Digital Game-based Learning in Primary School: What Issues Does/Does Not Recent Research Focus on?

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Keywords: Digital Game-based Learning, Elementary School, Systematic Literature Review, Learning Outcomes, Social Skills, Metacognitive Outcomes, Research Tools, Learning Theories, Constructivism, Social Constructivism.

Abstract: Recent research on Digital Game-Based Learning (DGBL) applied specifically in Primary Education is reviewed in a systematic way. 87 journal papers published in the last 4 years (2017 - 2020) are selected and analyzed in order to draw conclusions regarding the effectiveness of DGBL (i) in producing cognitive domain learning outcomes, (ii) in developing social skills, (iii) in producing affective / metacognitive outcomes, and (iv) in offering an enjoyable experience to Primary Education students. Apart from the classic questions of literature reviews, aimed at describing the methodology, aims and outcomes of the reviewed works, the current review is also interested (a) in the ways of integrating the digital game in the educational practice, in relation to the adoption of a specific learning theory and educational method and (b) in the measurement tools employed to evaluate the effectiveness of DGBL interventions, in relation to the aims set and the results obtained. The goal of this review is to reveal those aspects of DGBL that recent research focuses on and at the same time those aspects that are not adequately researched and require more attention and effort. The latter result is especially useful in the planning of future studies. The results record a steadily increasing research interest in DGBL and a strongly positive effect of DGBL in all the examined axes. On the other hand, they reveal an almost general lack of a solid foundation of DGBL interventions in learning theories and consequent educational methods – an alerting situation that deserves careful examination.

1 INTRODUCTION

Despite the fact that recognition of the educational potential of games goes back to antiquity, digital games, as exemplified by modern video games, have had many barriers to cross before they were recognized as valid and effective education 'tools'. Extensive and multi-faceted research has overthrown prejudice and inhibitions of teachers, parents and scientists against the introduction of digital games in formal education, especially for younger ages, on the grounds of addiction, social isolation, poor school performance and physiological problems (Griffiths, 2002; deFreitas, 2006; Ferguson, 2007). As a result, and thanks to their double potential as entertaining and educative activities, today digital games are widely exploited in education, under the Digital Game-Based Learning (DGBL) paradigm. In the form of *serious games*, DGBL is also used in professional environments (healthcare, military, companies, etc.) for the development of various skills (Gentry et al., 2019).

As the field of DGBL expands dynamically in multiple and innovative ways, including new technologies, platforms and devices, new issues are raised and new questions are posed for relevant research to answer. It is probably indicative of an alive and active field the fact that 'old', classic issues and questions are still open: classification of (educational) game types, categories of DGBL objectives, domains of expected outcomes and impacts of DGBL are issues research is still struggling with: '*Literature on games is fragmented and lacking coherence*' (Ke, 2009); '*An important limitation in this field is the incongruity of study designs*' (Kharrazi et al. 2012); '*The categorising*

and naming of skills and learning outcomes in a useful way presents a tricky problem' (Connolly et al., 2012). Furthermore, the need for '*Guidelines or a standardized procedure for conducting DGBL effectiveness research*' is recognized in (All et al., 2013) while evaluation results are often mixed or contradictory: '*... other studies showed the contrary, namely that DGBL environments did not produce positive learning outcomes*' (Hussein et al., 2019).

In the last two decades, the lack of empirical evidence on DGBL effectiveness has prompted a number of systematic literature reviews on the subject, which covered secondary education (Connolly et al., 2012; Boyle et al., 2016) and primary education (Hainey et al., 2016). Together, they have provided a comprehensive methodological framework for multi-component analysis of DGBL research.

Inspired by these works, the current study reviews recent (2017-2020) literature on DGBL effectiveness, focusing on research works that provide empirical evidence, i.e., report results from educational interventions using DGBL. Given the great differences in the needs, capabilities, preferences and objectives of students across education grades, this study is limited to Primary Education (PE), for methodological as well as for practical purposes.

The multi-component analysis framework established in (Connolly et al., 2012), adapted to the aims and scale of the present review, is employed to investigate the objectives and results reported in the body of 87 systematically selected journal publications. The DGBL objectives or axes used here for the coding and analysis of these publications are

(i)   cognitive domain learning outcomes (knowledge transfer),
(ii) social skills development (communication, collaboration),
(iii) affective outcomes (motivation, metacognition), and
(iv) experience of the learner (fun and enjoyment during the learning process).

The first 3 objectives correspond essentially to the set of 5 objectives identified in (Connolly et al., 2012) as grouped by (Bleumers et al., 2012).

Although methodologically the current review proceeds along the beaten track, it is innovative in certain other aspects. In recognition of the fact that DGBL results are not independent of the tools they were measured by, the current review addresses evaluation results and evaluation tools jointly, as a pair.

The learning theories under which DGBL interventions are designed and implemented are another critical factor often overlooked or not explicitly taken into account in existing reviews. For example, although the 'construction of knowledge' that is frequently mentioned as a major DGBL objective directly refers to the learning theory of constructivism, this or other learning theories are not included in the coding of reviewed works.

Directly connected to this gap is the absence from the coding schemes of existing reviews of the educational method/scenario under which DGBL interventions are carried out. Learning theories and consequent educational methods are important aspects of any educational intervention and decisive factors for the correspondence between aims and results. Conversely, the fun and entertainment element intrinsic in DGBL may lead off track an intervention that is not well-founded in the learning theory of choice.

The ultimate goal of the current review is to identify the open issues or research questions that recent relevant research does focus on, while at the same time to detect those issues or questions that are not adequately researched and would require more attention, effort and elaboration. In that sense, the results of this review may be useful both to education practitioners, who will be aided to make judicious choices regarding DGBL design and implemention in class, and to researchers in the field, who may benefit from having their attention directed to these less researched issues or questions.

2 REVIEW METHODOLOGY

2.1 Research Questions

The aim of this study is to investigate which learning outcomes (cognitive, skills-based or affective) are addressed by recent educational research on DGBL and which are not adequately covered and are therefore open to further research. To this end, two sets of detailed Research Questions (RQs) are formulated, whose answers are sought via the analysis of a selected body of publications.

The RQs in the 1st set are *descriptive* of the research body reviewed and of the features of the DGBL interventions implemented therein: (1) How popular is DGBL in recent research, as expressed by publications per year? (2) Is game used in DGBL as a means for instruction/learning or for student

evaluation? (3) Is the role of students as game makers, players, or both investigated? (4) Does game play take place in class, at home, or both? (5) Which major game types are employed in DGBL interventions? (6) Which learning subjects host DGBL interventions? (7) Under which learning theories are DGBL interventions implemented? (8) Which instruction/learning methods employ DGBL?

The RQs in the 2nd set address the learning outcomes obtained via DGBL, their type and extent along with the tools used to measure each of them: (9) What type of DGBL learning outcomes is recent research interested in? (10) What kind of cognitive domain learning outcomes does DGBL produce? What are the tools for their evaluation? (11) Does DGBL develop social skills? What are the tools for their evaluation? (12) Does DGBL develop metacognitive skills? What are the tools for their evaluation? (13) Do students engage in DGBL and enjoy it? What are the tools for the evaluation of engagement and fun?

2.2 Retrieval and Selection Procedure

The systematic literature review methodology employed in this study is a modified version of the one proposed for medical research in (Pai et al., 2004) combined with the methodology proposed for software engineering in (Kitchenham, 2004) along the major steps of *planning*, *conducting* and *reporting* the review.

Scopus (https://www.scopus.com/) and ERIC (Education Resources Information Center, https://eric.ed.gov/) are the two databases selected for publication retrieval, because they offer free online access and enhanced functionalities in organizing the search process and outcomes. They jointly cover education-related research adequately while they maintain a good balance between selectivity and coverage.

The query used on these databases is set up on the basis of

(i) the terms 'game', 'digital game', 'online game', 'game-based learning', 'elementary school', 'primary school', 'primary education', and

(ii) the inclusion criteria defined as {research type: primary research (not a review or a meta-analysis); publication year: 2017-2020; publication type: journal paper; language: English}.

The publications thus retrieved are 221 (Scopus: 109; ERIC: 112) including 35 duplicates (articles retrieved from both Scopus and ERIC).

The 1st screening was performed on the basis of title, abstract and keywords, independently by the two authors of the present paper, with inter-rater reliability measured by k = 86.3%. Disagreements were resolved by discussion and unanimous decision. Exclusion criteria (duplicate, not a primary study, not a journal publication, not referring to DGBL, not referring to Primary Education, uses DGBL and/or Primary Education in a different context, no educational intervention, no evaluation of outcomes) resulted in 113 articles being excluded and 108 articles being forwarded to the 2nd screening.

The 2nd screening was performed on the basis of full article texts, independently by the two authors of the present paper (k = 90.7%) and with the same exclusion criteria. 21 more articles were excluded, leaving thus a final set of 87 articles for further analysis. These are available online for the interested reader at http://ectlab.eee.uniwa.gr/Digital_Game_based_learning_review.pdf because of limited space herein. The selection process steps are outlined in the diagram in Figure 1.
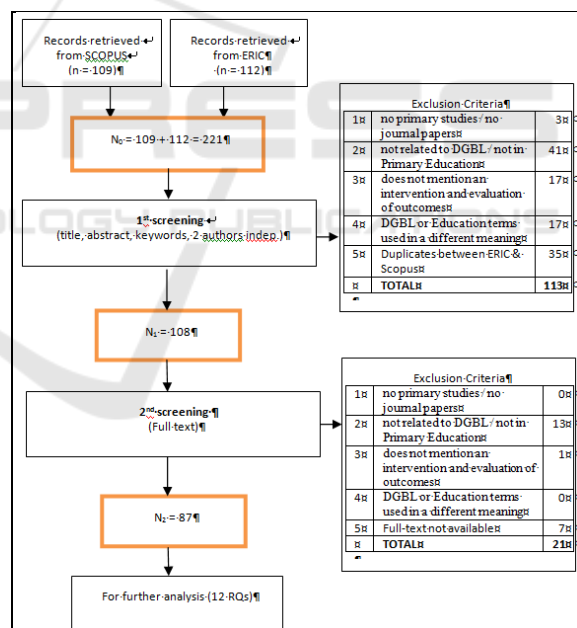

Figure 1: The selection process in steps.

Analysis of the body of the 87 articles finally selected across the two sets of RQs defined earlier was performed jointly by the two authors. Results are presented and discussed per RQ in the following section.

3 RESULTS AND DISCUSSION

3.1 Results on the 1st Set of RQs

3.1.1 DGBL Context-Descriptive Results

DGBL publication counts exhibit a linearly increasing trend along the year span of this study, as illustrated in Figure 2. This result indicates a clearly increasing research interest in the field, to the degree that the publications selected for this study are representative of the total body of relevant research. It should be noted here that only publications of research works that include empirical evidence are retained for analysis. The same type of increasing behaviour, however, is verified from all the 221 originally retrieved publications.
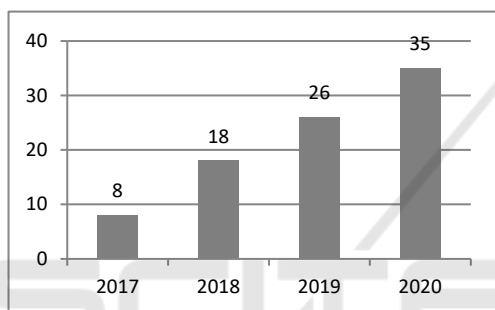

Figure 2: Number of publications per year in 2017-2020.

The journals that host these publications are, in descending order of publication counts: Australian Journal of Emergency Management (8), Australian Journal of Teacher Education (6), Child Abuse and Neglect (6), Computers in Human Behavior (5), Developmental Science (4), Elementary School Forum (4), Frontiers in Psychology (4), Information (3), Educational Technology & Society (3), Frontiers in Education (2), Education and Information Technologies (2), Computers and Education (2), Education Sciences (2), Educational Technology and Society (2), Educational Technology Research and Development (2). 31 more journals follow, with a single publication each. It is interesting that they cover disciplines as diverse as Education, Computer Science, Social Sciences – Psychology or Medicine – Healthcare.

Regarding the major use or role of the game in DGBL, the vast majority of research works (79 or 90.80%) use the game as an instruction/learning tool, as opposed to only 8 works (9.20%) that use it as an evaluation tool for the learning outcomes of the process. Results are shown in Table 1.

Table 1: The role of the game in DGBL.

The role of the game in DGBL	Nr. of works (percentage)
Instruction/learning tool	79 (90.80%)
Student evaluation tool	8 (9.20%)
Total	87 (100.00%)

Regarding the role of students/learners in the DGBL interventions reviewed, again a clear majority (74 research works or 85.06%) asked students to play the game; 10 research works (11.49%) asked them to make the game; 3 research works (3.45%) did both. Results are given in Table 2.

Table 2: The role of students in DGBL.

The role of students in DGBL	Nr. of works (percentage)
Game player	74 (85.06%)
Game maker	10 (11.49%)
Game maker & player	3 (3.45%)
Total	87 (100.00%)

This result reveals a strong dependency of teachers and students on ready-made, off-the-shelf game products in 85% of the cases; only in 15% of the cases students are asked to assume the active role of game makers.

Another implication is that this dependency on ready-made games possibly restricts the choices and twists the orientation of teachers when they decide on the type of intervention to implement and on the learning subject to host it. Constructionism, on the other hand, assures that students are far more motivated and engaged as makers rather than as players (Kafai & Burke, 2015).

DGBL interventions required the students to play games primarily in class (51 works or 58.62%) or at school (7 works or 8.05%). In only one (1) case (1.15%) game play takes place at home, while in 3 cases (3.45%) game play takes place both in class and at home. One more case refers to a 'third place' while a considerable percentage of research works (24 cases or 27.59%) fail to provide this information. Results are given in Table 3.

This result is in agreement to the comment in (Ronimus, & Lyytinen, 2015) that DGBL at home is under-researched as yet, despite the savings in school time it might offer. Other factors should of course be taken into account, if home play were to be investigated, such as the presence and impact of parents/adults, of siblings/co-players, etc.

Table 3: The environment where DGBL takes place.

Where does DGBL take place	Nr. of works (percentage)
In class	51 (58.62%)
At school	7 (8.05%)
At home	1 (1.15%)
Both in class and at home	3 (3.45%)
Third place	1 (1.15%)
Not specified	24 (27.59%)
Total	87 (100.00%)

The types of games selected for DGBL interventions are tabulated in Table 4, in descending order of frequency of use. Serious games head the list (31 cases or 26.72%), followed by simulation games (13 cases or 11.21%), computer programming games (11 cases or 9.48%), MMORG, puzzles and 'sandboxes' (8 cases or 6.90% each), augmented reality games, imagination games and quizzes (4 cases or 3.45% each), adventure games, education escape rooms and mini games (3 cases or 2.59% each), assessment games, digital board / card games, (2 cases or 1.72% each), casual games and training games (1 case or 0.86% each). 13 (11.21%) do not specify the type of game employed.

Table 4: The types of games used in DGBL.

Types of games	Nr. of works (percentage)
Serious/Subject-specific game	31 (26.72%)
Simulation	13 (11.21%)
Programming/Construction	11 (9.48%)
MMORG/Role playing	8 (6.90%)
Puzzle	8 (6.90%)
Sandbox	5 (4.31%)
Augmented Reality	4 (3.45%)
Quiz game	4 (3.45%)
Adventure game	3 (2.59%)
Education escape room	3 (2.59%)
Mini game	3 (2.59%)
Assessment game	2 (1.72%)
Board / Card game	2 (1.72%)
Casual game	1 (0.86%)
Training game	1 (0.86%)
Not specified	13 (11.21%)

The leading position of serious games reveals the concern of class teachers as well as researchers to select an educational game rather than a commercial, purely entertaining game for use in their interventions. On the other hand, this very choice prevents experimentation with commercial, entertaining games that, if appropriately handled, might nevertheless produce valid learning outcomes. The 2nd position of simulation games does not come as a surprise, given the technological advances that render them realistic and yet safe alternatives for students to explore out-of-reach environments or unavailable setups.

Simulation games, MMORGs and puzzles account for a cumulative 25.01%. This is in agreement to results reported in (Hainey et al., 2016), where these game types are found to be popular for use in education. Moreover, as reported in (Jabbar & Felicia, 2015), 68% of the games selected for DGBL interventions for knowledge and skills development are role playing games and puzzles. Their suitability for the Primary School target group and for the learning subjects taught to this group is an additional reason for the preference that researchers show for these types of games.

The learning subjects that host DGBL interventions are tabulated in Table 5, in descending order of frequency. Mathematics head this list with 29 cases (30.53%), followed by Language (13 or 13.68%), English as a 2nd language (8 cases or 8.42%), Sciences (7 cases or 7.37%), ICT (5 cases or 5.26%), Geography and History (3 cases or 3.16% each) and Art, Environmental protection, Healthcare (2 cases or 2.11% each). A number of other subjects follow that cumulatively account for 5.25% of the cases, such as the Analects of Confucious, Innovation, Socio-emotional education, Child abuse prevention, etc. 16 cases (16.84%) do not provide information on the learning subject that hosted the DGBL intervention (Table 5).

The leading position of Mathematics among the learning subjects that host DGBL interventions may be attributed to the traditional notoriety of Mathematics with students, which prompts teachers to seek more playful or enjoyable ways for teaching it. Conversely, serious games and simulations are capable of developing authentic experiences that support knowledge; they may also be easily combined with Mathematics. Mathematics are better understood when embedded in realistic, everyday situations (Freudenthal, 1991), such as those easily reproduced by games. The extensive use of digital games in Mathematics has already prompted research on this specific combination; it has thus been shown that DGBL and traditional instruction methods are equally effective in teaching Mathematics.

Table 5: Learning subjects that host DGBL interventions.

Learning Subject	Nr. of works (%)
Mathematics	29 (30.53%)
Language	13 (13.68%)
English as a 2nd language	8 (8.42%)
Science/Bioengineering	7 (7.37%)
ICT/Security/Anti-phishing	5 (5.26%)
Geography	3 (3.16%)
History	3 (3.16%)
Art	2 (2.11%)
Environmental studies	2 (2.11%)
Healthcare class	2 (2.11%)
Analects of Confucious class	1 (1.05%)
Innovation class	1 (1.05%)
Extra-curricular subject	1 (1.05%)
Socio-emotional education	1 (1.05%)
Child abuse prevention class	1 (1.05%)
Not specified	16 (16.84%)

The privileged relation of digital games and Mathematics certainly calls for further research. In the meantime, it should be repeated that this is exactly a verification of the comment made earlier on the dependency of the teachers on commercial, off-the-shelf games: if the majority of available games is on Mathematics, this is certainly a biasing factor for the teachers' choice of game and subject.

3.1.2 Learning Theories

The learning theory(ies) adopted by the teacher that designs and implements a DGBL intervention is a crucial factor often overlooked in existing research. The mere use of games in class is not automatically game-based learning, unless placed and implemented under an appropriate learning theory framework.

Results shown in Table 6 indicate that this is indeed the case with the majority of research works: 47 out of the 87 research works (54.02%) adopt cognitive constructivism, 13 research works (14.94%) adopt social constructivism and 9 research works (10.34%) adopt constructionism. Only 7 research works (8.04%) use games under a behavioristic framework. The later is known to practically cancel many of the DGBL pedagogical and educational advantages.

These results verify the findings reported in (Qian & Clark, 2016) on the dominance of constructivistic and constructionistic frameworks under which DGBL takes place, in alignment to

(i) the Socio-cultural theory of learning (Vygotsky, 1978) professing that '*learning occurs when it is social, active and situated*' as well as

(ii) newer results concluding that '*learning is most effective when it is active, experiential, situated, problem-based and provides immediate feedback*' as summarized in (Connolly et al., 2012).

Table 6: Learning theories that support DGBL.

Learning Theories	Nr. of works (percentage)
Cognitive Constructivism	47 (54.02%)
Social Constructivism	13 (14.94%)
Constructionism	9 (10.34%)
Behaviorism	7 (8.04%)
Cannot be concluded	15 (17.24%)

It is worth noticing that the majority of the reviewed works do not explicitly state their overarching learning theory; the above results are conclusions drawn from our analysis of the interventions as described in the relevant publications. Even worse, a non-negligible number of cases (15 cases or 17.24%) do not disclose enough information to allow conclusions as to the learning theory adopted – an alerting outcome that raises questions as to the validity of the results reported therein.

3.1.3 Educational Methods

An issue closely related to that of the adopted learning theory(ies) is the educational method(s) in which the DGBL intervention is embedded. Results tabulated in Table 7 reveal that Problem-based Learning is employed roughly by 1 in every 2 cases (42 works or 48.27%), followed by Collaborative Learning (14 cases or 17.07%), Discovery Learning (6 cases or 6.89%), Active and Experiential Learning/Learning by doing (5 cases or 5.75% each), Role playing (4 cases or 4.59%) and Drill & Practice (3 cases or 3.44%). Learning by Questions, Situated Learning, Project-based Learning and Personalized Learning follow with decreasing frequencies of use (Table 7).

These results are in agreement with the results on learning theories discussed in the previous paragraph, given that Problem-based, Collaborative,

Discovery, Active and Experiential Learning all fall under constructivism and its variations, found to collectively account for 90% of the cases, while Learning by Questions and Drill & Practice fall under behaviorism that accounts for 8% of the cases (see previous paragraph).

On the other hand, Project-based Learning and Personalized Learning are essentially constructivistic approaches; their low representation is probably due to the infrastructure and effort necessary for their preparation and implementation.

Table 7: Educational methods that support DGBL.

Educational methods	Nr. of works (%)
Problem-based Learning	42 (48.27%)
Collaborative Learning	14 (17.07%)
Discovery Learning	6 (6.89%)
Active Learning	5 (5.75%)
Experiential Learning / Learning by doing	5 (5.75%)
Role Playing	4 (4.59%)
Drill & Practice	3 (3.44%)
Learning by Questions	2 (2.29%)
Situated Learning	1 (1.14%)
Project-based Learning	1 (1.14%)
Personalized Learning	1 (1.14%)
Cannot be concluded	22 (25.28%)

In the majority of the cases, these results are concluded by the authors of the current paper via analysis of the description of the intervention rather than explicitly stated by the researchers in their publication. Still a considerable number of 22 cases (25.28%) do not give any evidence as to the employed method, meaning either that they do not consider it important or that an ad hoc approach was taken.

This is yet another alerting outcome, given the importance ascribed by Prensky (2007) to the careful choice by the teacher of the educational method and the scenario to be employed, in order for DGBL to bear fruit. Not all methods are equally effective for all target groups, ages or learning subjects. In fact, it is the educational method and the learning outcomes sought that should dictate the choice of the game in DGBL and not vice versa.

3.2 Results on the 2nd Set of RQs

The objectives of the utilitarian use of games are considered here to fall under three aggregate categories, namely, (i) cognitive learning outcomes (knowledge transfer), (ii) skills development (social skills, managerial skills, etc.), and (iii) attitudinal and behavioral change (affective outcomes, e.g. motivation, metacognition, etc.). Each objective is better served by specific game types and requires specific tools to measure their effectiveness (All et al., 2013).

A fourth class of interest under either the utilitarian or the purely entertaining use of games refers to the experience of the learner while involved in DGBL, as expressed by enjoyment, fun and engagement.

The classification of the 87 reviewed works into the above 3+1 classes is shown in Table 8 and illustrated in Figure 3. It reveals that cognitive domain learning outcomes constitute the most frequent research objective, investigated by approximately 3 in every 4 works (65 cases or 74.71%), followed by student experience (52 cases or 59.77%), affective outcomes (34 cases or 39.08%) and the development of social skills (21 cases or 24.14%).

Table 8: Objectives of the reviewed works.

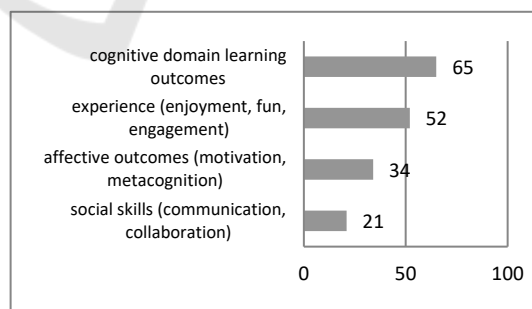| Objective	Nr. of works (percentage)
Cognitive learning outcomes (knowledge transfer)	65 (74.71%)
Experience (enjoyment, fun, engagement)	52 (59.77%)
Affective outcomes (motivation, metacognition)	34 (39.08%)
Social skills (communication, collaboration)	21 (24.14%)
Total	87 (100.00%)

Figure 3: Major objectives sought via DGBL.

3.2.1 Cognitive Domain Learning Outcomes

The results on the cognitive domain learning outcomes reported in the 65 relevant reviewed publications are summarized in Table 9. The outcomes are reported to be strongly positive (35 cases or 53.85%), positive (11 cases or 16.92%),

neutral (4 cases or 6.15%) and negative (3 cases or 4.62%). No strongly negative outcomes are reported. Mixed positive and negative results are reported in 9 cases (13.85%).

Table 9: Summarized results reported on Cognitive Domain Learning Outcomes.

Results on Cognitive Domain Learning Outcomes	Nr. of works (%)
Strongly Positive	35 (53.85%)
Positive	11 (16.92%)
Neutral	4 (6.15%)
Negative	3 (4.62%)
Strongly Negative	0 (0.00%)
Mixed (Positive and Negative)	9 (13.85%)
Fail to report	3 (4.62%)
Total	65 (100.00%)

Practically, 3 in every 4 research works report positive or strongly positive cognitive domain learning outcomes. This very encouraging perspective on DGBL is, once again, concluded by our analysis rather than clearly stated by the respective authors of the publications. The majority of the reviewed publications ignore the positive cognitive results they get and focus their interest and argumentation on affective (metacognitive / motivational) aspects.

3.2.2 Social Skills Development

The results reported by the 21 relevant reviewed publications on the development of social skills (communication and collaboration) via DGBL are summarized in Table 10. They fall mostly under the strongly positive (15 cases or 71.43%) and the positive (3 cases or 14.29%) class. A single case reports mixed results while 2 cases fail to report results despite their stated intension to do so.

Table 10: Summarized results reported on Social Skills Development via DGBL.

Results on Social Skills Development	Nr. of works (%)
Strongly Positive	15 (71.43%)
Positive	3 (14.29%)
Neutral	0 (0.00%)
Negative	0 (0.00%)
Strongly Negative	0 (0.00%)
Mixed (Positive and Negative)	1 (4.76%)
Fail to report	2 (9.52%)
Total	21 (100.00%)

The dominance of (strongly) positive results is explained by the social and collaborative nature of many – but not all – games. The chat facility is reported by students to be instrumental; many students state that they prefer online to face-to-face communication and collaboration. Competition with fellow players, with oneself or with time, is another intrinsic feature of games. Competition was found by (Chen et al., 2020) to be socially effective only in connection to specific game types (simulation games, role playing games and puzzles) and specific learning subjects (Mathematics, Language and Sciences). All these game types and learning subjects are ranking high in Table 4 and Table 5 and are therefore among the most intensively researched.

In contrast to this evidence and despite the fact that social constructivism is used a lot in connection to DGBL (see, e.g., Table 6), it seems that the development of social skills is the least researched among DGBL objectives. Careful evaluation of the effectiveness of DGBL in social skills development is a domain that clearly deserves more attention and research effort.

3.2.3 Affective / Metacognitive Outcomes

Results on the affective and metacognitive outcomes obtained via DGBL, as reported in the 45 relevant reviewed publications, are summarized in Table 11. As to the metacognitive outcomes, motivation and creativity aspects are of interest here. Results are reported to be strongly positive (36 cases or 80.00%). 2 cases (4.44%) report neutral results while 7 cases (15.65%) report mixed results.

Table 11: Summarized results reported on Affective / Metacognitive outcomes obtained via DGBL.

Results on Affective / Metacognitive Outcomes	Nr. of works (%)
Strongly Positive	36 (80.00%)
Positive	0 (0.00%)
Neutral	0 (0.00%)
Negative	2 (4.44%)
Strongly Negative	0 (0.00%)
Mixed (Positive and Negative)	7 (15.56%)
Fail to report	0 (0.00%)
Total	45 (100.00%)

These results are in alignment with existing research that finds a significant positive impact of DGBL both on the cognitive and the affective domain of the learner, e.g. on motivation (Yusoff et al., 2020) or creativity (Cook & Bush, 2018). The non-negligible cases of mixed results may be

ascribed to the different ways games are accepted by different target groups, e.g., lower motivation levels have been measured in female learner groups in connection to computer games (Butler, 2000; Hussein et al., 2019). The restrictive classroom environment has also been found to decrease motivation (Tuzun, 2006; Kebritchi et al., 2010).

3.2.4 Student Experience with DGBL

As to the experience of the students while involved in DGBL, results reported by the 52 relevant publications are summarized in Table 12. Enjoyment, fun and engagement are the aspects of interest here. Strongly positive results are reported by 39 cases (75.00%). One case reports neutral results while 12 cases (23.08%) report mixed results. Finally, 5 cases (11.11%) fail to report results although they state that they measure them.

Table 12: Summarized results reported on the experience of the students while involved in DGBL.

Results on the experience of the students while involved in DGBL	Nr. of works (%)
Strongly Positive	39 (75.00%)
Positive	0 (0.00%)
Neutral	1 (4.76%)
Negative	0 (0.00%)
Strongly Negative	0 (0.00%)
Mixed (Positive and Negative)	12 (23.08%)
Fail to report	5 (11.11%)
Total	52 (100.00%)

Strongly positive results are an expected outcome: enjoyment, fun and engagement are intrinsic to the entertaining character of games, digital games being no exception. These are the very reasons why games are employed in education in the first place.

Mixed results, on the other hand, may be due to the fact that different target groups enjoy different game types. Enjoyment depends on age, gender, even digital literacy and skill: more skillful players are reported to have more fun and get more engaged than inexperienced players, especially in MMORG or simulation games (Bluemink et al., 2010; Keebler et al., 2010).

3.2.5 DGBL Effectiveness & Evaluation Tools

The evaluation of DGBL effectiveness along the four major axes or objectives and the evaluation results obtained, as summarized in the previous paragraphs, depend critically on the evaluation tools employed to this end. It is generally accepted that not all tools are equally suitable for all objectives. Pre- and post-tests, for example, have been pointed out as the most appropriate tool for the evaluation of cognitive domain learning outcomes as early as the 1960's – especially within an experimental design with an experimental (DGBL) and a control (no DGBL) group (Campbell et al., 1963). Questionnaires are considered to serve better evaluation of affective outcomes such as motivation and metacognition while qualitative tools such as observation or interviews are employed across all objectives, if practically feasible.

The 87 reviewed research works have been analysed as to the evaluation tools employed for each of their objectives. Given the variety of existing tools and evaluation plans, the following 10 tools or classes of similar tools have been listed during the analysis step:

1. Pre- and post-intervention knowledge test/Questionnaire,
2. Only pre-intervention knowledge test/Questionnaire,
3. Only post-intervention knowledge test/Questionnaire,
4. Intermediate knowledge test/Questionnaire,
5. Delayed (follow-up) evaluation activity/test,
6. Class observation, field notes, teacher diary,
7. Audiovisual recording,
8. Structured interviews/focus group discussions with students,
9. Structured interview or discussion with the class teacher, and
10. Stealth assessment (scores in this game/in other games).

The evaluation tools employed for the evaluation of the cognitive domain learning outcomes obtained via DGBL are given in Table 13.

Among the evaluation tools reported in Table 13, the pre- and post-tests are clearly dominant as they are used in practically all 65 cases, except for the 3 cases which fail to report on their tools. These tools represent the 'sampling' approach to evaluation. Class observation, observation sheets and teacher diaries along with video recording (1 case) are employed by practically 1 in every 4 cases(24.62%). These tools represent the 'longitudinal' approach to evaluation that is much more demanding; hence, the lower frequency of use. Stealth evaluation (direct use of the game scores to grade the student) is also very popular (13.85%) as it is an automatic byproduct of game play. Follow-up tests are also

Table 13: Summarized results on the tools employed for the evaluation of Cognitive Domain Learning Outcomes obtained via DGBL.

The tools employed for the evaluation of Cognitive Domain Learning Outcomes obtained via DGBL	Nr. of works (%)
Pre- and post-intervention knowledge test / Questionnaire	52 (80.00%)
Only pre-intervention knowledge test / Questionnaire	5 (7,69%)
Only post-intervention knowledge test / Questionnaire	5 (7,69%)
Intermediate knowledge test / Questionnaire	2 (3.08%)
Delayed (follow-up) evaluation activity/test	5 (7.69%)
Class observation, field notes, teacher diary	16 (24.62%)
Audiovisual recording	1 (1.54%)
Structured interviews / focus group discussions with students	11 (16.92%)
Structured interview or discussion with the class teacher	2 (3.08%)
Stealth assessment (scores in this game/in other games)	9 (13.85%)
Fail to report	3 (4.62%)
Total Relevant Cases	65 (100.00%)

used to some extent (7.69%). It is interesting that, on top of these tools, interviews and discussions with students are also held in numerous cases (16.92%).

The picture is almost reversed when examining the tools employed for the evaluation of DGBL effectiveness in social skills development (Table 14). The longitudinal approach with class observation, observation sheets, teacher diaries and audiovisual recordings is dominant (57.14% plus 14.29%) followed by interviews with the students that also very popular (42.86%). Pre- / post- / intermediate or follow-up tests are scarcely used, as they are not matched to social skills evaluation.

The tools employed for the evaluation of the affective / metacognitive outcomes obtained via DGBL are given in Table 15.

Post-intervention questionnaires dominate the affective outcomes evaluation results with 51.11%. Knowledge tests are not used here at all. Pre- and post-intervention questionnaires are also popular (26.67%). Interviews with students (35.56%) and teachers (40.00%) are in regular use. This is clearly a back-loaded process, where information obtained before the intervention has limited value.

Table 14: Summarized results on the tools employed for the evaluation of the Social Skills developed via DGBL.

The tools employed for the evaluation of Social Skills developed via DGBL	Nr. of works (%)
Pre- and post-intervention knowledge test / Questionnaire	2 (9.52%)
Only pre-intervention knowledge test / Questionnaire	1 (4.76%)
Only post-intervention knowledge test / Questionnaire	3 (14.29%)
Intermediate knowledge test / Questionnaire	0 (0.00%)
Delayed (follow-up) evaluation activity/test	1 (4.76%)
Class observation, field notes, teacher diary	12 (57.14%)
Audiovisual recording	3 (14.29%)
Structured interviews / focus group discussions with students	9 (42.86%)
Structured interview or discussion with the class teacher	1 (4.76%)
Stealth assessment (scores in this game/in other games)	0 (0.00%)
Fail to report	2 (9.52%)
Total Relevant Cases	21 (100.00%)

Table 15: Summarized results on the tools employed for the evaluation of the Affective/Metacognitive outcomes obtained via DGBL.

The tools employed for the evaluation of the Affective/Metacognitive outcomes obtained via DGBL	Nr. of works (%)
Pre- and post-intervention knowledge test / Questionnaire	12 (26.67%)
Only pre-intervention knowledge test / Questionnaire	1 (2.22%)
Only post-intervention knowledge test / Questionnaire	23 (51.11%)
Intermediate knowledge test / Questionnaire	0 (0.00%)
Delayed (follow-up) evaluation activity/test	1 (2.22%)
Class observation, field notes, teacher diary	16 (35.56%)
Audiovisual recording	4 (8.89%)
Structured interviews / focus group discussions with students	18 (40.00%)
Structured interview or discussion with the class teacher	5 (11.11%)
Stealth assessment (scores in this game/in other games)	1 (2.22%)
Fail to report	0 (0.00%)
Total Relevant Cases	45 (100.00%)

The tools employed for the evaluation of the experience of the learners while involved in DGBL are given in Table 16.

Table 16: Summarized results on the tools employed for the evaluation of the experience of the learners while involved in DGBL.

The tools employed for the evaluation of the experience of the learners while involved in DGBL	Nr. of works (%)
Pre- and post-intervention knowledge test / Questionnaire	8 (15.38%)
Only pre-intervention knowledge test / Questionnaire	3 (5.77%)
Only post-intervention knowledge test / Questionnaire	19 (36.54%)
Intermediate knowledge test / Questionnaire	0 (0.00%)
Delayed (follow-up) evaluation activity/test	2 (3.85%)
Class observation, field notes, teacher diary	16 (30.77%)
Audiovisual recording	4 (7.69%)
Structured interviews / focus group discussions with students	20 (38.46%)
Structured interview or discussion with the class teacher	4 (7.69%)
Stealth assessment (scores in this game/in other games)	3 (5.77%)
Fail to report	5 (9.62%)
Total Relevant Cases	52 (100.00%)

As it can be seen in Table 16, the learner experience is evaluated mostly by interviews with the students (38.46%), post-intervention questionnaires (36.54%), class observation, observation sheets and teacher diaries (30.77%) and audiovisual recordings (7.69%). Pre- and post-intervention questionnaires are also employed (15.38%). Stealth evaluation is also used to some extent, as high scores in the game are considered to be connected to high levels of engagement and enjoyment.

4 CONCLUSIONS

A systematic review of recent (2017-2020) literature is presented in the current study, aiming to report on the effectiveness of DGBL for Primary Education students along the axes of (i) cognitive domain learning outcomes, (ii) social skills development, (iii) affective / metacognitive / motivational outcomes and, finally, (iv) student fun, enjoyment and engagement.

The aim is to identify the issues and questions recent relevant research focuses on in contrast to those not given the deserved attention and effort. Results show that recent research focuses primarily on acquired knowledge and secondarily on fun and engagement of students, as predicates of motivation for learning.

Affective / metacognitive / motivational outcomes are less researched despite the fact that student motivation is the major reason for DGBL (Garris et al., 2002).

Social skills development is certainly another area deserving more attention, especially given the collaborative nature of many games employed in DGBL.

Finally, the learning theory and educational method under which DGBL interventions are designed and implemented are not mentioned or justified in the vast majority of reviewed works – an alerting result that reveals a lack in solid theoretic foundation of experimental research on the subject and calls for further investigation.

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