

# STEAM Learning Environment on Gamification System to Promote Innovators: A Bibliometric Analysis and Systematic Review

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## Abstract

The STEAM learning environment with a gamification system has been found to promote innovators by enhancing creative thinking and innovation skills in students. It can engage and motivate students, making the course content come alive. The objective of this study is to provide an overview of the research conducted in the field of STEAM education with a focus on gamification, specifically examining studies published within the last six years. A bibliometric analysis and systematic reviews were performed to examine the trends in published literature on steam learning environment on gamification systems to promote innovators between the years 2018 and 2023. The retrieval of pertinent documents was conducted by employing keywords associated with “TITLE-ABS-KEY (“steam” AND “gamification” AND “innovation” AND “skill” AND “innovator” AND “learning environment” AND “ecosystem”)” in the title, abstract, and keywords of the documents. Consequently, a total of 5 documents were obtained from the Scopus database for the purpose of conducting bibliometric analysis and systematic review. The review examines the pattern of publication growth, identifies the papers with the highest citation counts, determines the primary sources of these articles, assesses the productivity of writers, analyzes the leading countries contributing to the field, and identifies the prominent subject areas within the research domain. Based on the results of our investigation, it can be concluded that Thailand exhibits the highest level of productivity in terms of publications and citations. Education and Information Technologies is widely recognized as the primary scholarly resource in its field. Through the co-occurrence of keywords analysis, we determined that the most significant keywords associated with steam learning environment on gamification systems to promote innovators are gamification, creative thinking, steam education, design thinking and digital learning ecosystem and so on. The computer science and social science domains have the highest number of published documents.

**Keywords:** gamification, steam, steam education, bibliometric analysis, systematic review, scopus

## 1. Introduction

Gamification in STEAM learning environments presents both challenges and opportunities for promoting innovation. One challenge is the increasing failures and unsatisfying results from educational innovations implementation and application, which can be addressed through gamification’s diverse elements and characteristics (Kummanee et al., 2020). Another challenge is the need for collaboration among multiple disciplines, which can be facilitated by game-centric methods that encourage design thinking skills and experimentation (Yordanova, 2020). Gamification also offers opportunities for increasing student engagement and motivation in the teaching-learning process, as well as developing leadership skills and promoting collaborative work (Murray et al., 2017). It provides a way to handle educational innovation challenges by assigning potential gamification tools to different educational innovation groups (Hernández et al., 2021). Overall, gamification strategies in STEAM learning environments have the potential to enhance the effectiveness of educational innovations, promote collaboration, and develop important skills for future success (Palomino et al., 2020). Gamification has been found to have a positive effect on students’ motivation in STEAM learning environments. By incorporating game elements into non-game contexts, gamification increases user interaction and motivation (Cavus et al., 2023). Studies have shown that gamification is effective in fostering students’ motivation in online learning settings (Ertan & Kocadere, 2022). Additionally, the level of gamification implemented can significantly impact motivation, engagement, and performance, with higher levels of gamification leading to greater

improvements in these areas (Hazra, 2022). Computer-assisted gamification has also been found to increase students' motivation to learn computer programming (Cuervo-Cely et al., 2022). Furthermore, the application of gamification tools in secondary school settings has been shown to increase students' motivation in the dimensions of attention, relevance, confidence, and satisfaction (Cornejo-Torres et al., 2023). Overall, gamification has the potential to enhance students' motivation in STEAM learning environments by creating engaging and enjoyable experiences.

Gamification strategies for promoting innovation in STEAM learning environments include the use of a digital learning ecosystem involving STEAM gamification (Kummanee et al., 2020). This ecosystem consists of biotic components such as teachers, students, and parents, as well as abiotic components like hardware, software, and pedagogical theories. The STEAM education approach, which involves defining problems, designing tools, producing instruments, testing and evaluating solutions, and presenting work, is also effective (Raphael, 2015). Additionally, incorporating game mechanics and game thinking into learning environments can enhance learners' motivation and engagement (Lavoué et al., 2018). Adapting gaming features based on a player model can further enhance engagement, as learners with adapted features spend more time in the learning environment (Huang et al., 2020). Furthermore, the use of a visual programming game with a Qualifying Rank strategy can enhance learners' motivation and engagement in a STEAM-oriented mathematics course (Olabe et al., 2020). Overall, integrating STEAM and Educational Makerspaces in the classroom can provide a group learning environment that promotes innovation and overcomes traditional obstacles in STEAM projects.

Bibliometrics refers to the quantitative examination and analysis of scientific publications and patterns within a specific academic domain (Saputro et al., 2023). The process entails the examination and evaluation of various scholarly sources, such as articles, books, and other published materials, with the aim of assessing the contributions made by individuals or groups of researchers, organizations, and countries (Rodríguez, 2006). Bibliometrics provides insights into the growth and development of publications, their distribution, variable keywords, and author collaboration (Greener, 2022). It helps in mapping relationships between concepts, identifying research directions and trends, and mapping the state of the art in a field (Mulet-Forteza et al., 2022). Bibliometrics, through the examination of citations and collaborations, has the capability to discern fundamental research, geographical hubs of expertise, and prominent authors (Tamtam et al., 2023). It is a valuable tool for evaluating research, making editorial decisions, and providing a basis for strategic and economic intelligence activities. Overall, bibliometrics is a method that allows for the analysis of the evolution, current state, and future trends in a scientific field through the analysis of publications and their characteristics.

Systematic reviews in the field of educational technology have gained importance in recent years. These reviews aim to synthesize and accumulate the results of primary studies, identify research gaps, and guide future studies. The use of systematic reviews has been observed in various areas of educational technology, including digital technology in preschool education (Atış-Akyol et al., 2023), language teaching and learning (Moorhouse et al., 2023), and early childhood education (Marín-Juarros, 2022). These reviews provide insights into the current situation of technology use in education, the types and features of technology, pedagogical implications, and research gaps. They also highlight the need for more emphasis on pedagogical utilities and social aspects of technology use in language teaching (Su et al., 2023). Systematic reviews serve as a valuable resource for researchers, educators, and practitioners in the field of educational technology, providing guidance for future research directions and informing decision-making processes (Botelho et al., 2022).

Because of the importance that a steam learning environment on gamification systems to promote innovators has taken, the research objectives for this study are as follows:

RO1: To examine the impact and scholarly output of the subject matter within the previous six-year period.

RO2: To identify the most frequently cited documents in STEAM education with gamification domain.

RO3: To examine the top publications and citations of the publishing documents.

RO4: To ascertain the authors who have demonstrated the highest level of productivity, along with their respective affiliated organizations and countries.

RO5: To identify leading countries based on the number of publications in the field

RO6: To find the citation distribution of publications.

RO7: To identify the predominant and emerging keywords in the field by conducting the co-occurrence analysis of authors' keywords.

RO8: To identify the characteristics of included studies.

RO9: To specific the conceptual framework of a steam learning environment on gamification systems to promote innovators.

## 2. Method

The research was classified as quantitative due to the utilization of statistical methods for the analysis and interpretation of the data, enhancing comprehension of the findings (Grazziotin et al., 2022). The application of bibliometrics was employed, which refers to a scholarly discipline that utilizes mathematical and statistical techniques for the examination and computation of scientific data (Huang et al., 2020). As a data collection technique, the bibliometric analysis and systematic review were used, for which the search string was assigned: "TITLE-ABS-KEY ("steam" AND "gamification" AND "innovation" AND "skill" AND "innovator" AND "learning environment" AND "ecosystem")" in the Scopus database. A descriptive bibliometric analysis and systematic review were applied to the data obtained because criteria were quantified by year, authors, geographic area and type of document published (Hwang et al., 2021).

### 2.1 Search Strategy

All journals, conference proceedings, reviews and book chapters published to date have been considered as part of this analysis. The keywords such as steam, gamification, innovation, skill, innovator, learning, environment and ecosystem were used to extract the desired article from the Scopus data-base. In order to maintain simplicity and conciseness in the literature review, the search string will consist of carefully selected keywords "TITLE-ABS-KEY ("steam" AND "gamification" AND "innovation" AND "skill" AND "innovator" AND "learning environment" AND "ecosystem")". The search query was executed on the 13rd of November, 2023. As of November 13, 2023, the study incorporated all documents pertaining to steam and gamification from the Scopus database. To investigate the patterns of growth in scholarly and professional literature pertaining to steam learning environment on gamification systems to promote innovators, the time period from 2018 to 2023 was chosen as the designated timeframe for analysis. Then received a total of 7 documents, upon which we used many filters in order to obtain the appropriate number of articles. In the specified time period, a comprehensive selection of 7 scholarly articles was identified from various sources including journals, conference proceedings, reviews, and book chapters. Among the 7 publications considered, it was found that only 5 were published in the journal. Consequently, our final dataset comprised solely of these 5 articles, upon which the subsequent data analysis was conducted. A total of 5 documents were included in this investigation. The process of inclusion and exclusion as described in the article is illustrated in Figure 2.

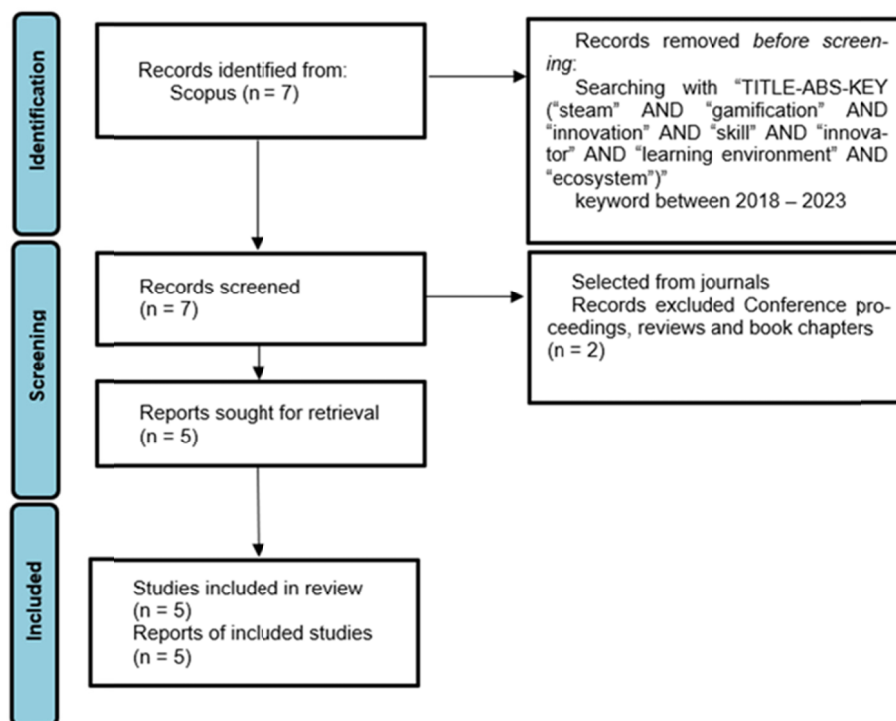


Figure 1. PRISMA 2020 of article selection

### 3. Analysis and Results

#### 3.1 Publication Trend

It was observed that the publication count commenced in 2018, utilizing data spanning the preceding five years. The publication trend can be classified into two discrete portions in order to clarify the nature of its development. The initial phase pertains to the period between 2018 and 2020, during which scholars commenced exhibiting a keen interest in the integration of steam learning environment on gamification systems to promote innovators, leading to the publication of scholarly articles on this subject matter. The subsequent period of reduce in publication output spanned from 2021 to 2022, during which the annual quantity of published documents experienced a rise from 0 to 1. The growth chart of the publication effectively illustrates two key aspects: firstly, the emergence of steam learning environment on gamification systems to promote innovators as a nascent field of research, and secondly, its potential as a subject of future investigation and development.

#### Documents by year

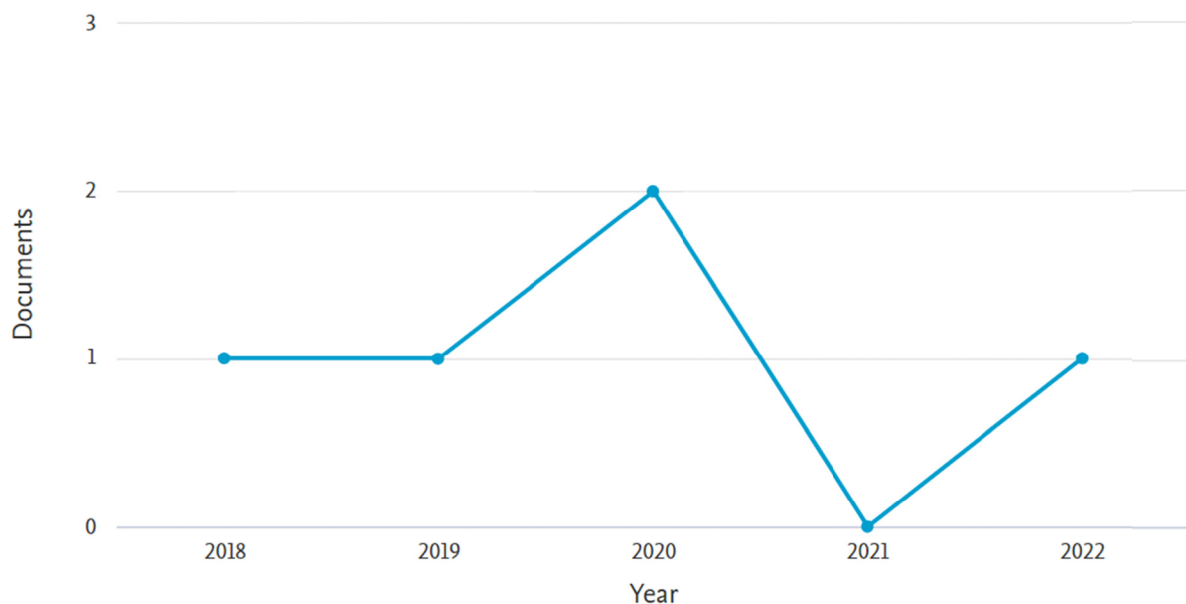


Figure 2. The publication growth trend

Figure 2 shows the growth trend in scientific publications in a steam learning environment on gamification systems to promote innovators. Researchers and academics in this field have shown a growing interest between 2018 and 2020. The peak of “a steam learning environment on gamification systems to promote innovators” discussions in the academic field was in 2020, with two documents published that appeared in our research, as represented in figure 2.

#### 3.2 Top Cited Articles

The three most frequently referenced publications on the topic of a steam learning environment on gamification systems to promote innovators are “Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning environment”, “Digital learning ecosystem involving steam gamification for a vocational innovator” and “New trends in education as the aspect of digital technologies”. Table 1 is a compilation of the top 5 articles that have received a high number of citations, including their respective citation counts and the titles of the sources from which they originated.

Table 1. Top cited articles

Rank	Title	Authors	Year	Source Title	Citations
1	Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning environment	Wannapiroon N.; Pimdee P.	2022	Education and Information Technologies	31
2	Digital learning ecosystem involving steam gamification for a vocational innovator	Kummanee J.; Nilsook P.; Wannapiroon P.	2020	International Journal of Information and Education Technology	25
3	New trends in education as the aspect of digital technologies	Ordov K.; Madiyarova A.; Ermilov V.; Tovma N.; Murzagulova M.	2019	International Journal of Mechanical Engineering and Technology	7
4	Effects of Steamification Model in Flipped Classroom Learning Environment on Creative Thinking and Creative Innovation	Wannapiroon N.; Petsangri S.	2020	TEM Journal	6
5	Deriving a gamified learning-design framework towards sustainable community engagement and mashable innovations in smart cities: Preliminary findings	Lee C.-S.; Kuok-Shoong D.W.	2018	International Journal of Knowledge and Systems Science	6

### 3.3 Top Sources

The investigation was to assess the potential influence of publishing documents on citation frequency by comparing the number of publications and citations. The five most significant documents are referenced in Table 2. Education and Information Technologies is the document that has the greatest number of publications, totaling 1, and has received a total of 31 citations. Nevertheless, the most frequently referenced is titled "Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning environment." This article, "Digital learning ecosystem involving steam gamification for a vocational innovator," was published in the International Journal of Information and Education Technology, which holds the second position in the list with a total of 1 publication and 25 citations. It is not necessary that the most cited article also belong to the top journal, but generally, it is widely believed that having one's work published in the top five or ten sources can potentially enhance the probability of receiving citations.

Table 2. Top 5 sources

Rank	Source	TP	TC	Cite Score 2022	SJR 2022	SNIP 2022	Publication Type	The Most Cited Article	Time Cited
1	Education and Information Technologies	1	31	8.2	1.249	2.260	Journal	Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning environment	31
2	International Journal of Information and Education Technology	1	25	2.0	0.243	0.551	Journal	Digital learning ecosystem involving steam gamification for a vocational innovator	25
3	International Journal of Mechanical Engineering and Technology	1	7	1.2	0.293	0.311	Journal	New trends in education as the aspect of digital technologies	7

4	International Journal of Knowledge and Systems Science	1	6	3.0	0.255	0.557	Journal	Deriving a gamified learning-design framework towards sustainable community engagement and mashable innovations in smart cities: Preliminary findings	6
5	TEM Journal	1	6	1.9	0.231	0.546	Journal	Gamified evaluation in steam	6

### 3.4 Top Authors

We have found leading authors with more publications who made contributions to the field. We discovered that Wannapiroon, N. is the top author in the steam learning environment on gamification systems to promote innovators category, with 2 publications and 37 citations. Nilsook, P. is ranked second with 1 publication and 25 citations each. Wannapiroon, P. is the top third author, with 1 article and 25 citations. Table 3 presents the top 5 authors, ranked according to their respective positions. Each author’s pertinent details, including their Scopus ID, total publication count (TP), h-index, total citation count (TC), current affiliation, and country of origin, are included in the table.

Table 3. Top 5 authors in STEAM education with gamification field

Rank	Author	Scopus Author ID	TP	h-Index	TC	Current Affiliation	Country
1	Wannapiroon, N.	57221100517	2	3	37	Rajamangala University of Technology Suvarnabhumi	Thailand
2	Nilsook, P.	35759156200	1	11	25	King Mongkut’s University of Technology North Bangkok, Bangkok	Thailand
3	Wannapiroon, P.	35759613600	1	10	25	King Mongkut’s University of Technology North Bangkok, Bangkok	Thailand
4	Kummanee, J.	57216508003	1	1	25	Dusit Technical College	Thailand
5	Ordov, K.	57190022789	1	7	7	Plekhanov Russian University of Economics	Russia

### 3.5 Leading Countries

Figure 3 highlights the leading countries based on the number of publications in the field. The top five countries are Thailand, Kazakhstan, Malaysia, Russia, and Singapore with 6 and 3 documents respectively.

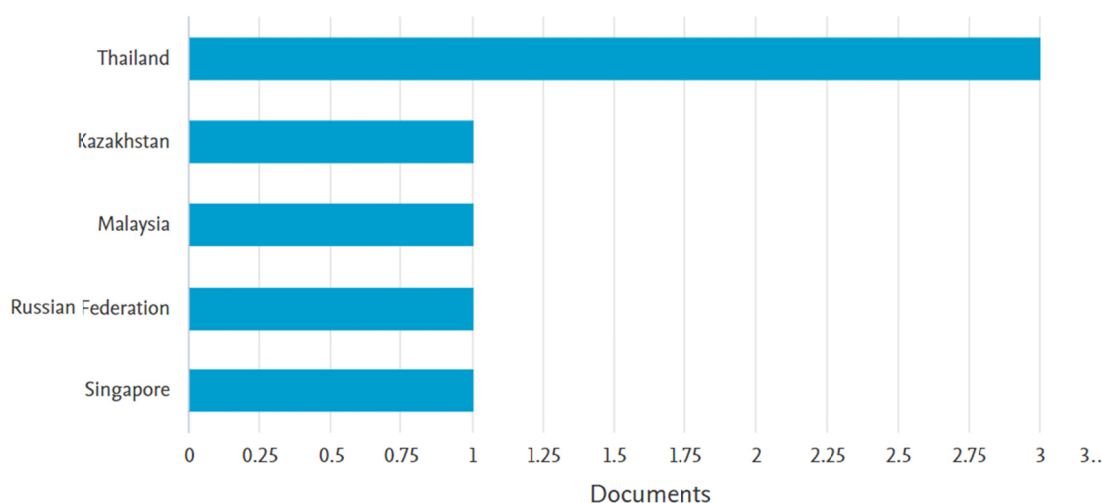


Figure 3. Leading countries

### 3.6 Subject Area

The distribution of the published literature in the steam learning environment on gamification systems to promote

innovators across the various disciplines Figure 3 shows that 27.3% of the articles belong to the field of computer science, while 27.3% are relevant to the field of social sciences. 18.2% of the total publications are published in business, management, and accounting, while 18.2% of the total publications are in the area of decision sciences. Only 9.1% of the articles belong to the engineering field. The distribution of the publications according to their subject areas is shown in Figure 4.



Figure 4. Subject area distribution of published articles

### 3.7 Co-Occurrence of the Author Keywords

Co-occurrence (author keywords). We conducted a co-occurrence analysis to know the keywords authors have used in their studies so far. Our results after running a co-occurrence analysis of author keywords revealed 30 keywords used in the papers related to STEAM education with gamification. The minimum number of keyword occurrences was set at 1 to be included in the analysis. As a result, 15 keywords were found to meet the criteria. The most prominent key-words occurred were gamification, creative thinking, steam education, design thinking, digital learning ecosystem, innovative skills, innovator, mashable product/service innovations, media-models, smart cities, vocational innovator, digital learning environment, innovation skills, steam-ification and stem with 4, 2, 2 and 1 occurrences (Table 4). Figure 6 depicts the data overlay visualization, and Table 4 depicts the keywords, their occurrences, and total link strength (TLS).

Table 4. Most significant keywords in STEAM education with gamification

Keyword	Occurrences	TLS	Keyword	Occurrences	TLS
gamification	4	4	media-models	1	1
creative thinking	2	2	smart cities	1	1
steam education	2	2	vocational innovator	1	1
design thinking	1	1	digital learning environment	1	1
digital learning ecosystem	1	1	innovation skills	1	1
innovative skills	1	1	steam-ification	1	1
innovator	1	1	stem	1	1
mashable product/service innovations	1	1			

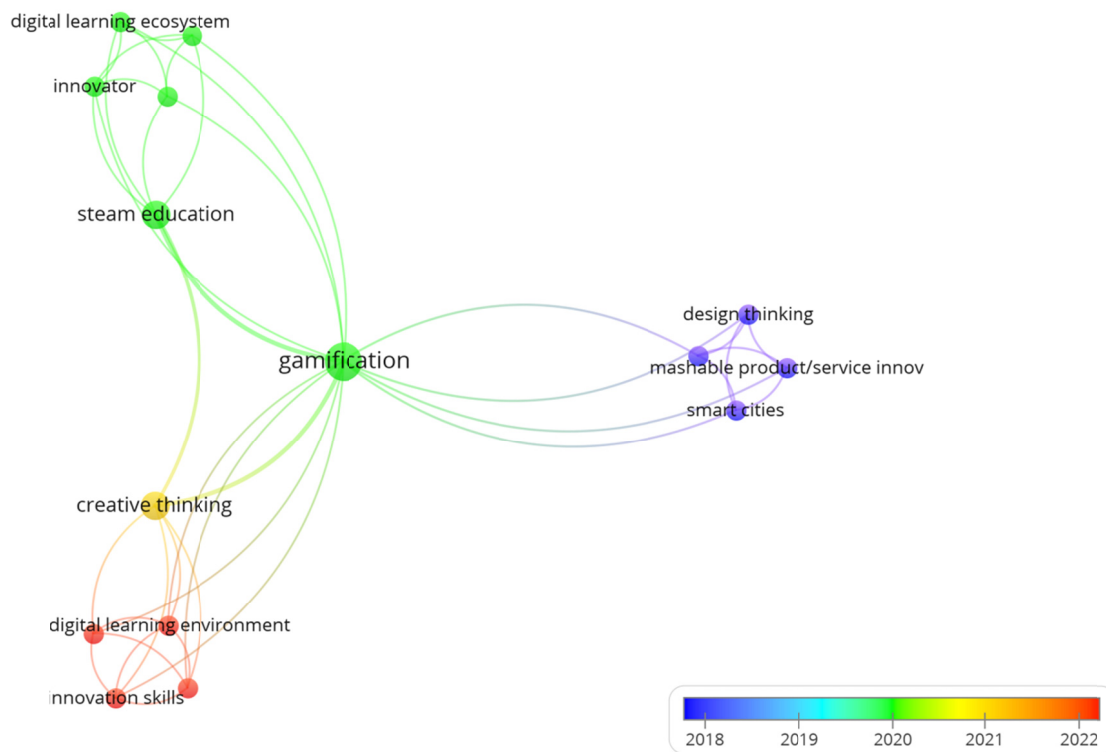


Figure 5. Co-occurrence (author keywords) analysis of keywords

### 3.8 Characteristics of Included Studies

The five selected articles related to a steam learning environment on gamification systems to promote innovators that met the inclusion criteria were reviewed individually. Insights, results, methods used, and contributions are presented in Table 5.

Table 5. Characteristics of included studies

No.	Title	Insights	Results	Methods Used	Contributions
1	Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning environment (Wannapiroon & Pimdee, 2022)	The paper discusses the development of a digitally based virtual classroom learning environment (VCLE) that incorporates gamification mechanisms to enhance creative thinking and innovation skills in Thai undergraduate students in STEM/STEAM disciplines. The paper does not specifically mention the promotion of innovators.	- VCLE STEAM-ification process enhances creative thinking and innovation. - Students achieve higher levels of creativity and innovation with VCLE STEAM-ification compared to traditional teaching.	- Mix-method research approach (quantitative and qualitative methods) - Systematic review of factors affecting STEAM-ification process	- Pre-service teachers and institutions need to be technologically savvy. - Digital storytelling and use of digital media.



2	Digital learning ecosystem involving steam gamification for a vocational innovator (Kummanee et al., 2020)	The paper discusses the use of a digital learning ecosystem involving STEAM gamification to develop a vocational innovator. It explains the conceptual framework, design, and evaluation of the model. However, it does not specifically mention the promotion of innovators in the gamification system.	<ul style="list-style-type: none"> <li>- Conceptual framework of digital learning ecosystem involving STEAM gamification</li> <li>- Evaluation of the model deemed appropriate level</li> </ul>	<ul style="list-style-type: none"> <li>- Analysis of digital learning ecosystem involving STEAM gamification</li> <li>- Development and evaluation of digital learning ecosystem involving STEAM gamification</li> </ul>	<ul style="list-style-type: none"> <li>- Quality education meeting international standards</li> <li>- Improvement in country's competitiveness</li> </ul>
3	New trends in education as the aspect of digital technologies (Ordov et al., 2019)	The answer to the query is not mentioned in the paper. The provided paper discusses the relevance and use of digital technologies in education, but it does not specifically address the topic of a STEAM learning environment on a gamification system to promote innovators.	<ul style="list-style-type: none"> <li>- Digital technologies are widely used in various areas of society, including education.</li> <li>- The digitalization of education identifies risks and problems that require solutions.</li> </ul>	<ul style="list-style-type: none"> <li>- Survey conducted with 100 respondents from different age groups</li> <li>- Use of social networks and media for information dissemination</li> </ul>	<ul style="list-style-type: none"> <li>- Non-linear relationship between bank competition and stability</li> <li>- Implications from oversight regulators or authorities</li> </ul>
4	Effects of Steamification Model in Flipped Classroom Learning Environment on Creative Thinking and Creative Innovation (Wannapiroon & Petsangsri, 2020)	The paper discusses the use of a STEAMification model in a flipped classroom learning environment to enhance creative thinking and creative innovation. It mentions the use of gamification elements in the learning activities. However, it does not specifically address the promotion of innovators.	<ul style="list-style-type: none"> <li>- Students studying through STEAMification had higher creativity.</li> <li>- Students studying through STEAMification had higher quality of creative innovation.</li> </ul>	<ul style="list-style-type: none"> <li>- Evaluation form for creative skills, creative innovation, and satisfaction</li> <li>- Data analysis using content analysis, mean, and standard deviation</li> </ul>	<ul style="list-style-type: none"> <li>- Development of the STEAMification model in flipped classroom learning environment</li> <li>- Comparison of creative scores and quality scores of creative innovation between STEAMification model and traditional approach</li> </ul>
5	Deriving a gamified learning-design framework towards sustainable community engagement and mashable innovations in smart cities: Preliminary findings (Lee et al., 2018)	The answer to the query is not explicitly mentioned in the paper. The word "STEAM" is mentioned in the abstract, but it is not further discussed or elaborated upon in relation to gamification or promoting innovators. The paper is about deriving design factors for community engagement and mashable opportunities/innovations in smart city communities through gamified learning.	<ul style="list-style-type: none"> <li>- Improved outbound logistics operations in terms of quality control and operation efficiency after implementing IOLMS for three months.</li> </ul>	<ul style="list-style-type: none"> <li>- Meta-analysis of two gamified media-model opportunities</li> <li>- Qualitative research method using rich data</li> </ul>	<ul style="list-style-type: none"> <li>- Methodology with six structured steps for analysis process.</li> <li>- Case study on analysis of catastrophes in Valparaiso.</li> </ul>

### 3.9 The Conceptual Framework

The conceptual framework of STEAM Learning Environment on Gamification System to promote innovators involves integrating STEAM education with gamification elements to enhance creative thinking and innovation skills (Wannapiroon & Pimdee, 2022). The STEAM learning process consists of five steps: investigation, discovery, connection, creation, and reflection (Wannapiroon & Petsangsri, 2020). Gamification applies game mechanics and dynamics to motivate learners and make learning more engaging (Kummanee et al., 2020). By incorporating gamification into the learning environment, students are encouraged to think creatively, participate in problem-solving, and collaborate with others (Lee et al., 2018). This approach can enhance students' creative thinking and innovation skills, aligning with the characteristics of 21st-century skills. The use of digital technologies, such as virtual learning ecosystems, can further support the implementation of the STEAM learning

environment and gamification system. Overall, the integration of STEAM education and gamification can create a conducive environment for developing innovators with the necessary skills for the future.

#### 4. Conclusion

The findings of this study will contribute to the academic community's knowledge and comprehension of the worldwide influence of a steam learning environment on gamification systems to promote innovators. The utilization of quantitative techniques in bibliometric analysis allows for the identification and examination of various key aspects within a given field of study. These aspects include the core sources, top authors, top keywords, top publishing country, highly cited articles, co-occurrence maps of terms, and the co-occurrence of author keywords, among others. A total of 5 research documents and 75 citations have been accumulated over the course of the past 6 years in relation to the research outputs pertaining to steam learning environment on gamification systems to promote innovators. The phenomenon of publication trends has experienced significant few growths for short years and is projected to persist in the future. The articles that have received a high number of citations have been identified, as have the authors, journals, and countries that have demonstrated the highest levels of productivity. Approximately 27.3% of papers in the STEAM education with gamification literature are from computer science and social sciences, while 18.2% are from business, management, and accounting and decision sciences sectors. The article by Wannapiroon N.; Pimdee P. titled as "Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: a conceptual model using a digital virtual classroom learning" is the highly cited article with 31 total citations. Education and Information Technologies is the distinguished publications in the area domain. Wannapiroon, N., Nilsook, P., Wannapiroon, P., Kummanee, J. and Ordov, K. are the most prolific author in the said field. Thailand, Kazakhstan, Malaysia, Russia, and Singapore are the top five countries actively involved in the publication of steam learning environment on gamification systems to promote innovators research. The most significant keywords in steam learning environment on gamification systems to promote innovators published literature are gamification, creative thinking, steam education, design thinking and digital learning ecosystem. The five selected articles related to a steam learning environment on gamification systems to promote innovators that met the inclusion criteria were reviewed individually. Insights, results, methods used, and contributions. The conceptual framework of steam learning environment on gamification systems to promote innovators combines STEAM education with gamification to boost creative thinking and innovation skills. The five-step STEAM process, including investigation, discovery, connection, creation, and reflection, is complemented by game mechanics and dynamics. This approach encourages problem-solving, collaboration, and innovation, aligning with 21st-century skills. Digital technologies like virtual learning ecosystems support this integration. This study offers guidelines for future researchers to pursue, enabling them to concentrate their efforts on critical domains where attainable outcomes may be achieved.

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