A Conceptual Network Analysis of Gamification Practices in Primary and Secondary Education

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***Abstract*— Gamification is not a new concept, but it has gained a significant momentum in the past years for several reasons, including but not limited to the ubiquity of technology, the growing ease in the use of the game design applications and the growing number of technologically savvy individuals. Such individuals are routinely using smartphones and other computing devices for various tasks, including playing games and using e-learning platforms. Gamification is mostly defined as the use of game design elements and game mechanics in a non-game context, with the main objective of engaging and motivating users. The existing research points to the possibility of improving the performance of students in the learning process, and this paper presents a state of the art, conceptual network analysis of gamification practices in learning processes with the aim to better understand game-based learning in primary and secondary education. The results from this paper would be used for the development of a novel learning platform based on artificial intelligence techniques.**

Keywords*— gamification, concaptual network analysis, primary education, secondary education

I. Introduction

Gamification is defined by Deterding et al. [1] as the use of game design elements in non-game contexts, and is generally considered as a fairly rapidly growing field.

Whilst gamification can be used in almost any social context, in education some of the main research questions according to [2] are: *1) What educational contexts does gamification apply to, and 2) What game elements are used in gamification of educational systems?* For game elements in gamification, authors propose the principles of gamification design (goals, challenges and quests, customizations, progress monitoring, feedback, competition and engagement, social aspects and engagement, visible status, content unlocking, freedom of choice, freedom of failure, storytelling, etc.) and game mechanics (points, badges, levels, flowcharts, leaderboards, virtual currencies, avatars). The authors emphasize that there are limitations in research efforts which deal with the effectiveness of the use of game elements in an educational environment, and that the development of software tools to support gamification in an educational context would positively contribute to such research efforts in the field. Figures 1 and 2 respectively represent an overview of the number of papers that deal with individual elements of game mechanics (showing which elements are the most popular), and principles of gamification design. "Engagement" as a concept appeared with relatively strong connections within our conceptual network analysis.

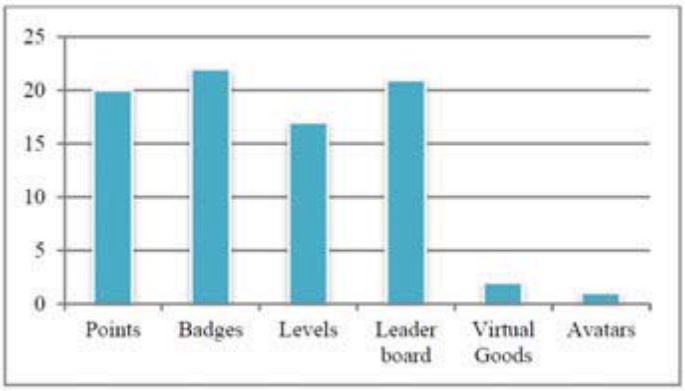

Fig. 1: Elements of game mechanics [2]; points, badges, levels and scoreboards stand out as the most frequent elements in research papers

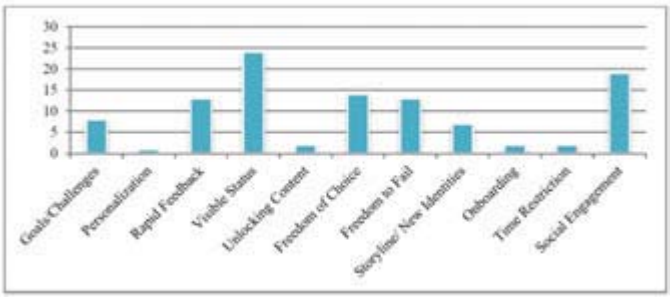

Fig. 2: Principles of gamification design and distribution according to the occurrence rate in scientific papers [2]

Gamification has largely been applied to approaches to student learning in higher education, as can be observed from

Target audience	Number	Frequency (%)
Higher Education	12	46.15%
Non-specific context/level	6	23.08%
Training and Tutorials	3	11.54%
Languages	2	7.69%
Elementary Education	2	7.69%
Lifelong Education	1	3.85%

TABLE 1: Target audience distribution [3]

the TABLE 1, showing the distribution of the gamification target users [3].

Also, the authors identified 7 goals of gamification that represent "motivation" as a major factor in gamification research efforts:

- Mastering skills, thus enhancing certain student competences;
- Challenges that add value to the learning process;
- Student involvement in the learning process through a simpler and more interesting learning process;
- Improving learning while maximizing knowledge acquisition;
- Behavioral changes by rewarding desirable and punishing undesirable behaviors;
- Socialization through various mechanisms of socialization and group learning;
- Guidelines - discussing the benefits of gamification as a means of motivation and coping with learning difficulties.

Within the paper [4] the authors give an overview of the fields in which the principles of gamification have been adopted: science, mathematics, foreign languages, cultural heritage, health, computer sciences, software engineering, business and logistics. The authors find that gamification encourages collaboration between students, independent learning, homework completion, facilitates assessment, integrates exploratory approaches, and enhances student creativity. Improving motivation and involvement are emphasized by the authors as the main motivation for adopting gamification techniques - to make learning more attractive, "engaging" and effective. Our research shows that there are indeed strong connections involving a concept "motivation" within the resulting network analysis graph.

The goal of [5] is to discover how to implement game elements within the course Computer Games, and to observe students' perceptions of implementation. It has been noted that elements such as goals, scoreboards, and big boss fights have been accepted favorably by students, which is consistent with the results of other papers such as [6]. The element that received the most student approval was the fight against the "big boss" enemy, which actually represented the final exam in front of a panel of experts in the field of computer games. Students also positively evaluated the use of the element of happiness, that is, randomness. Students were not satisfied with the way in which collaborative teams were formed (randomly created student groups), and with some other aspects of implementation.

In a report describing gamification experiences in higher education, the authors of [7] report correlating gamification with college pass rates, and participation in voluntary activities and challenging tasks. The authors also associate gamification with a greater level of interaction within the course and an increased level of focus on a course design. The paper summarizes the result of a three-year study of gamification by a Dutch technical university over technically challenging courses such as computer organization and cloud computing, and over a total of over 450 students.

The authors of [8] describe one significant drawback of the body of work in the field of gamification in educational processes, namely the relatively small number of empirical studies and the large number of theoretical papers lacking experimental moments to describe the experiences of the students. Our own analysis confirms this claim, as there are relatively weak connections on the concept "empirical research" in the resulting conceptual network graph. Nevertheless, researchers conclude that gamification has a positive impact on the education of engineering topics by making topics more manageable, increasing intrinsic motivation, scientific knowledge, collaboration, interest, and reducing or better managing the amount of work [8].

In the context of empirical research, the authors of [9] describe an experiment in which game elements such as grades, levels, scoreboards, challenges, and badges were used to enhance teaching in a graduate course. Using a variety of metrics, the authors compared the results of a gamified course with the same course that was performed without using gamification. The results showed significant increases in attendance at lessons and online participation, proactive behaviors, and study of course reference materials. According to the authors, the students found that the gamified instance of the course was more motivating, interesting and easier to learn than other courses.

Villagrasa and other authors [10] provided an overview and conceptualization of gamification for the 3D Art course in higher education. They discuss the importance of introducing story flow and game mechanics into the course, such as tracking development, credits, and virtual currency, and state that the use of gamification increases student involvement and motivation, as well as the overall effectiveness of the learning process, compared to conventional non-gamification teaching methods. However, as in most conceptual papers, in conclusion, the authors do not base their conclusions on a specific case study or experiment conducted.

Hamari and others [11] raise the question "does gamification work" in their review of 24 empirical studies of gamification. The most common elements of gamification through the aforementioned research are points, scoreboards and badges. According to most of the cases investigated, gamification has contributed to the positive effects and benefits of the learning

process, but with certain limitations, which should be further explored.

A model for introducing gamification into the field of e-learning within higher education is presented in [12], where authors state that the successful integration of gamification leads to greater levels of student satisfaction, motivation and involvement. The authors state that e-learning should include elements of gamification, and the main stages of development include analysis, planning, development, implementation and evaluation, with particular emphasis (through all stages) on customer experience. The authors also emphasize the importance of personalization within the e-learning system.

In 2012, the Rochester Institute of Technology's School of Interactive Games and Media developed an actual game system called "Just Press Play" to help students actively engage with the learning environment and to foster positive social behaviors that can lead to academic success. In this way, connections between students from different ages and with the faculty are encouraged, attending workshops, suggesting ideas for course development, etc. The leading goal of the game was thus to increase students' involvement in the life of the University for the sake of academic and social success [13].

"Who is Herring Hale?" is an alternative reality game developed in 2006 at Brighton University to assist new students in orienting and adjusting to student life, and to improve student inclusion [14]. The game included points and prizes, a series of 10 tasks (one per week), with a background story about time travel and the support of an online community on the campus social network. The assignments were based on physical and online services available to students. The game included hidden clues, codes, and encrypted content contained within the usual information about a particular service. The results of applying this method showed that the format of the game was not liked by all students, but also proved to be very effective for those students who accepted the game.

SCOOT [15] is an interactive mixed-reality game created for Australian universities and museums between 2004 and 2009, using a variety of platforms (mobile, web, public displays) as tools to guide players to their target locations and tasks. The game uses the real and virtual worlds as the backdrop of gameplay, and focuses on the Role Play Game (RPG) genre, which is chosen to be largely compatible with the intentions of the game's design, with elements such as roles, missions, exploration, narrative.

Star Question is a system developed to help students test the knowledge learned on a course, and includes grading, commenting, and badge systems [16]. Students involved with Star Question reportedly found it helpful to experience increased levels of understanding, repeat lessons, and reduced stress when repeating lessons and preparing for tests.

Multiplayer Classroom is developed for course "Theory and Practice of Game Design" at Indiana University [17], and included a game-based rating system and experience points, a final grade level course evaluation in game, guilds (groups within the classroom) created by students based on shared interests and ideas, and collaboration and localization within guilds to achieve a common group goal.

Classcraft is also inspired by RPG games, and the first version of the system was developed by Canadian teacher Shawn Young in 2011. The system's official release was launched in 2014 and is now available as a web and mobile application. It is a system that allows management and collaboration among students through playing RPG games, and is used actively from the lower grades of primary school to higher education institutions in a large number of countries. The system includes player role selection (such as wizard, warrior or healer), avatars, health points, action points, random events, and other elements of RPG games. Students progress through levels by solving quests and thus gaining "powers" they can use during class - such as skipping a question on a test or consulting with a classmate on how to solve a task. The analytical part of the platform allows teachers to observe and analyze student behaviors. "Classcraft" as a concept appeared within our conceptual network analysis with several connections, marking its appearance within primary and secondary schools.

SimSchool (www.simschool.org) is a virtual classroom platform available as a web-based "populated" application with so-called "simStudents" who have artificial emotional intelligence (they can laugh, cry, be frustrated, raise their hand, seek attention, etc.). The system is based on theories of cognition, emotion, social behavior, for the purpose of providing an "authentic experience" for teachers who aim to understand students and deliver effective teaching.

Labster (https://www.labster.com/) provides a virtual lab environment for courses such as biology and chemistry, contains graphics and scenarios which can be perceived as a game.

CodeCombat is a web application that allows you to learn programming languages (Python, JavaScript, CoffeeScript, Lua) in a playful RPG environment. The player can select a character in the game and must write code to perform tasks and accomplish goals in the game. CodeCombat contains game elements such as progress tracking, damage level, health level, speed and weapons of players, clan formation, content unlocking, missions, rewards, points, virtual currencies, etc.

Plantville is a simulation game developed by Siemens that enables new and potential employees to understand the management of industrial plants and technologies.

The Radix Endeavor (https://www.radixendeavor.org/) is a MMOPG (massively multiplayer online game) developed in 2013 at the Massachusetts Institute of Technology for middle and high school students learning statistics, proba- bility, genetics, algebra, geometry. etc. The system contains narratives, graphic elements of the game, character selection and customization, collaboration, tasks and goals, monitoring progress, overcoming problems, etc.

In the next sections we will introduce our methodology, containing the conceptual network analysis of gamification practices in order to better understand game-based learning in primary and secondary education.

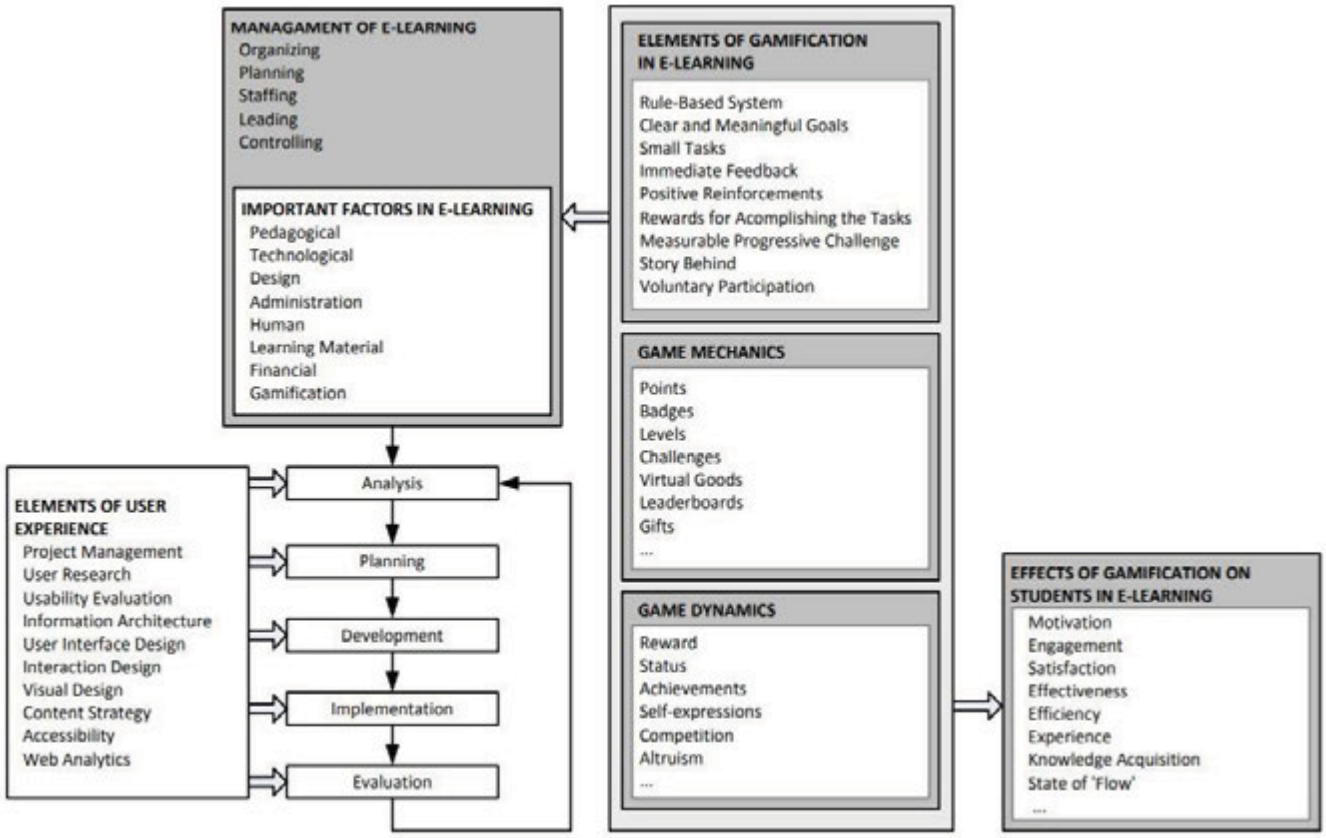

Fig. 3: A model for introducing gamification into an e-learning system [12]

II. Methodology

Herien, in order to identify most important topics in the domain of gamification in primary and secondary education we have adopted a methodology similar to the one used in previous papers [18], [19], [20]. In order to construct a conceptual network based on publications we use a bipartite graph constructed through co-occurence of two keywords on a particular paper. In other words, we consider to concepts (keywords) which represent the nodes of the graph to be connected by an edge if they occur on the same paper.

Firstly, to find the relevant publications we have systematically searched through more than 400 papers which turned out on the identified keyword combinations consisting of mostly "gamification", "education", "primary", "elementary", "middle", "secondary" in common bibliographic databases. Because a number of papers had not made clear about the school context on which the gamification was applied within the paper title, nor within the abstract, manual research and context understanding of such papers was unavoidable in order to properly include papers within this work. The final set of papers which were relevant to our study had 41 entries of which 5 didn't have specified keywords. Thus the keywords of 36 papers were analyzed and visualized using Gephi. The visualised network is shown on figure 4.

In the visualization nodes (concepts) are represented as red rectangles with the actual keyword written inside and edges are displayed as curved lines. The thickness of the edges's line indicates the weight of the edge - i.e. if there is a connection between two concepts on more papers, the line will be thicker. The Fruchterman Reingold algorithm has been used to construct the graphs layout.

III. Discussion

As one can see from figure 4 there is one main well connected cluster (formed around the expected concept "gamification") as well as two smaller clusters on the left hand side of the visualization. Additionally, there are six weaker connected clusters at the edges of the graph.

The concept "gamification" in the main cluster is the most central node and shows strongest connections to the concepts: "primary school", "children", "student", "secondary education"; "game based learning" and interestingly "mobile learning".

Connected concepts relating to specific subjects and learning fields include "physics", "elementary mathematics", "natural sciences", "algebra", pointing to possible domains of gamification implementations. Also, there is an indication of using gamification for students with disabilities: concepts

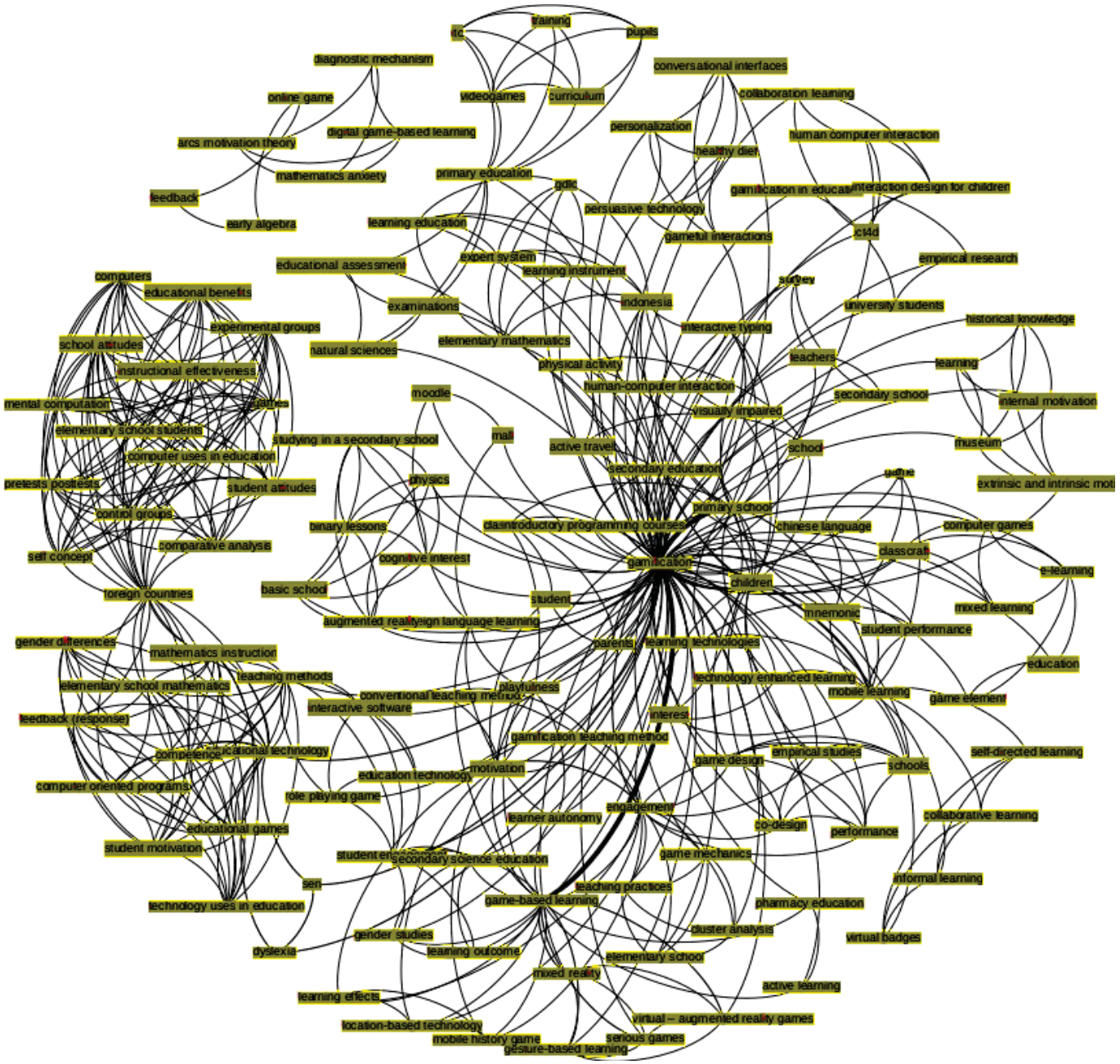

Fig. 4: Conceptual Network visualized using Gephi

such as "dyslexia" and "visually impaired" showed up within the network with significant connections.

The two smaller clusters have formed due to papers that used procedurally generated keywords, and as can be seen from the visualization are only weakly connected to the rest of the graph. This in a way indicates that procedurally generated keywords are quite different from author picked ones.

IV. Conclusion

In this paper we have provided a conceptual network analysis of most relevant gamification publications in primary and secondary education. After a literature review and systematic publication search we have extracted the keywords used and constructed a conceptual network visualization. The constructed network is well connected with one main cluster which formed around the most central node "gamification", two smaller clusters which formed due to automated keyword generation techniques as well as 6 smaller clusters with weaker connection to the main body of the graph.

The topology of the graph indicates a cohesive field of research since only one smaller cluster is disconnected from the rest of the graph meaning that all other clusters of papers usually have some keywords used in common.

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