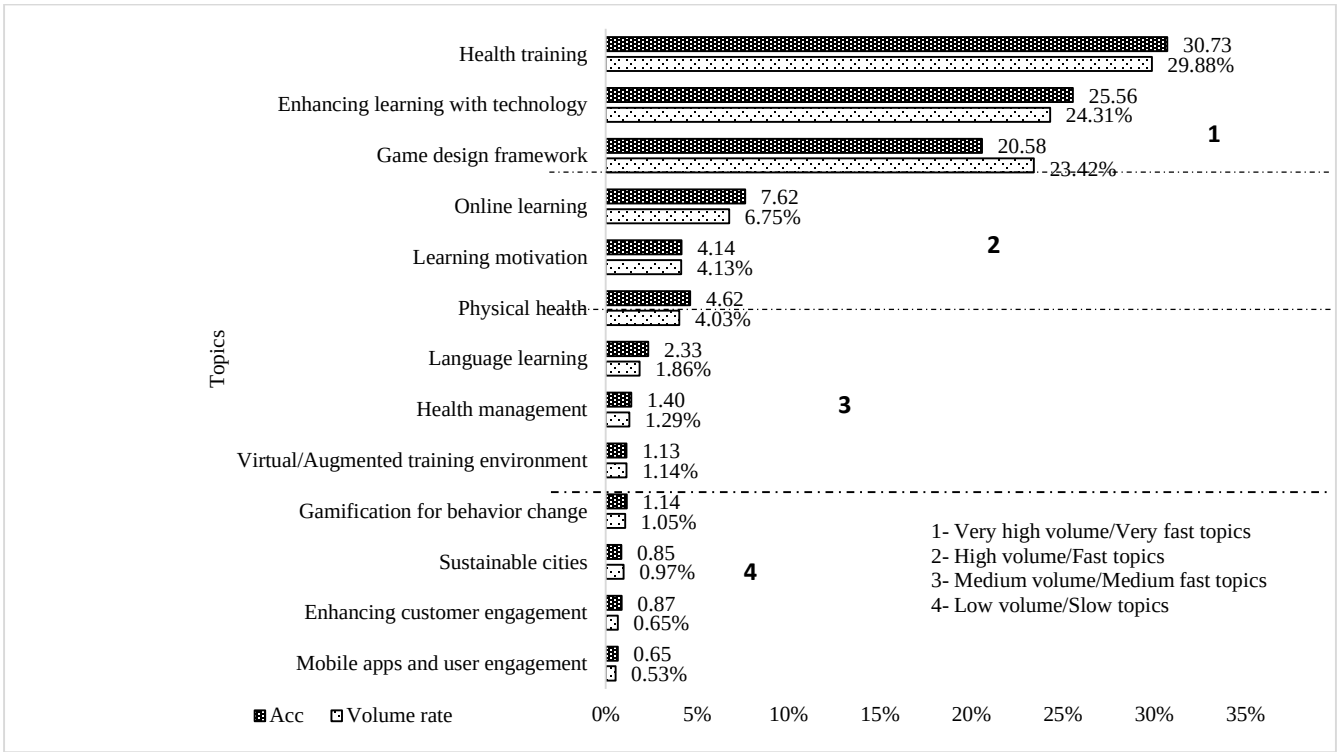


FIGURE 2. **Volume ratios and accelerations of the topics**

B. CHANGES OF TOPICS ACCORDING TO TIME

To analyze the change of topics over time and conduct trend analysis (to address RQ2), the twelve-year period was divided into three-year intervals. Table 1 presents the findings related to these intervals, including the number of publications during each period. By considering the publication counts within these intervals, the percentages representing the volume of each topic relative to itself and in comparison to other topics over time were determined.

TABLE 1
DISTRIBUTION OF THE NUMBER OF ARTICLES RELATED TO THE TOPICS ACCORDING TO THREE-YEAR PERIODS

Topics \ Periods	2011-2013	2014-2016	2017-2019	2020-2022	Total
Health training	14	139	410	854	1417
Enhancing learning with technology	13	122	293	725	1153
Game design framework	30	143	363	575	1111
Online learning	1	18	103	198	320
Learning motivation	1	16	74	105	196
Physical health	0	15	48	128	191
Language learning	0	4	19	65	88
Health management	2	8	11	40	61
Virtual/Augmented training environment	0	6	18	30	54
Gamification for behavior change	0	6	13	31	50
Sustainable cities	0	7	14	25	46
Enhancing customer engagement	0	1	7	23	31

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Mobile apps and user engagement	0	2	4	19	25
Total	61	487	1377	2818	4743

With the help of the table 1, the volume percentages and acceleration values of each topic in periods (the change within the topic itself) and the volume percentages and acceleration values of a topic compared to other topics in any period (the change of the topic compared to other topics) were calculated and given in table 2.

TABLE 2
VOLUME RATIOS AND ACCELERATIONS OF TOPICS WITHIN THEMSELVES AND COMPARED TO OTHER TOPICS IN PERIODS

Topics	Periods	Volume ratio and acceleration of the topics within themselves over time		Volume ratio and acceleration of topics compared to other topics over time	
		Vol	Acc	Vol	Acc
Health training	2011-2013	0.99%	19.70	22.95%	2.33
	2014-2016	9.81%		28.54%	
	2017-2019	28.93%		29.77%	
	2020-2022	60.27%		30.31%	
Enhancing learning with technology	2011-2013	1.13%	20.01	21.31%	0.95
	2014-2016	10.58%		25.05%	
	2017-2019	25.41%		21.28%	
	2020-2022	62.88%		25.73%	
Game design framework	2011-2013	2.70%	16.70	49.18%	-8.93
	2014-2016	12.87%		29.36%	
	2017-2019	32.67%		26.36%	
	2020-2022	51.76%		20.40%	
Online learning	2011-2013	0.31%	21.13	1.64%	1.99
	2014-2016	5.63%		3.70%	
	2017-2019	32.19%		7.48%	
	2020-2022	61.88%		7.03%	
Learning motivation	2011-2013	0.51%	18.88	1.64%	0.83
	2014-2016	8.16%		3.29%	
	2017-2019	37.76%		5.37%	
	2020-2022	53.57%		3.73%	
Physical health	2011-2013	0.00%	21.83	0.00%	1.40
	2014-2016	7.85%		3.08%	
	2017-2019	25.13%		3.49%	
	2020-2022	67.02%		4.54%	
Language learning	2011-2013	0.00%	23.86	0.00%	0.75
	2014-2016	4.55%		0.82%	
	2017-2019	21.59%		1.38%	
	2020-2022	73.86%		2.31%	
Health management	2011-2013	3.28%	19.18	3.28%	-0.64
	2014-2016	13.11%		1.64%	
	2017-2019	18.03%		0.80%	
	2020-2022	65.57%		1.42%	
Virtual/Augmented training environment	2011-2013	0.00%	18.89	0.00%	0.33
	2014-2016	11.11%		1.23%	
	2017-2019	33.33%		1.31%	
	2020-2022	55.56%		1.06%	
Gamification for behavior change	2011-2013	0.00%	20.00	0.00%	0.30
	2014-2016	12.00%		1.23%	
	2017-2019	26.00%		0.94%	
	2020-2022	62.00%		1.10%	
Sustainable cities	2011-2013	0.00%	17.83	0.00%	0.22
	2014-2016	15.22%		1.44%	
	2017-2019	30.43%		1.02%	
	2020-2022	54.35%		0.89%	
Enhancing customer engagement	2011-2013	0.00%	24.19	0.00%	0.28
	2014-2016	3.23%		0.21%	
	2017-2019	22.58%		0.51%	
	2020-2022	74.19%		0.82%	
Mobile apps and user engagement	2011-2013	0.00%	23.60	0.00%	0.19
	2014-2016	8.00%		0.41%	
	2017-2019	16.00%		0.29%	
	2020-2022	76.00%		0.67%	

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When table 2 is examined, for example, while calculating the frequency of studying the topic "Health training" over time, row-based reading was performed on Table 1. Accordingly, the volume rate of the relevant topic in each period (number of publications in period i/total number of publications) was calculated as 0.99%, 9.81%, 28.93% and 60.27% respectively. While calculating the frequency of this topic compared to other topics in the periods, a column-based reading was made on Table 1. Accordingly, the frequency of studying the topic "Health training" in the first period compared to other topics (number of publications in period i/total number of publications in that period) was calculated as 22.95%, 28.54%, 29.77% and 30.31%. The similar situation was calculated for all topics, and in this way, the percentages and accelerations of each topic being studied within itself and in comparison to other topics over time were calculated.

By utilizing the Table 2, firstly, the change of the topics within themselves over time was analyzed. In this context, accelerations were calculated over the values of the volume ratios of the topics in periods. In Figure 3, the acceleration values of the volume ratios of all topics in periods (Acctopic, period) are given in order.

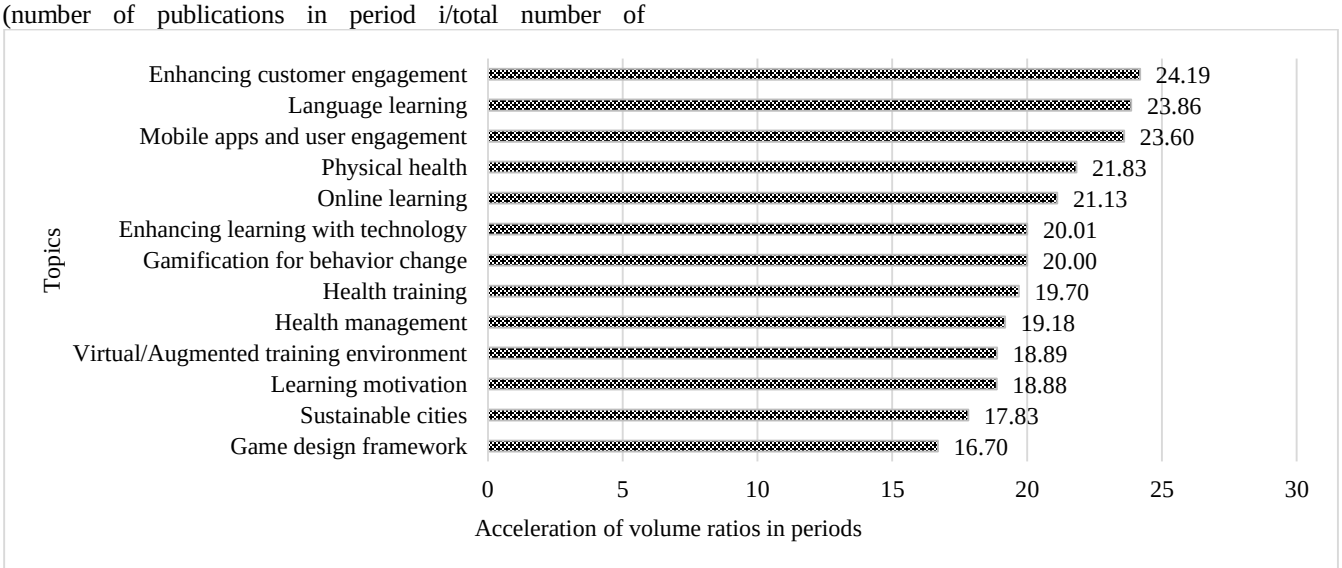


FIGURE 3. **Accelerations of the volume ratios of the topics within themselves over time**

Figure 3 shows that there is a gradual increase in the volume rates of all topics. However, there are notable differences in the acceleration rates between various topics. The top three topics with the highest acceleration rates are "Enhancing customer engagement", "Language learning" and "Mobile apps and user engagement". Although the slope values are similar, they differ from the other topics. On the other hand, the three topics with the slowest growth rate are "Learning motivation", "Sustainable cities" and "Game design framework".

Considering the change in the volume rates of the topics in the periods, it was determined in which time periods each topic started to be studied more. For example, the volume ratios of the topic "Healt training" in the periods were calculated as "0.99%, 9.81%, 28.93%, 60.27%" respectively. Looking at these percentages, it is seen that there is a sharp increase in the volume rate from the first period to the second period (approximately 10 times). In this case, it can be said that this topic showed a significant increase in volume in the second period. Similarly, the change in the volume ratios of all topics was analyzed and it was determined that each topic became more prominent/studied more. These data are visualized in Figure 4.

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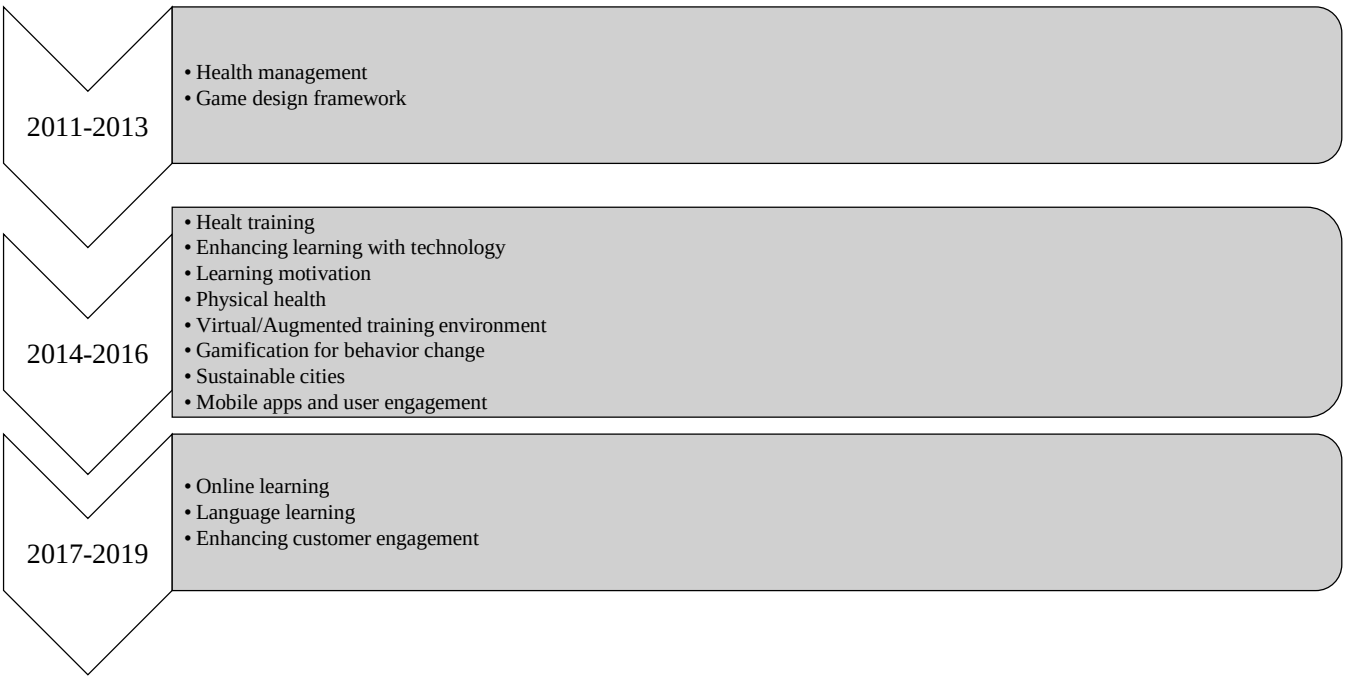


FIGURE 4. **Time periods when topics come to the fore**

As can be seen in Figure 4, the majority of the topics (eight topics) started to be studied predominantly in 2014, two topics started to be studied more in 2011, and three topics started to be studied more in 2017. Secondly, the change of the topics over time was evaluated by comparing them with other topics. In other words, the volume ratios of each topic in the periods were compared with the volume ratios of other topics. In this way, the trend analysis of each topic over time compared to other topics was made and this situation is visualized in Figure 5. Figure 5 is a visualization of the change of each topic in periods compared to the volume ratios of the other topics in a sequential manner according to acceleration values.

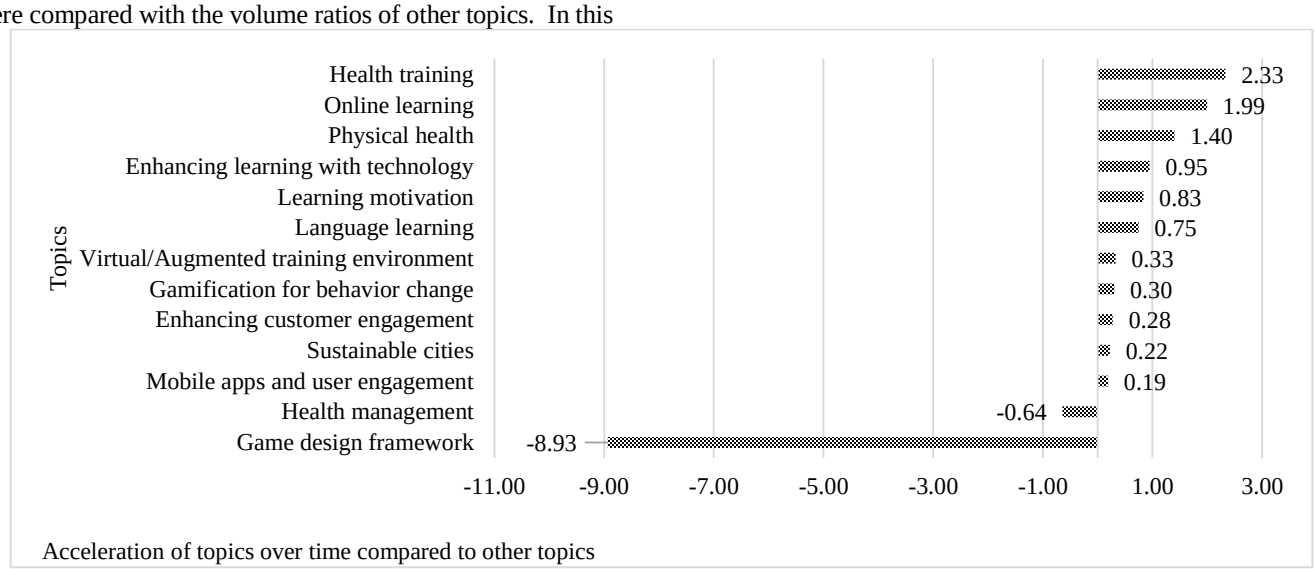


FIGURE 5. **Acceleration of topics over time compared to other topics**

As depicted in Figure 5, the volume ratios of eleven topics exhibited an increasing trend compared to other topics, while the volume ratios of two topics showed a decreasing trend compared to other topics. In other words, eleven topics were more extensively studied over time relative to other topics, whereas two topics received less attention compared to other topics. The topic that demonstrated the highest acceleration rate compared to other topics (i.e., the topic that was studied the most intensively over time relative to other topics) was "Health training", followed by "Online learning" and "Physical health" in second and third place, respectively. On the other hand, the topics that experienced the largest decline in acceleration compared to other topics were "Game design

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framework" and "Health management", respectively. Additionally, by considering the volume ratios of the topics within the periods relative to other topics, the prominence of the topics during those periods was determined. From another point of view, the prominent topics in each period compared to other topics were obtained. The top five topics with the highest volume compared to other topics in each period are listed and presented in Figure 6.

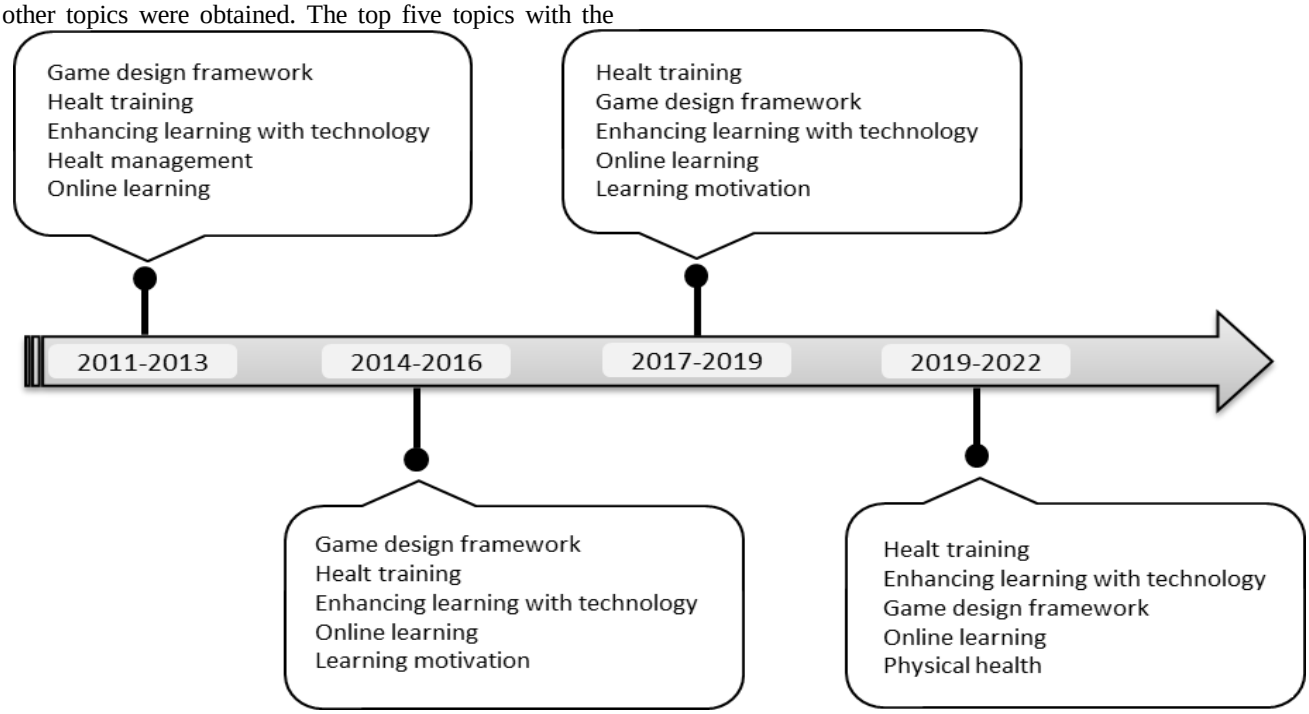


FIGURE 6. **Distribution of the top five topics with the highest volume in the periods**

Figure 6 shows that "Game design framework" was the most studied topic between 2011-2013 and 2014-2016, while "Health training" and "Enhancing learning with technology" were the second and third most studied topics, respectively. Between 2017-2019 and 2020-2022, "Health training" ranked first. While "Game design framework" ranked second between 2017-2019, it dropped to third place between 2020-2022. The topic of "Enhancing learning with technology" ranked third between 2017-2019 and second between 2020-2022.

C.EXAMINING THE RELATIONSHIPS OF TOPICS WITH PYLDAVIS

PyLDAvis visualization tool was used to answer the third research question (RQ3). PyLDAvis is an effective tool for visualizing the results obtained in topic modeling analyses [66], [67]. The pyLDAvis screenshot output of the model to explore the relationships between the topics and the content of the topics is given in Figure 7.

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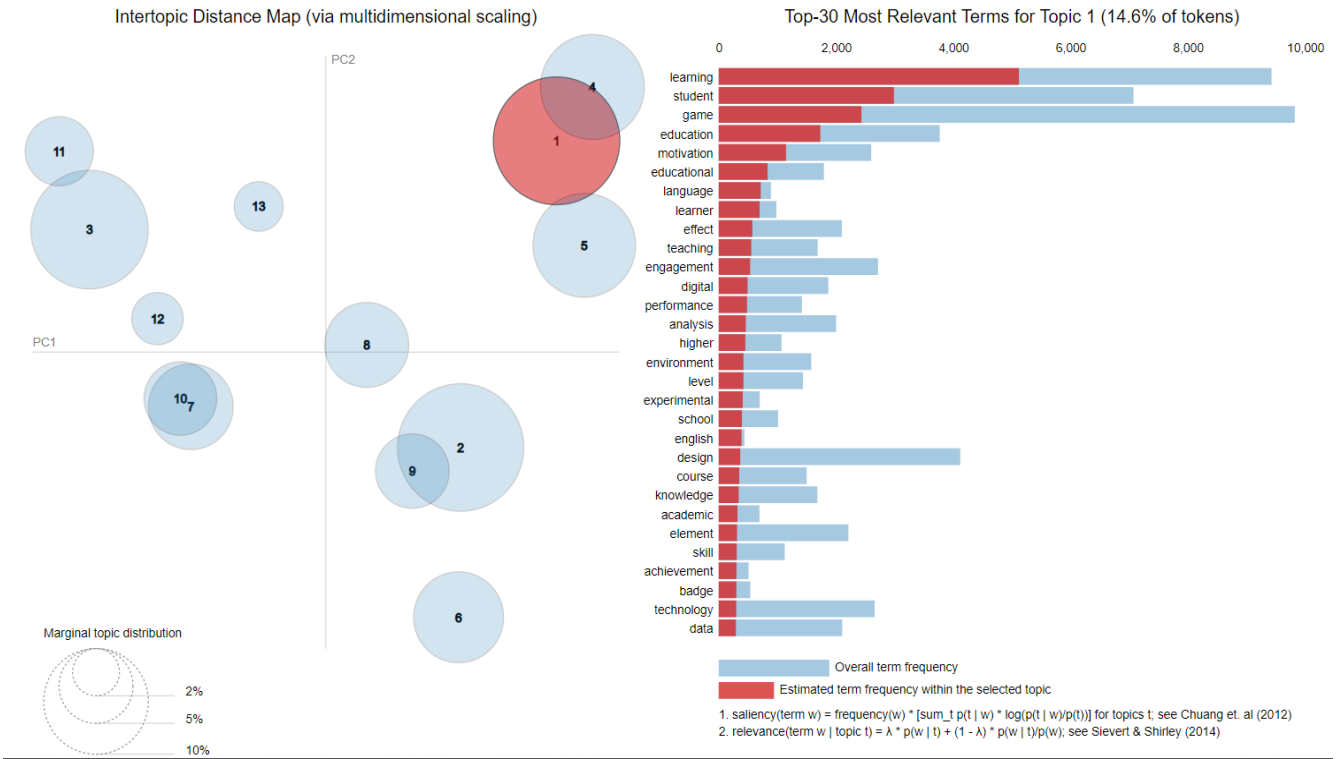


FIGURE 7. **Distance map between topics**

When Figure 7 is examined, the prevalence and relationships of different topics related to gamification obtained by LDA method are visualized. The size of the circles indicates the prevalence of the related topic. The relationships between topics can be understood through their position on the Visualization [67]. The distance map between topics shows the similarity or dissimilarity between the topics learned by the LDA model. When the topics are analyzed, it can be said that topic 3 "Health traning" and topic 11 "Physical health", which overlap in the PC1 positive region, have similar characteristics and are related. Likewise, it can be said that the topics numbered 1 "Learning motivation", 4 "Online learning" and 5 "Enhancing learning with technology" show similar characteristics and are related. In addition, LDA topic modeling with the visualization tool revealed that the thirteen topics formed four clusters. The first cluster includes topics 1, 4 and 5, which are "Learning motivation", "Online learning" and "Enhancing learning with technology" respectively. The second cluster has in common (topics 3 and 11) the importance of raising awareness and increasing engagement in health education and physical health using gamification methods. The common point of the third cluster (topics 7 and 10) is related to mobile applications and the use of gamification techniques to increase users' engagement. Finally, the common point of the fourth cluster (topics 2 and 9) is related to the link between the goal of creating sustainable cities using gamification methods and developing a game design framework.

IV. DISCUSSION AND CONCLUSION

A. THE MOST STUDIED TOPICS IN GAMIFICATION

As a result of the topic modeling analysis, articles on gamification were grouped under thirteen topics. Among these topics, the most voluminous ones (the most studied topics) were found to be "Health training" (29.88%), "Enhancing learning with technology" (24.31%) and "Game design framework" (23.42%). The number of publications on these three topics constituted three quarters of the total number of publications (77.62%). The least voluminous topics are "Sustainable cities" (0.97%), "Enhancing customer engagement" (0.65%) and "Mobile apps and user engagement" (0.53%).

"Health training" is one of the most studied topics in the field of gamification because health education is crucial to help people adapt to healthy lifestyles, prevent or treat diseases. Gamification is a strategy used in health education to provide an effective learning experience [68]. Gamification can promote learning by making health education more immersive, engaging and participatory [69]. Gamifying health education programs aims to increase users' motivation [70]. Therefore, researchers working on this topic apply gamification methods to meet this demand and motivate users about health and develop health-related gamification projects. The second most studied topic was "Enhancing learning with technology". Gamification has the potential to increase learning motivation by making the learning process more interactive, fun and motivating [71]. Research has shown that gamification techniques engage students, increase their

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willingness to learn and help them achieve better learning outcomes [72], [73]. The focus of research on "enhancing learning with technology" may be on how technology can enhance the learning experience and promote collaborative learning [74].

The third most studied topic is the "Game design framework". The effectiveness and success of a game relies on a carefully considered game design [75]. Gamification aims to create effective learning experiences using the basic principles of game design [11]. In order for gamification projects to be effective, it is important to determine the right game design strategies [76]. The "game design framework" can help to identify the metrics used to measure and evaluate the effects of game design in gamification projects [75]. This is important to better understand the effects of gamification practices and to increase the success of future projects. Gamification projects are often topic to a process of continuous improvement and iteration. The "game design framework" allows analyzing the current game design, identifying opportunities for improvement, and iterations [77]. In this way, gamification projects can be made more effective and users can have better learning experiences. These results show that gamification applications can be used not only for entertainment purposes but also for more serious purposes such as learning and health. Moreover, the volume rates of papers show that gamification can be used in other areas, for example, behavior change, sustainable cities, customer engagement, and so on.

B. THE MOST ACCELERATED TOPICS IN GAMIFICATION

In order to identify trends in gamification studies, the acceleration of the topics over time, within themselves and relative to other topics were examined. For the change of topics over time and trend analysis, the twelve-year period was divided into four periods of three years each. In addition, the periods in which the topics were first started to be studied and the prominent topics in the periods were determined.
The most accelerated topics over time were "Health training" (30.73%), "Enhancing learning with technology" (25.56%) and "Game design framework" (20.58%). The last three topics with the slowest growth rate were "Enhancing customer engagement", "Mobile apps and user engagement" and "Sustainable cities", respectively. When the topics with the highest increase are analyzed, it draws attention as the topics with the highest volume. In other words, "Health training", "Enhancing learning with technology" and "Game design framework" are both among the topics with the highest volume and the most studied topics over time. Therefore, it can be said that these three topics have an important place in the field of gamification.

"Enhancing customer engagement", "Language learning" and "Mobile apps and user engagement" were the topics with the highest acceleration value. In addition, "Enhancing customer engagement" and "Language learning" are among the topics that have been studied for the first time in the third period (2017-2019). Therefore, it can be said that these topics are newer than other topics. "Enhancing customer engagement" was the first topic that gained the most acceleration for itself. Organizations are turning to gamification strategies to increase customer loyalty and customer engagement [5]. Customer centricity encourages companies to use gamification tools to strengthen customer relationships [18]. Gamification can enhance and connect customers' interactions with products and services [78]. Gamification can be used to motivate customers and create a reward system [8]. The second topic that has gained the most acceleration for itself is "Language learning". Language learning is often seen as a challenging process and can affect learners' motivation [79]. Gamification can increase learners' motivation by making the language learning experience fun [80]. Moreover, language learning is an interactive process and learners need to interact with others to improve their language use skills [81]. Gamification can create a social environment by encouraging interaction among learners [82]. The third topic with the most acceleration for me was "Mobile apps and user engagement". The use of mobile devices is increasing day by day and becoming an important part of people's daily lives [83]. Gamification can be a potential tool to attract users and increase engagement through mobile apps [84]. Gamification can offer experiences tailored to users' personal goals, interests, and learning needs [85]. Mobile applications provide anytime and anywhere accessibility [86]. Users can spend their time efficiently by using gamified mobile applications on various topics such as language learning, health and fitness, and skill development.

On the other hand, the top three topics whose weight increased the most compared to other topics over time were determined as "Health training", "Online learning" and "Physical health", respectively. "Health training", which shows the most acceleration compared to other topics, draws attention as the topic with the highest number of articles in the field of gamification and the most accelerated topic. Although this topic ranked second in the first two periods among the prominent topics according to the periods, it has ranked first since 2017. Therefore, this shows that "Health training" is still a topic that is still being studied and continues to be popular. The second most accelerated topic compared to other topics was "Online learning". "Online learning" draws attention as a topic that has been studied since the first periods and has increased in popularity. In recent years, online learning methods and platforms have gained significant popularity. Especially the development of digital technologies and the widespread use of the internet make it easier for people to learn about various topics with remote access. Gamification can increase learning motivation by making online learning

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experiences more interactive and fun[87]. The third topic that accelerated the most compared to other topics was "Physical health".

Gamification allows users to set physical health goals and track their progress [88]. It can also increase users' awareness of physical health issues and increase their motivation [89]. On the other hand, the topics with the biggest decline in acceleration compared to other topics were "Game design framework" and "Healt management", respectively. These topics are also noteworthy as the first topics to be studied in the field of gamification. Although "Game design framework" ranked first in the first two periods, it has declined since 2017.

C. IMPLICATIONS OF THIS STUDY

This section presents a framework in which the study's conclusions and implications for the future are presented in line with the study's findings and discussion. The topic modeling analysis identified 13 main topics.

1. Health training
2. Enhancing learning with technology
3. Game design framework
4. Online learning
5. Learning motivation
6. Physical health
7. Language learning
8. Health management
9. Virtual/Augmented training environment
10. Gamification for behavior change
11. Sustainable cities
12. Enhancing customer engagement
13. Mobile apps and user engagement

Our study reveals that in the context of gamification, the focus is primarily on "Health training" (29.88%), "Enhancing learning with technology" (24.31%) and "Game design framework" (23.42%). There are specific reasons and implications for the prominence of these topics.

The prominence of Health Education can be attributed to the need for the health sector to adopt technology and gamification approaches. In particular, the need for continuing education of healthcare workers and the skill development requirements of healthcare professionals may explain the growing interest in gamification research in the field of health education. Furthermore, extraordinary situations, such as the COVID-19 pandemic, may have accelerated the use of gamification methods to deliver health education more effectively. Needs and challenges in the education and health sectors can shape gamification research. For example, as the need for continuing education in the health sector grows, more gamification work could be done in the area of health education.

The prominence of the topic of Enhancing Learning with Technology suggests that the rapid development of educational technologies may have led to the exploration of gamification methods to make learning more effective and engaging. Especially the widespread use of distance education and online learning platforms may have increased the need for enhancing learning with technology. The rapid advancement of technology may lead to more sophisticated gamification techniques and new application areas. In particular, new technologies such as augmented reality (AR) [90] and virtual reality (VR) may have a major impact on gamification.

Finally, the complexity of gamification requires the development of customized game design frameworks to increase effectiveness and efficiency. Therefore, increased research on game design frameworks can help gamification projects to be more successful. User experience design and the development of feedback mechanisms can influence the future of gamification. Users responding more positively to gamified educational materials may encourage research in this.

Among the thirteen topics mentioned, the first three topics receive significant attention. The reasons why other topics are less studied may be different. Priority is an influential factor in the prominence of these topics. For example, topics such as health training and online learning may be researched primarily to respond to the rapidly changing needs of the health and education sector. Other topics may therefore be less studied. In addition, some topics have limited areas of application. For example, topics such as sustainable cities or enhancing customer engagement in a particular sector may be of less interest outside a particular geographical region or industry. Some topics may be more complex or challenging. For example, gamification for behavior change or designing virtual/augmented learning environments may require more expertise and resources than other topics.

These reasons may explain why certain topics are less studied, but do not diminish their importance. Some topics may receive more attention in the future and it is possible that research areas may change or evolve.

V. LIMITATIONS AND FUTURE WORKS

This study aims to explore the research interests and trends of articles in the field of gamification from the past to the present (up until the end of 2022). The study stands out for its innovative approach as the most comprehensive analysis based on semantic analysis using topic modeling. However, there are certain limitations to consider. Firstly, the dataset is limited to peer-reviewed articles in the Scopus database. This limitation arises from the intention to ensure research quality by focusing on journal articles. Future studies can expand the scope by searching more comprehensive databases and including various document types. The topic modeling analysis employed the widely used and accepted LDA algorithm. In future research, comparative studies using different algorithms can be conducted. Another significant aspect is the importance of replicating such studies across gamification or its subtopics over specific periods, especially for the most voluminous or rapidly evolving topics. Including

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the study of Steven Chopade's model [91], we will develop a new model and a questionnaire among university students, which will show us what the effect of gamification is on the following factors: students' learning, students' challenge, students' reward, students' engagement, and students' motivation to affect students' achievement. This is what we will study in the future; see Appendix C. This would provide insights into the sustainability of the findings from the current study and how trends in topics may evolve over time. It would allow for tracking trend changes in the field more robustly.

APPENDIX A
TOPICS, THE FIRST FIFTEEN TERMS THAT MAKE UP THE TOPICS, TOPIC VOLUME RATIOS AND ACCELERATIONS

Topics	The first fifteen terms that make up the topics	Volume rate	Acc
Health training	intervention | patient | health | training | participant | app | child | cognitive | mobile | self | effect | care | application | treatment | task	29.88%	30.73
Enhancing learning with technology	learning | education | technology | student | process | educational | model | application | teacher | teaching | system | development | software | tool | engineering	24.31%	25.56
Game design framework	game | design | element | user | system | serious | framework | player | process | engagement | model | experience | context | learning | application	23.42%	20.58
Online learning	student | learning | course | online | teaching | education | classroom | engagement | activity | experience | escape | room | class | university | teacher	6.75%	7.62
Learning motivation	learning | student | game | education | motivation | educational | language | learner | effect | teaching | engagement | digital | performance | analysis | higher	4.13%	4.14
Physical health	physical | activity | intervention | exercise | participant | game | cognitive | adult | older | analysis | increase | health | active | difference | training	4.03%	4.62
Language learning	reading | child | knowledge | platform | covid | advertising | language | game | assessment | loss | comprehension | analysis | pandemic | intervention | morphological	1.86%	2.33
Health management	bias | game | management | pain | diabetes | attention | serious | modification | intervention | health | decision | participant | patient | anxiety | disorder	1.29%	1.40
Virtual/Augmented training environment	virtual | reality | user | system | rehabilitation | training | environment | experience | technology | immersive | game | augmented | patient | cultural | data	1.14%	1.13
Gamification for behavior change	health | social | intervention | user | game | behavior | app | engagement | mental | design | mobile | element | digital | technology | people	1.05%	1.14
Sustainable cities	energy | digital | city | game | platform | smart | urban | community | sustainable | development | public | building | social | technology | data	0.97%	0.85
Enhancing customer engagement	engagement | consumer | service | intention | customer | brand | user | value | online | marketing | experience | model | data | effect | technology	0.65%	0.87
Mobile apps and user engagement	app | apps | mobile | user | design | behavior | intervention | feature | participant | alcohol | consumption | mhealth | data | health | application	0.53%	0.65

APPENDIX B
DISTRIBUTION OF THE NUMBER OF ARTICLES ON THE TOPICS BY YEARS

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Health training	0	2	12	31	42	66	95	131	184	248	286	320	1417
Enhancing learning with technology	1	2	10	21	46	55	64	93	136	191	264	270	1153
Game design framework	1	4	25	31	42	70	94	98	171	193	169	213	1111
Online learning	0	0	1	4	6	8	16	35	52	45	73	80	320
Learning motivation	0	1	0	3	5	8	15	27	32	25	40	40	196
Physical health	0	0	0	4	4	7	7	17	24	35	43	50	191
Language learning	0	0	0	1	1	2	2	10	7	14	25	26	88
Health management	0	1	1	0	2	6	3	7	1	6	9	25	61
Virtual/Augmented training environment	0	0	0	1	4	1	7	5	6	4	12	14	54
Gamification for behavior change	0	0	0	1	1	4	2	6	5	4	16	11	50
Sustainable cities	0	0	0	1	4	2	4	5	5	9	10	6	46
Enhancing customer engagement	0	0	0	0	0	1	2	2	3	2	9	12	31
Mobile apps and user engagement	0	0	0	0	0	2	2	1	1	4	7	8	25
Total	2	10	49	98	157	232	313	437	627	780	963	1075	4743

APPENDIX C

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