Serious Games for Learning: A Quantitative Review of Literature

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Abstract. There exists a considerable amount of digital games that are described and published in the scientific literature. Among them, there are those considered as "serious games", whose foremost goal differs from pure entertainment, being conceived mainly for training, capacity building, and education among other ends. Serious digital games for learning represent an important part of this whole set, and it is relevant to observe the actual state-of-the-art about the research in this field. In this sense, this paper presents a quantitative literature review on previous papers published in peer-reviewed conference proceedings or journals related to digital games for learning.

Keywords: Serious games · Game-Based learning · Digital games · Learning · Educational games

1 Introduction

The incorporation of Information and Communication Technologies (ICTs) in the processes of teaching and learning is increasing quickly. Nowadays, the meaning of "education through ICT", is not simply to give people computers; rather, it implies that teachers are ready for the adoption of this paradigm, improving students' skills, using the appropriate software tools, combining adequately artistic elements like sound, animation and design in educational contexts, and using playful elements to facilitate students' learning [1].

Serious games (SG) have been originally defined by Abt [2] as having *an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining.* This classical definition may be seen to contrast with another foundational definition of

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games themselves, given by Huizinga [3], as *a free activity standing quite consciously outside "ordinary" life as being "not serious", but at the same time absorbing the player intensely and utterly*, although Huizinga remained vague on the notion of 'not serious' (see [4] on this matter).

Among the wide array of SGs, the focus point of this paper are those SGs intended to promote learning (of something) and have the intrinsic intention of improving the learning and/or teaching processes, unlike "pure" entertainment games. In a broad sense, educational games, or SGs for learning, represent a subset of SGs, even though educational – or at least training – aspects are always involved in the conception of a SG if viewed under the lens of its traditional definition. However, many definitions of SGs blur the differences among SGs and SGs for learning, such as the one from Michael and Chen [5]: *a serious game is a game in which educating (in its various forms) is the main objective, instead of entertainment.* This range of definitions of SGs and related genres such as game-based learning further complicate the discussion surrounding these terms (see also [6]). Sometimes, for example, citizen science games, where players collaboratively produce data on scientific tasks are considered serious games as well (e.g., [7, 8]). In an effort to overcome this 'genrefication', others have thus attempted to offer more holistic definitions and proposed terms such as 'applied games' [6]. However, despite this long-lasting discussions and efforts, the term SG continues to be widely used within academia and industry.

Serious Games cannot be simply defined as digital games made with educational and entertainment value added as decorators: the educational aspects must be present in the whole conception of the game. Serious games have being gaining importance in the educational field [9], offering positive learning experiences [10]. They were found to be effective, in many cases, for learning, skills development, and information retention and some results show that they facilitate knowledge acquisition [11]. More than this, they bring an important factor to the learning process, that is, motivation [12, 13]. However, as mentioned by Vandercruysse et al. [14], the positive results are dependent on many variables that range from the students' background to game design aspects and the subject being learned.

In this sense, this work presents an additional contribution to previous works [10, 11, 14], among others, indicating the continuous growth of SG research. This contributes to the current state-of-the-art of investigations related to serious games that support learning.

1.1 On the Various Definitions Around Serious Games

Despite having broad definitions, as above mentioned, SGs are games that are designed in a way such that the player is meant to learn something, to train some ability, or to acquire some skill [15]. Undoubtedly, since they often present a considerable potential in the teaching-learning process [16, 17], they frequently are confused with the subset of educational games.

The effective use of SGs allows to address challenges in the learning process, especially if: they are adaptive; they propose clear goals and sub-goals; they allow or even induce collaboration between players/students, even though this collaboration is achieved through competition; and people are satisfied when they play them – a real immersion is desirable.

SGs are also related to Game-Based Learning (GBL). According to some authors (e.g., [18, 19]), GBL refers to any learning process that is motivated, induced, or conducted by one (digital or physical) game – or a suite of them. Many authors, like Deguirmendjian et al. [1] and Miljanovic and Bradbury [20], for instance, have recently conducted studies that are related to SGs and GBLs.

The overall aspect in GBL is to use games as triggers to involve (and hopefully improve) students in their own learning processes, as well as to serve as aiding tools for teaching processes, too. In GBL, through the use of games, the main role of the teacher becomes to motivate and empower students' knowledge to develop a deep and meaningful learning [21]. However, to properly achieve this purpose with digital games, teachers must have a solid knowledge of how to integrate ICTs into curricula and syllabi, and how to integrate GBL activities into the classroom [22].

The player experience of a serious game will be guided by a problem, while entertainment games will generally be full of action and have lots of possibilities. Also, according to [23] it is advised *to develop the story in a serious game based on the user's action, while in an entertainment game random effects are often applied*.

2 Literature Review

This paper deals with a quantitative assessment of literature related to papers about SGs designed to improves students' learning. The articles were selected in May 2019 and are indexed in the international conference and journal databases Scopus[1], DBLP[2], ACM Digital Library[3], IEEExplore[4], Google Scholar[5], and Science Direct[6].

2.1 Search String

At first, papers were searched using only the word `"game"`. However, as this search is extremely broad and the results, as expected, included all kinds of entertainment games as well as other unrelated papers (like those related to enterprise games, physical games, sports in general and game theory, or the field of artificial intelligence). As such, the search term was replaced by the term `"serious game"`. Some search engines did not consider the word "games" in the plural, so the search had to be refined using wildcards `"serio*"` and the logical connector `AND "game*"` so that both words are considered within the search. The wildcard `"*"` in `"game*"` means that the engine can search words like: `"games", "gamer", "gamers"` and other words that start with `"game"`.

During this process, it has been observed that there is a considerable amount of papers that are related to SGs, but their metadata considered the word "Educate" instead.

[1] https://www.scopus.com (Accessed: August, 2020).
[2] https://dblp.uni-trier.de/ (Accessed: August, 2020).
[3] https://dl.acm.org/ (Accessed: August, 2020).
[4] https://ieeexplore.ieee.org/Xplore/home.jsp (Accessed: August, 2020).
[5] https://scholar.google.com/ (Accessed: August, 2020).
[6] https://www.sciencedirect.com/ (Accessed: August, 2020).

However, "Educate" (root word) has several derivative words, as well, for example: education, educational, educative, educated, educates, educating. Therefore, it was decided to use a wildcard for this word as well, that is `"educa*"`.

Finally, to further refine the search string for SGs focused on education and also incorporate papers related explicitly to educational games, it was needed to use some logical connectors:

```
(((educa*) OR (serious*)) AND (game*))
```

where the `"*"` represents any character or set of characters.

2.2 Filtering Criteria

Metadata searching criterion. The search string is compared to the following metadata: the "title", "abstract" or "keywords" in each of the scientific repositories and indexes. Two additional criteria were as well: date and language.

Chronological criterion. When reviewing the literature, it has been verified that there are published papers related to SG going back to the 1990s. However, in our case, only the last 8 years have been considered to focus on recent activity in the field. That is, the first filter criterion was to consider only papers published between 2011 to 2018.

Language criterion. The second filter criterion was to consider only articles that were written in English, since the databases that are part of this study generally consider articles written in that language.

2.3 Flowchart for Research Papers Collection

Given the selection, filter, and optimization criteria discussed above, the process of collecting scientific articles can be summarized in the flowchart depicted in Fig. 1. Each database considered for this study was analysed individually and sequentially; that is, one was processed after the other. For each database, the search string described in Sect. 2.1 was applied, containing the derivable terms "`educa*`" or "`serious*`" joint with the derivable term "`game*`". These terms were searched for within the metadata (i.e., *title*, *keywords,* or *abstract*) of the published article. Then the articles are filtered based on the criteria outlined in Sect. 2.2 (only English articles published between 2011 to 2018).

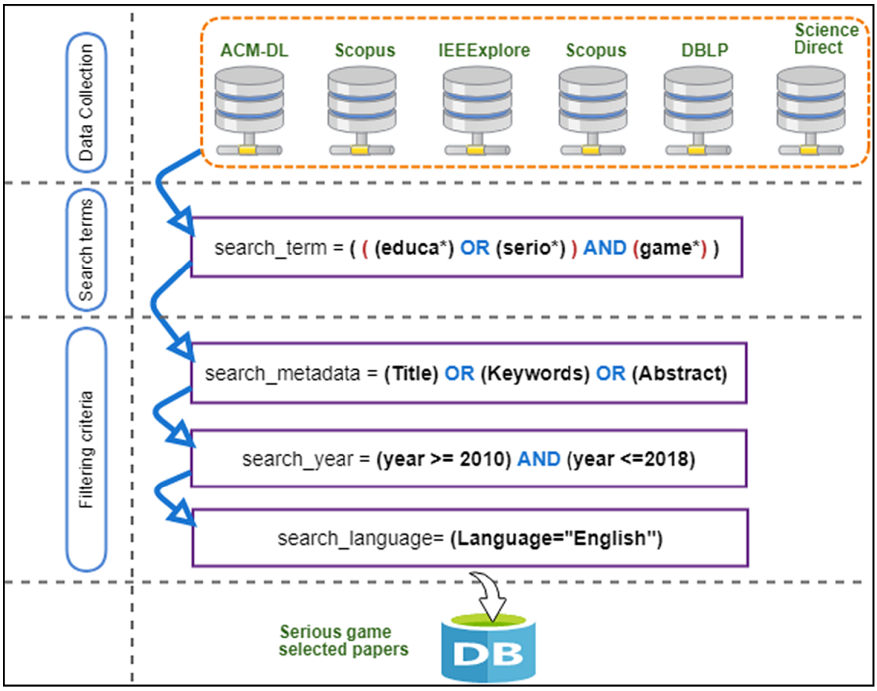

Fig. 1. Flowchart for research papers collection

3 Results and Discussion

Having defined the process of collecting the scientific articles from the aforementioned databases, results were obtained from each of the databases.

In the following we will contrast the results when only considering the field "*title*" – because, most of the search engines index the title of the research articles – with results obtained by searching within all three fields, that is, "*title*", "*abstract*" and "*keyword*", in this way there are more possibilities to find research articles.

3.1 Results

Table 1 shows the results obtained when searching within the "*title*" only. The column *"source"* indicates the database from which the information has been extracted; the "*total*" column gives the total number of scientific articles that the query has returned; the "*query*" column shows the query that has been used to obtain the results; and finally the "*target field*" column indicates the field on which the query was applied. In this first case, for all databases, the search was performed within the "*title*" field.

In each of the databases, the language used to make the queries differs from each other with respect to the use of logical connectors. For example, in the ACM Digital Library (DL) the query is `"acmdlTitle:(+game* serious* educa*)"`, which means that looking in the field "*Title*", `"` + `game*"` requires the presence of the "`game*`" term

Table 1. Searching by title only

Source	*Total*	*Search String*	*Target Field*
ACM-DL	4,994	`acmdlTitle:(+game* serio* educa*)`	Title
IEEExplore	1,189	`((("Document Title":educa*) OR "Document Title":serio*) AND "Document Title":game*)`	Title
Scopus	4,599	`TITLE (((education OR serious OR educational OR educative) AND (game OR games)))`	Title
DBLP	2,996	`(educa* || serio*) && (game*)`	Title
ScienceDirect	453	`Title: (education OR serious OR educational OR educative) AND (game OR games)`	Title
Google Scholar	4,100	`allintitle:(game OR games) and (education OR serious OR educational OR educative)`	Title
Total	**18,331**		

(and its derivatives) and must additionally find the term *serious** (and its derivatives) or the term *educa** (and its derivatives). In contrast, ScienceDirect does not accept the use of wildcards, so all the derived words must be put together by the logical OR connector.

Table 2. Searching by 3 or more fields

Source	*Total*	*Search String*	*Target Field*
ACM-DL	11,042	`(+game* serio* educa*)`	Any field
IEEExplore	6,807	`((("Document Title":educa*) OR "Document Title":serio*) AND "Document Title":game*)`	Title, abstract, keywords
Scopus	21,340	`TITLE-ABS-KEY (((education OR serious OR educational OR educative) AND (game OR games)))`	Title, abstract, keywords
DBLP	2,996	`(educa* || serio*) && (game*)`	Title
ScienceDirect	1,287	`Title, abstract, keywords: (education OR serious OR educational OR educative) AND (game OR games)`	Title, abstract, keywords
Google Scholar	19,000	`serious game education educational educative`	Any field
Total	**62,472**		

Table 2 shows the results obtained from the second search. In this case, the "*target field*" includes in some cases the search for "*title*", "*abstract*" and "*keyword*". In the case of the ACM-DL and Google Scholar, the search does so in all fields, including within the same document or the name of the conference or journal.

Table 3 shows the evolution of SG publications in conferences or journals from 2011 to 2018. The last column labelled with "%" shows the growth from 2011 to 2018 in percentages. For example, the "ACM-DL" database (digital library contains 1,235 publications published in 2011, and 1,648 publications published in 2018, resulting in a growth of 33.44%.

Table 3. Evolution of SG publications from 2011 to 2018

	2011	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*Total*	*%*
ACM-DL	1,235	1,271	1,233	1,338	1,347	1,459	1,511	1,648	11,042	33.44%
IEEExplore	872	806	895	946	764	756	823	945	6,807	8.37%
Scopus	1,913	2,028	2,242	2,525	2,827	3,116	3,297	3,392	21,340	77.31%
DBLP	291	263	365	414	442	405	440	376	2,996	29.21%
Science Direct	90	116	95	150	192	170	216	258	1,287	186.67%
Google Scholar	1,690	2,130	2,200	2,440	2,560	2,690	2,620	2,670	19,000	57.99%
								Total	**62,472**	

In summary, the number of publications on serious games for learning purposes has increased in recent years. Google Scholar and Scopus have more papers indexed in their databases than the other ones.

3.2 Discussion

Comparisons were made between searching just in *title* field versus searching in several fields: *title*, *abstract* and *keywords*. As expected, results are five times more numerous in almost all databases, except for DBLP, as seen in Fig. 2.

The ACM-DL is a library that specializes in computer science and is focused on gathering research in that area. It indexes articles of conferences, specialized magazines, technical reports, books, et cetera. For this reason, it has a considerable amount of documents related to Serious Games. Around 5,000 papers were found when searching within the title of publications and more than 11,000 when including other target fields.

IEEExplore is a database that indexes the title, the abstract, author, citations, references, DOI, published in (conference or journal name), and the content of research papers related to science, computing, electronics, electrical, and related branches, therefore, the coincidences of the term sought can be better in some cases. Numbers are lower if compared to the ACM-DL: 1,000 papers found by title only and almost 7,000 when expanding the search to other fields.

Scopus is a database with a greater volume of information because it covers all areas of knowledge. Besides storing journals, it has information on monographies, conference

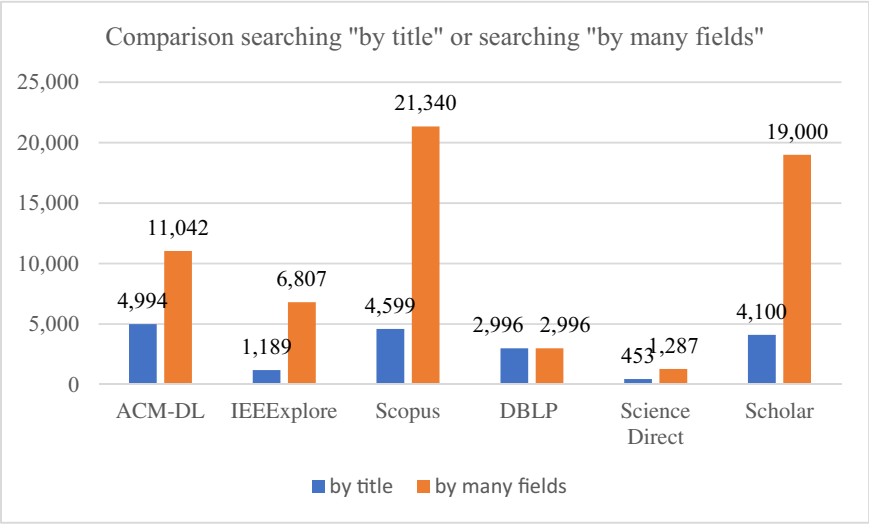

Fig. 2. Comparison of two types of searching

proceedings, book chapters and others, and its coverage reaches back to 1970. That is one of the reasons that we found more articles indexed and related to serious games: just a few papers less than the ACM-DL when searching for title, but an impressive number of papers retrieved when the expanded search was performed – more than 20,000 papers related to the topic in some manner.

DBLP only looks for matches of the search string in the title and the search includes the author metadata automatically. For example, it also includes results if the term `game*` is part of the author name. DBLP does not have a way to exclude terms that match the name, as such the exclusion has to be done manually, which sometimes could not be an addressable issue. On the other hand, the main feature of DBLP is that it is a database specialized in Computer Science. DBLP also only indexes the titles of the articles, so there is no option to add search fields for the abstract and keywords. Therefore, the search for `"title"` and `"multiple fields"` returned around 3,000 papers for both cases, as shown in Fig. 2.

ScienceDirect was the database with the lowest number of articles related to the search terms, when compared with the other databases (both in the search by title and in the search by several fields): around 500 papers in the first case, and 1,500 in the second. This is mainly because it only indexes scientific articles from conferences, magazines, and book chapters; in addition, an article listed in ScienceDirect always implies that it comes from a peer-reviewed source, which is a more demanding requirement than posed by other databases.

In the case of Google Scholar, it has the characteristic that it is not necessary to use wildcards to include the derived words, since the search engine does it automatically. For example, if `"game"` is placed as a term, it automatically considers the derivative words

such as game, games, gaming, gamer. Google Scholar is a search engine that searches several databases; therefore, it is like a metasearch engine for scientific articles and, consequently, it is expected that the amount of retrieved papers is large in comparison – in the reported search, around 4,000 papers were retrieved by "title" and more than 19,000 were retrieved in the extended search.

Each database analysed was growing in number of publications from 2011 to 2018. Figure 3, shows that publications covering SGs are growing continuously.

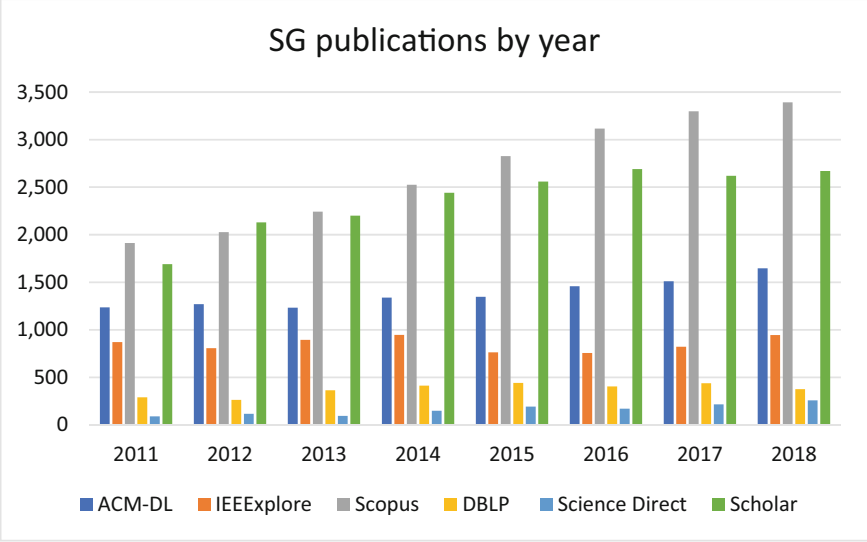

Fig. 3. Evolution of SGs publications in the last 8 years

4 Conclusion and Future Work

This work presented a quantitative overview of literature related to the publication of scientific articles on serious games for learning in the last 8 years (2011-2018) in the most relevant scientific databases in computer science related fields: ACM-DL, IEEExplore, Scopus, DBLP, ScienceDirect, and Google Scholar. A flowchart for searching and extraction process of the articles was presented and a search string including terms related to serious games and game-based learning was defined.

Searches were performed in two ways: first, the search was only performed in the "title" section of the article, returning a total of 18,331 papers. The second search considered a broader search, accepting the search string appearing in the "title", "abstract", or "keywords" of each article, resulting in 62,472 papers. The large amount of publications is growing every year, showing the increased interest of researchers in SGs.

Future work aims to perform a systematic literature review, following a strict protocol to exclude those articles that are not really related to SGs for learning, but were wrongly included for some reason, such as a mismatch with any other academic field.

On the other hand, as a further work, it is proposed to automate this search by creating a search engine that could extract the data automatically, then processing the filters, then excluding articles that seem to have been wrongly selected, and finally showing the results through appropriate tables or charts. In such an approach, it would be enough to insert the search string and the system would automatically determine the derived words. Clearly some text mining and artificial intelligence techniques will need to be applied to achieve this.

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References

1. Deguirmendjian, S.C., de Miranda, F.M., Zem-Mascarenhas, S.H.: Serious game developed in health: Integrative literature review. J. Health Inform. **8**, 110–116 (2016)
2. Abt, C.C.: Serious games (1970). https://books.google.com.pe/books?id=axUs9HA-hF8C&printsec=frontcover&hl=es#v=onepage&q&f=false
3. Huizinga, J.: Homo Ludens: Essay on the Social Function of the Game. Serisia. Gallimard, Paris (1951)
4. Rodriguez, H.: The playful and the serious: An approximation to Huizinga's Homo Ludens. Game Stud. **6**, 1604–7982 (2006)
5. Michael, D.R., Chen, S.L.: Serious Games: Games that Educate, Train, and Inform. Muska & Lipman/Premier-Trade (2005)
6. Schmidt, R., Emmerich, K., Schmidt, B.: Applied games–in search of a new definition. In: International Conference on Entertainment Computing, pp. pp. 100–111 (2015)
7. Baaden, M., Delalande, O., Ferey, N., Pasquali, S., Waldispühl, J., Taly, A.: Ten simple rules to create a serious game, illustrated with examples from structural biology (2018)
8. Dippel, A., Fizek, S.: Laborious Playgrounds: Citizen science games as new modes of work/play in the digital age. In: The playful citizen: civic engagement in a mediatized culture. Amsterdam University Press (2018)
9. Carvalho, M.B., et al.: An activity theory-based model for serious games analysis and conceptual design. Comput. Educ. **87**, 166–181 (2015)
10. De Freitas, S.: Are games effective learning tools? a review of educational games. J. Educ. Technol. Society. **21**, 74–84 (2018)
11. Backlund, P., Hendrix, M.: Educational games-are they worth the effort? a literature survey of the effectiveness of serious games. In: 2013 5th international conference on games and virtual worlds for serious applications (VS-GAMES), pp. 1–8 (2013)
12. Wouters, P., Van Nimwegen, C., Van Oostendorp, H., Van Der Spek, E.D.: A meta-analysis of the cognitive and motivational effects of serious games. J. Educ. Psychol. **105**, 249 (2013)
13. Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T., Boyle, J.M.: A systematic literature review of empirical evidence on computer games and serious games. Comput. Educ. **59**, 661–686 (2012)
14. Vandercruysse, S., Vandewaetere, M., Clarebout, G.: Game-based learning: A review on the effectiveness of educational games. In: Handbook of research on serious games as educational, business and research tools, pp. 628–647. IGI Global (2012)
15. Marsh, T.: Slow serious games, interactions and play: Designing for positive and serious experience and reflection. Entertainment Comput. **14**, 45–53 (2016)

16. Guillén-Nieto, V., Aleson-Carbonell, M.: Serious games and learning effectiveness: the case of It'sa Deal! Comput. Educ. **58**, 435–448 (2012)
17. Baalsrud Hauge, J., Judd, N., Stefan, I.A., Stefan, A.: Perspectives on accessibility in digital games. In: Clua, E., Roque, L., Lugmayr, A., Tuomi, P. (eds.) ICEC 2018. LNCS, vol. 11112, pp. 402–406. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-99426-0_51
18. Ruiz-Molina, M.-E., Gil-Saura, I., Berenguer-Contri, G.: Information and communication technology as a differentiation tool in restaurants. J. Foodservice Bus. Res. **17**, 410–428 (2014)
19. Qian, M., Clark, K.R.: Game-based Learning and 21st century skills: a review of recent research. Comput. Hum. Behav. **63**, 50–58 (2016)
20. Miljanovic, M.A., Bradbury, J.S.: A review of serious games for programming. In: Göbel, S., Garcia-Agundez, A., Tregel, T., Ma, M., Baalsrud Hauge, J., Oliveira, M., Marsh, T., Caserman, P. (eds.) JCSG 2018. LNCS, vol. 11243, pp. 204–216. Springer, Cham (2018). https://doi.org/10.1007/978-3-030-02762-9_21
21. Cerinšek, G., et al.: Recommendations to leverage game-based learning to attract young talent to manufacturing education. In: Alcañiz, M., Göbel, S., Ma, M., Fradinho Oliveira, M., Baalsrud Hauge, J., Marsh, T. (eds.) JCSG 2017. LNCS, vol. 10622, pp. 187–202. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-70111-0_18
22. Shah, M., Foster, A.: Developing and assessing teachers' knowledge of game-based learning. J. Technol. Teach. Educ. **23**, 241–267 (2015)
23. De Bock, R.: Serious Games: games for Learning. (2018)