

Game Research Trends at the Annual ASEE Conference: A 15-year Content Analysis

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Abstract

The purpose of this study is to examine the game-related publications from the annual American Society of Engineering Education (ASEE) conference using content analysis methodologies. Our search included the terms game, gaming, gamer, gamify, and gamification from 2006-2020 resulted in 176 relevant publications. Our analysis focused on document metadata and abstracts, a methodology similar to other content analyses examining journals' trends over time. We used text mining software Leximancer¹ to examine the overall themes in the text and to investigate the evolution of game related research in five-year periods. The software provided evidence for the status of the field and changes over time. Leximancer applied automatic processing of the text in determining a semantic model for critical terms and concepts, highlighting the role of development and design, measurements of learning, and changes in term use over time. The 15 year period was characterized by a focus on students, games, and learning, including topics on the methods of teaching (i.e, pedagogy) and design of learning experience. Virtual reality, STEM education, and gamification were relevant in specific periods of time. There is a need for future research in mixed reality applications, diversity of gamification techniques, and the use of non-digital games.

Introduction

The addition of games in educational environments can have a powerful impact on student learning, motivation, and self-regulation². Whether they are designed for sensory stimuli through multimedia, learner control through game choice, or feedback through progress monitoring, game-based learning increases overall motivation to learn and, consequently, student engagement³, participation, attendance, motivation, and satisfaction^{4,5}. The volume of research on games and learning in the past 15 years has grown along with related theoretical frameworks, methods, and areas of study^{6,7,8}. In engineering education, there are a variety of game-based approaches for teaching and learning with generally positive results⁹, although there is a need for more transparency in design and more rigorous methodological techniques¹⁰.

This growth in gaming research is also reflected at the American Society for Engineering Education (ASEE) annual conference proceedings, expanding from 12 papers during the 2001-2005 conferences to 73 papers during 2016-2020, a six fold increase over 20 years. By examining the evolution of gaming trends over time, the results can be used to inform the ASEE community of areas of study and directions for future research. Thus, the purpose of this content

analysis is to explore (a) the thematic trends of ASEE gaming conference papers over time and (b) the semantic relationships between concepts.

Methods

Content Analysis Methodology

Content analysis is a research procedure for making reproducible and valid inferences by analyzing text or other media¹¹. This definition is relatively similar to the description provided by Holsti nearly five decades ago, as "any technique for making inferences by objectively and systematically identifying specified characteristics of messages" (p. 14)¹². Content analysis has previously been conducted by time-consuming manual processing, such as hand coding text. With the development of lexical, linguistic, and statistical software packages, researchers are now able to digitally analyze large volumes of qualitative information by identifying the essential concepts and themes¹³. Content analysis can measure and quantify the repetition of certain words, terms, topics, or concepts in a set of chronological or contemporary texts. Researchers can examine and filter a large volume of data with relative ease in a systematic manner through content analysis¹⁴. This technique is useful in discovering, describing, and explaining the focus of individuals, groups, or institutions¹⁵.

Leximancer Software

Leximancer is a text mining software that can code large qualitative datasets, and this data mining software has been validated and used in various research dimensions¹⁶, including the education sector¹⁷. Leximancer autonomously examines text documents such as Microsoft Word, PDF, or Excel file in a general language and automatically analyzes the information content to identify the main ideas in each document, such as central themes, high-frequency words, and related terms. Due to its digital text identification feature, Leximancer can quantitatively analyze a large text document very quickly¹⁸. Because of this unique quality, Leximancer has been used in systematic reviewing to select keywords¹⁹ and to trace changes in abstract content within research articles over a specific timeline^{20,21}.

Leximancer performs autonomous unsupervised scrutiny of texts that are uploaded as individual files or folders. In evaluating the text, Leximancer runs two forms of analysis simultaneously: a semantic analysis that pulls on the characteristics of entities, words, or compilations of words, and a relational assessment that is determined by the frequency of occurrence¹⁶. This creates a catalog of terms that are ranked according to their rate of recurrence and interrelationships with each other. Leximancer then develops a thesaurus of interrelated words, clustered by their semantic and relational connection, labeled as *concepts*. Then the interrelated concepts are merged to form *topics*. The preliminary result is a list of thematic topics, containing concepts and text extracted from the data to refer to each concept. The extracted text can be viewed in its original context to which helps readers to interpret the data.

There are two ways to visualize output in Leximancer. First is a concept map that provides an overall view of the semantic data (Figure 1, right; see Figure 2). The key concepts are represented as colored bubbles, and the colors are heat mapped to indicate the significance or relationship. Warm colors such as red, crimson, orange, brown represent more important themes, and cool

colors such as blue, green, teal symbolize less important themes. The size of the bubbles represents the number and distance of the concepts. Inside the bubbles, there are collections of interlinked dots, or nodes, where each node represents an individual concepts. The vicinity of the bubbles and concept nodes indicates similarity of term, where the most closely related are grouped together. In this paper, we present the data using both a 3D visualization (circles or bubbles) and concepts map (concepts connected by lines). The concept map view also provides access to a ranked list of concepts in comparison to each other. For example, the term *students* ranked at 100% relevance but this does not imply that the term is present in all text segments (see Figure 2).

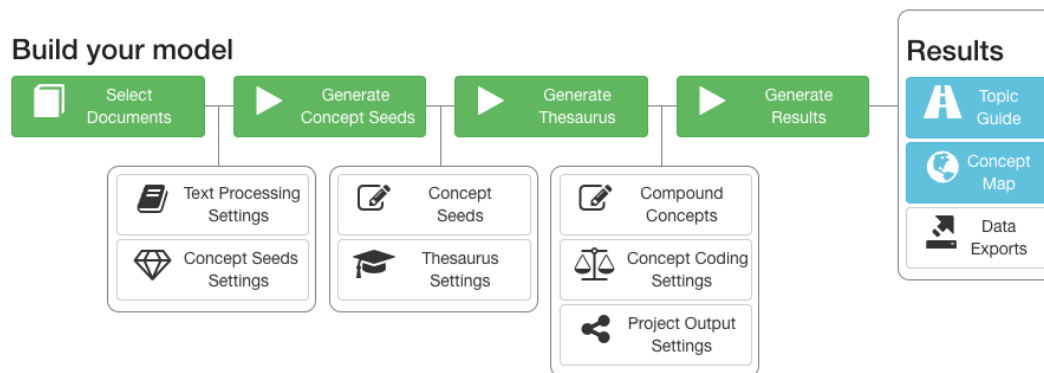


Figure 1: Leximancer text modeling process. Permission granted by Leximancer.

Second, the software compiles the data into a topic guide of closely related concepts. This textual presentation of the data uses a subject index format to group interrelated items and organize segments of text. In contrast to the concept map view, the topics provides a rich environment to qualitatively examine related data.

Data Collection

Gaming research papers in engineering education were infrequent in the early 2000's¹⁰⁹, and prior to 2006, there were few abstracts published in the ASEE annual conference proceedings. Therefore, the data search included all ASEE annual conference papers from 2006-2020 using the ASEE Conference Proceedings Search. The search terms included game, gaming, gamer, gamify, and gamification in the title of the paper. Relevant paper abstracts and metadata were included in the sample. We reviewed each abstract and excluded papers on topics not related to games and learning, such as game theory or sports, and papers without abstracts. This resulted in 176 publications, segmented into 2006-2010 (n=39), 2011-2015 (n=64), and 2016-2020 (n=73). The Computers in Education Division and NSF Grantees Poster Session included the highest number of papers (Table 1). To access the research data supporting this publication, see <https://doi.org/10.25380/iastate.14428304>.

Table 1: Top 10 ASEE divisions with gaming focused papers from 2006-2020.

Division	Number of Papers
Computers in Education	31
NSF Grantees Poster Session	20
Educational Research and Methods	12
K-12 and Pre-College Engineering	10
Computing and Information Technology	7
Mechanics	7
Manufacturing	6
Chemical Engineering	5
Industrial Engineering	5
Electrical and Computer	5

Figure 2 provides a snapshot of the concepts over the past 15 years of conference papers through a 3D visualization and a ranked list. The largest clusters center on students (100%; the highest relevance is set at 100%) games (82%), learning (48%). Throughout the paper, the concepts maps include a G for the game node and S for the student node in similar locations in an effort to orient the reader viewing the maps. Larger images of the concept maps are given in the Appendix (Figure 6-9).

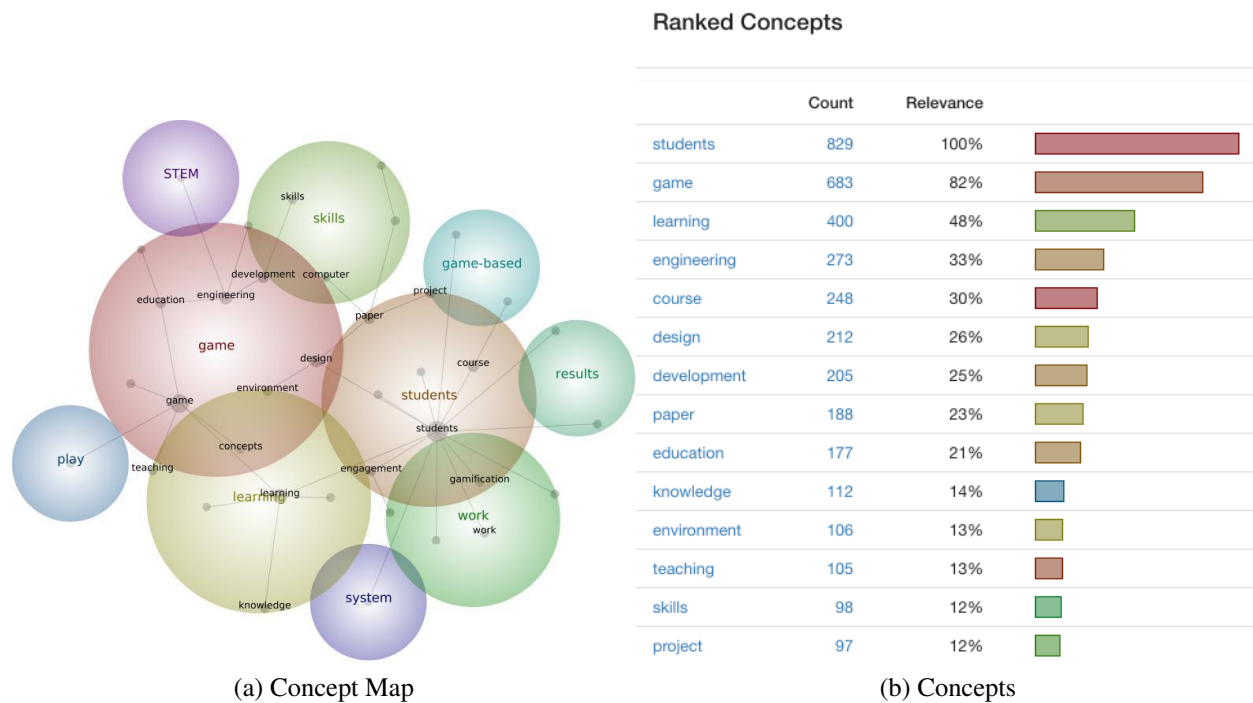


Figure 2: 15 year concept map (a) and ranked concepts (b).

Results

2006-2010

In the early 2000's, there was a small but growing field of researchers examining how games could be used for learning. Books such as *Good Video Games and Good Learning*²² and *Playing to Learn*²³ helped to expand ideas of the value of games in diverse applications. The PlayStation3 and Wii were new gaming systems and *Wii Fit* (2007), *Assassin's Creed* (2007) and *Minecraft* (2009) were released. The computer-based virtual world *Second Life* was at it height of popularity, attracting musicians, politicians, and university campuses²⁴. In the context of research, "it appeared no longer debatable whether a 'game studies' field will emerge, but rather, what shape it will take" (p.51)²⁵.

The papers presented at ASEE from 2006-2010 reflected the early field of game-based learning. Authors were beginning to create and research games for education and instruction, particularly in the computing fields. Within the abstracts, three themes emerged: Interactive, Education, and Technical. The topics are distinct in both location and relationships on the concept map. The Interactive (Figure 3) topic included concepts on the affordances of games in contrast to Education, focused on the pedagogical considerations. The third theme centered on the specific educational context, in this case Technical or computing education.

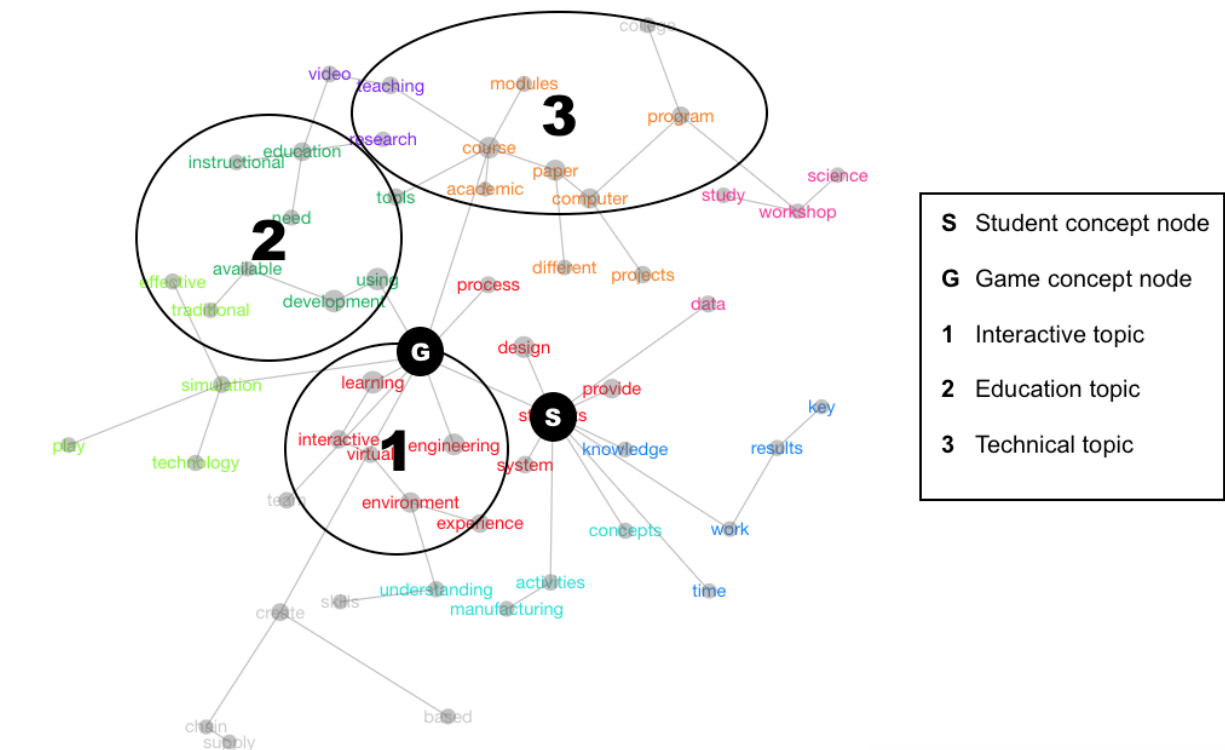


Figure 3: 2006-2010 concept map.

A closer examination of the abstract text provided more information to help understand the results (Table 3). First, the topic Interactive connected several concepts that described the benefits of using games for learning, including "a fun and engaging learning environment"²⁶ or "use of

games delivered in a learner-centered environment”²⁷. The term virtual was also used as a descriptor for an interactive gaming experience, but in reference to 3D graphics on desktop computers and less about virtual reality technology, a development we will see represented in the 2016-2020 time period.

Table 2: Most frequent topics from 2006-2010.

Topic (text segments)	Concepts	Example Abstract Text Segment
1.Interactive (n=33)	Interactive, learning, virtual, environment	An immersive interactive laboratory experiment developed based on a multi-player computer game engine, which allows the students to collaboratively assemble the experimental setup of an industrial plant emulator within the game environment and subsequently run remote and virtual experiments, was deployed in a pilot implementation. ²⁸
2.Education (n=20)	Instructional, educational, process, developed, research, traditional	However, when we adapted the game-based instructional model to a different course, a dynamic systems and control course, the improvements, so far, have been less dramatic. In this paper, we re-think how a video game can be used to teach Dynamic Systems and Control. ²⁹
3.Technical (n=17)	Computing, teaching, courses, learn, programs	Game development generates a great deal of excitement among undergraduate computing students. Many students are disappointed to find that they will not learn how to build computer games in their required computing courses. ³⁰

The second topic, Education, grouped concepts describing instruction and evaluation with games. Thematically, researchers were developing, testing, and researching instructional or educational games, particularly in contrast to traditional methods of instruction. For example, Collier described a comparison study ”demonstrating that students in the video game-based course learn more deeply than students in more traditional textbook-based courses.”³¹

The third topic centered on the academic context of the game, summarized as Technical. During this time period, the terms programming and computing were discussed in connection to teaching and learning. This included computer science and computer engineering courses, and games created by the researcher themselves or the re-purpose of commercially available games such as *Tetris*³² and *The Game of Life*³³. Although engineering (26%) and science (7%) appeared on the ranked list of concepts, they were not a topical connection between the abstracts.

2011-2015

The second decade of the 2000’s was characterized by a large growth in gaming systems and new games. The release of the iPad expanded the possibilities for gaming with younger students and

mobile gaming apps improved in functionality and capability²³. Top grossing games include *World of Warcraft* (2012), *Candy Crush* (2013), and *League of Legends* (2015)³⁴. Award winning educational games at the Game4Change Festival during this time included *Reach for the Sun* (Science), *Mission US: A Cheyenne Odyssey* (American History), and *Quandary* (Ethics)³⁵. The term gamification was spreading in academia and industry and, for the first time, overtook the term game-based learning in the corpus of US books (i.e., Google Ngram³⁶). The National Research Council (NRC) published *Learning Science through Computer Games and Simulations* (2011), stating that "evidence for the effectiveness of games for supporting science learning is emerging but is currently inconclusive. To date, the research base is very limited" (p.54). Although the NRC report included many recommendations to strengthen game research, the authors made note of the high potential for games to impact learning.

As with the previous five years, the three themes were distinct on the concept map. The topics were also conceptually similar, with a topic on design of the learning environment (i.e., Instructional Design; Figure 4), a topic on pedagogical frameworks (i.e., Concepts), and a topic on content areas (i.e., STEM).

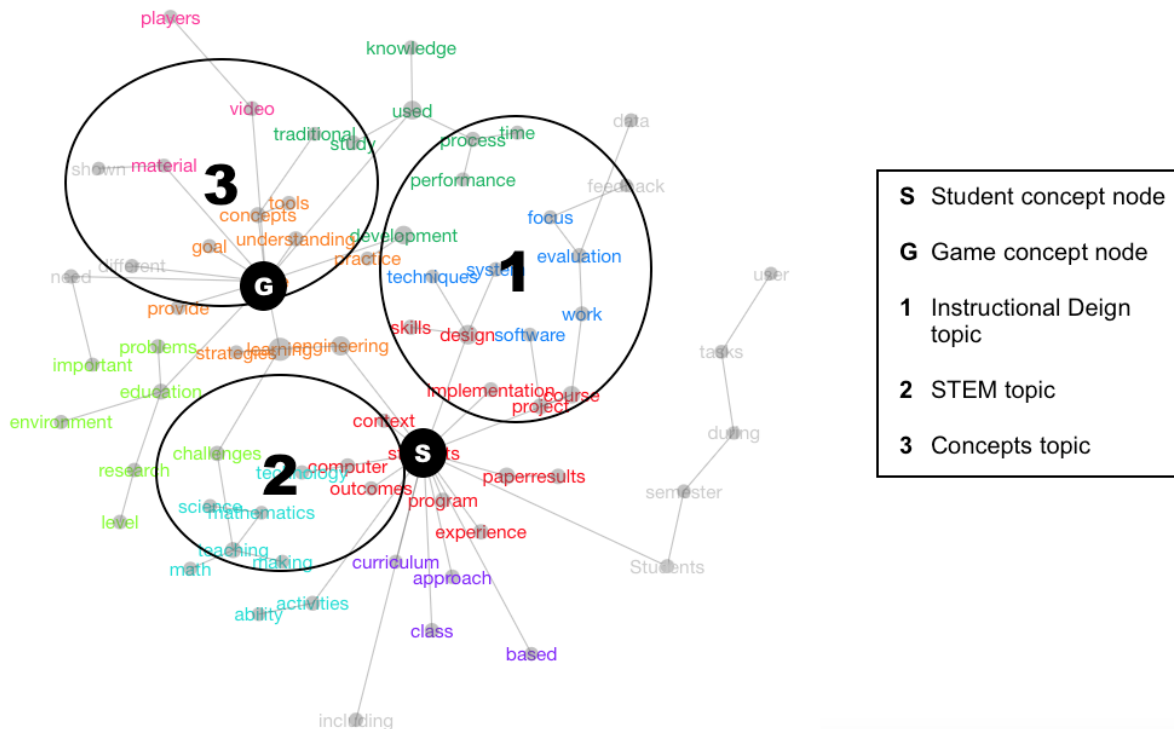


Figure 4: 2011-2015 concept map.

Several of the trends in the abstracts continued from the the previous five years, but with a shift in focus (Table 3). First, the Instructional Design topic included concepts on strategies for active learning and teaching. Studies include project-based^{37 38} and engineering design teaching methods^{39 40 41}. The Concepts topic also included pedagogical applications, but with a focus on the benefits of games for learning STEM as compared to more traditional methods. The abstract texts include the phrases "games are known to be a very effective" and "In contrast with traditional methods", providing evidence of the change between the way things have been taught,

and this new strategy with promising results.

The final topic STEM illuminated an increase in diversity of content areas presented in the abstracts, individually and in combination. Overall, engineering was most relevant concept at 27% (in comparison to students at 100%) , followed by technology (7%), science (5%), and mathematics (4%). Several studies took an interdisciplinary approach, bringing together different fields of study around an electric grid game⁴², an earthquake game⁴³, or video game development⁴⁴.

Table 3: Most frequent topics from 2011-2015.

Topic (text segments)	Concepts	Example Abstract Text Segment
1.Instructional Design (n=41)	Process, project, design	The main objective of the game is to teach the engineering design process to the students in a fun gaming environment. The serious game has different levels (tutorial, water tower level and train bridge level) and progressions. ⁴⁵
2.STEM (n=34)	Technology, computer, mathematics, science	In order to provide an interactive way to engage children and educate them in the field of medical devices, a life-sized version of the game Operation by Hasbro, Inc. was made. The overall goal of the game was to stimulate interest in engineering and technology through the demonstration of a relatable application. ⁴⁶
3.Concepts (n=32)	Understanding, tools, traditional, shown	The first course in thermodynamics has traditionally been a challenge for students in engineering programs. The course typically introduces students to many entirely new concepts of continuum mechanics, and often relies upon still-new calculus tools in order for the students to understand the theory. ⁴⁷

2016-2020

The gaming industry continued to grow and expand into mixed reality mediums. *Pokemon Go* was released in 2016, becoming the top grossing augmented reality game in history⁴⁸. The HTC Vive also entered the consumer market that year. The technical advancements quickly led to higher fidelity and wireless VR options. STEM education had greater representation at the Games4Change awards, including *DragonBox Numbers* (mathematics), *At Play in the Cosmos* (science), and *Rabbids Coding* (computer science)³⁵. The awards also reflected the mixed reality gaming trend with the maker kit *Nintendo Labo* (engineering and computer science) and the virtual reality experience *Tree* (science). This time period ended with the disruptive COVID-19 pandemic in 2020 and a sharp increase in number of users for collaborative games (e.g., *Among Us*) where players can connect remotely⁴⁹.

Table 4: Most frequent topics from 2016-2020.

Topic (text segments)	Concepts	Example Abstract Text Segment
1.Learning (n=101)	Classroom, elements, feedback, gamification, motivation	Accordingly, the purpose of this research was to survey contemporary engineering education literature and categorize the different ways that digital and non-digital games have contributed to learning in engineering. ⁵⁰
2.Gamification (n=69)	Elements, gamification, positive, study, feedback, motivation	In this paper, we describe our efforts to investigate which aspects of gamification students find the most motivating. We present our gamification platform, GamerCard, which was used for four semesters in an upper-level game design course at our institution. ⁵¹
3.Instructional Design (n=54)	Approach, paper, project, design, strategies	This paper will present the findings of a pilot study integrating formal collaborative learning strategy into a game development course (CGT 245: Game Development I) taught at a large Midwestern university in the United States (Purdue University). ⁵²
4.Engagement (n=53)	Engagement, increase, classroom, elements motivation, positive	These games cover topics in pre-calculus, calculus, physics, and chemistry and incorporate learning elements diegetically. This paper will focus on techniques for implementing learning components as diegetic elements in games to increase player engagement. ⁵³
5.Virtual (n=50)	Virtual, education	Students were taught the basics of the Nintendo Switch development environment along with basics of virtual reality (VR), and asked to design a simple VR game. Nintendo Labo VR kits were also utilized in the workshop. ⁵⁴

Discussion and Limitations

The research papers on games and gaming presented at ASEE increased from 2006-2020. In some ways, the topics of research stayed consistent over time while some concepts were present for only a particular period of time. For example, in each segment of five years, there was a focus on pedagogy (e.g., education, learning, engagement, motivation) and designing games for learning (e.g., evaluation, strategies, projects). These concepts were a uniform thread over time. Conversely, special topics of interest appeared and disappeared. Initially, the gaming studies were primarily in computing fields and this expanded into other STEM areas over time. From 2016-2020, interdisciplinary work increased and gaming research in mathematics decreased.

With the advancement of VR and AR technology, many games are now being offered with VR and AR options. This can be demonstrated through the emergence of virtual reality in the 2016-2020 time period. Widespread usages of personal computers and mobile devices have made gaming and game-based learning more popular than ever. A wide variety of types of games have evolved, and numerous online gaming communities have grown where players interact, socialize, and play using diverse technologies and digital mediums.

The ASEE papers included few non-digital games, and there is a need for more research in this area. Beyond card games and board games, researchers may want to consider mixed reality or escape rooms type games. Initially, escape room games were introduced as a leisure activity. However, it is now considered a pedagogical tool in many institutions as activities in this type of game help the player develop soft skills such as teamwork and collaboration. It is even possible to use escape room games for technical exams⁵⁵.

As gamification is gaining popularity, so are the game strategies at the center of the research studies. However, gamified components are frequently limited to leader boards, badges, and points, and academics and researchers should look for other components beyond the three most popular items⁵⁶. Collaborative design with instructional designers, UX researchers, and experts from other fields may create innovate experiences using unique gaming elements.

The content analysis in this paper utilized titles and abstracts for analyzing text. We were limited by the information provided by authors in the abstracts and the choice of words to describe each study. We recommend that authors pay special attention to providing thorough abstracts and relevant paper titles. Complete information in these areas will facilitate future content analyses.

Conclusion

This content analysis compiled and analyzed 176 abstracts published in the ASEE journal from 2006 to 2020. The papers on gaming increase over time and varied in key topics. Discussions on game pedagogy and design were evident throughout the 15 year period. Games in different STEM fields expanded over time with a greater focus on virtual reality and gamification. Overall the ASEE papers reflected the change over time in personal gaming technologies and the growing research in game studies. Recommendations for future research include studying the student experience using advanced technologies, diversifying research on gamification elements, and the inclusion of non-digital game play.

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Appendix

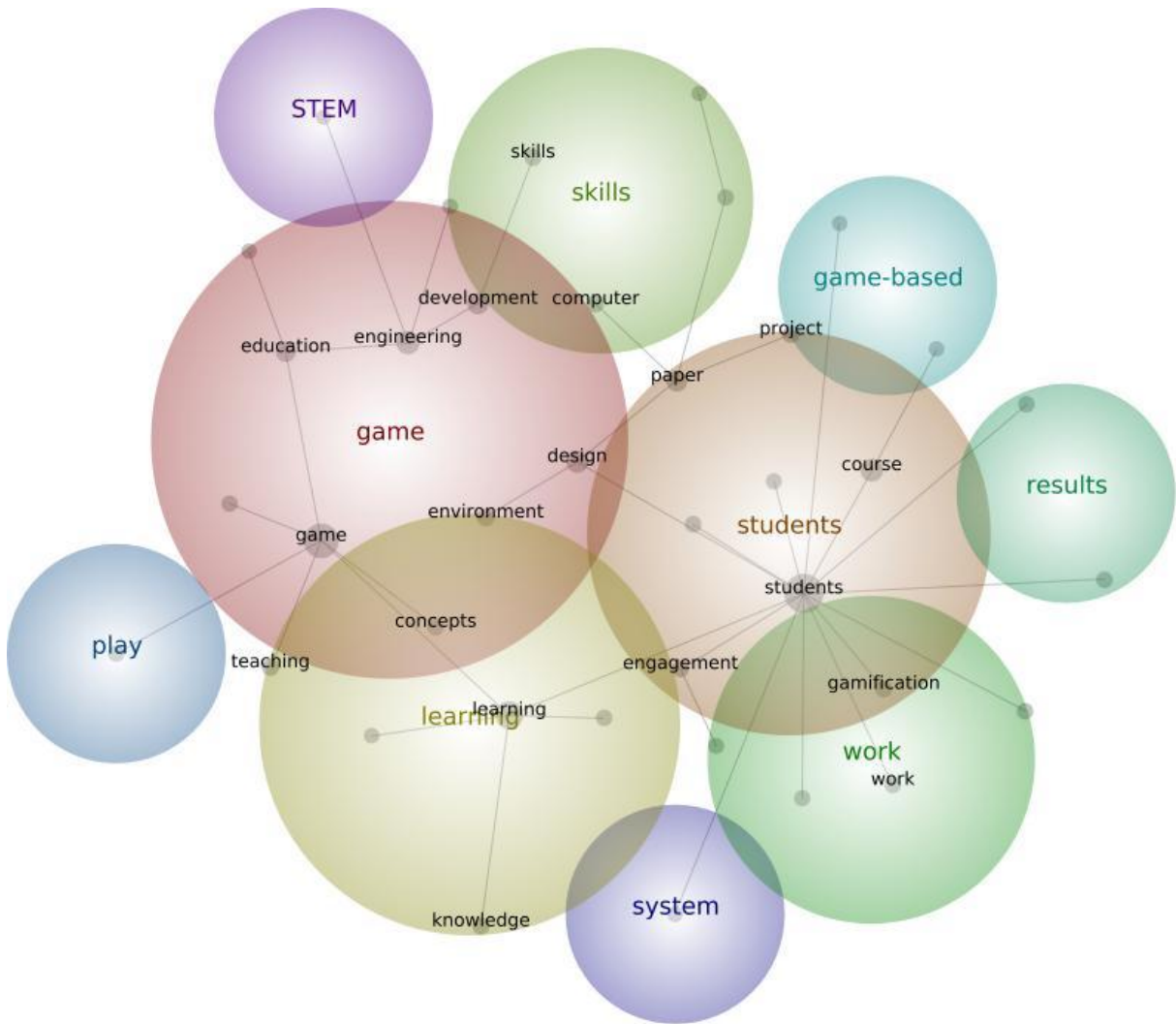


Figure 6: 15 year concept map.

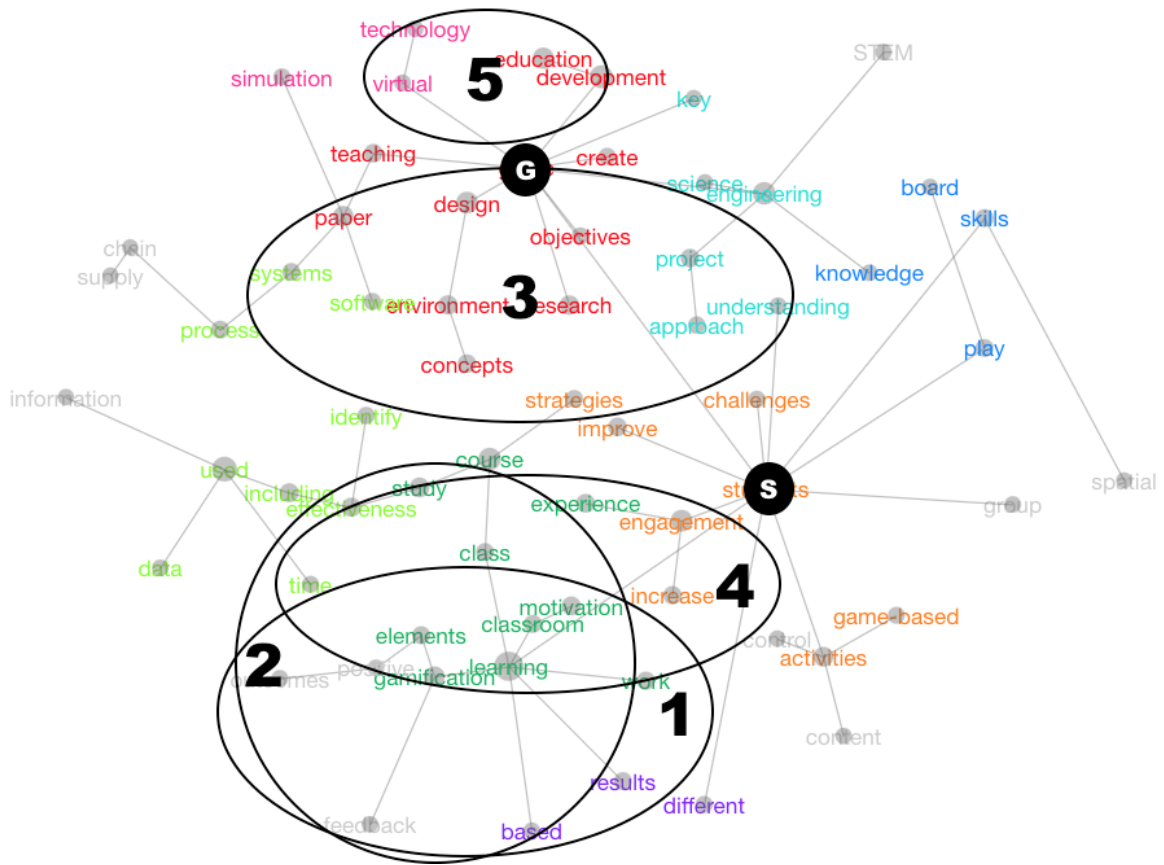


Figure 9: 2016-2020 concept map.