Educational Games – Are They Worth The Effort?

A literature survey of the effectiveness of serious games

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***Abstract*— Over the last decade educational games have become more and more popular. There are many games specifically designed as educational games, as well as a number of entertainment games that have been successfully used for educational purposes. The EduGameLab project aims to stimulate the use of games in the classroom. This paper presents a meta-analysis of the effectiveness of game-based learning and focuses specifically on empirical evidence on the effectiveness of using games in education in the last decade. Moreover, the study focuses on usage in formalized school contexts, i.e. pre-school, elementary school, secondary school, high school and higher education. As secondary aims we also assess whether there are any clear methodological trends and whether a link could be found between the outcome of empirical studies and the evaluator being a stakeholder in the game development.**

Keywords—games; education; literature survey; effectiveness

I. INTRODUCTION

In recent years, educational games have become more and more prevalent (e.g. [1]). There is an abundance of specifically designed educational games [1], [2]. There are also many entertainment games that have been used for training or education [3]. Educational games are serious games specifically used for education. Serious games, in turn, is a concept with numerous definitions. In a broad sense the term refers to the idea of using games (specifically designed ones as well as entertainment games) for purposes beyond pure entertainment.

The aim of this paper is to make a meta-analysis of scientific studies on the educational effectiveness of games, to reveal what types of studies there are and what they conclude. With educational games being widely used, there is a clear need to analyse how the effectiveness of game-based learning has been studied and how the results from such studies can inform practitioners. From a practitioner's point of view there is a need, not only to establish the usefulness and effectiveness of educational games, but also for useful input for the effective development and use of educational games in practice. A secondary aim is to provide an overview of what types of studies there are that evaluate educational games and if there are any particular methodological trends in the area of serious games research. Finally our study identifies whether there is any evidence of a link between the outcomes of empirical evaluations in the field of serious games and the involvement of the evaluator as a stakeholder in the game development process.

This paper focuses on the sub-group of educational games in order to delimit our survey. As Tobias et al. [1] state, no survey of game research can list every study that has been made. The study was carried out in the frame of the EduGameLab, which aims to stimulate the use of serious games in the classroom. Based on the focus of the project, we focus our study on studies published in the last decade (between 2002 and 2012) and studies that have empirically evaluated the learning effect in some way. We also limit our study to games used in formalized school contexts, i.e. pre-school, elementary school, secondary school, high school and higher education. In order to limit our study further, we have decided to only include papers published in scientific journals.

Furthermore, Tobias et al. [1] argue that the superiority of games for instruction has not been established. We attribute this to different reasons. When dealing with educational games from both a practitioner's view point as well as from a scholarly view point we find a number of challenges. One major challenge is to prove their effectiveness and efficiency as educational tools. The issue of effectiveness refers to how well we can isolate and measure the actual learning effect form games. This is an important matter as we wish to better understand if and how games are effective as pedagogical tools beyond accidental learning. However, even if we manage to identify a number of studies that show the effectiveness there is still the issue of practical use in teaching. In this aspect there are even further problems to be solved, spanning user acceptance (from teachers, students and parents), technological restrictions, as well as questions concerning curricula and content [3].

II. BACKGROUND AND RELATED RESEARCH

There are numerous definitions of computer games and there are also widely used general conceptions. Salen and Zimmerman [4] summarize eight different definitions focusing on different elements and arrive at a quite condensed definition: "A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome." The definition is narrow, in particular with respect to the restriction to quantifiable outcome. In many occasions a

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more open characterization, such as the one provided by Prensky [5], including the elements *rules*, *goals* and *objectives*, *outcomes* and *feedback*, *conflict*, *competition*, *challenge*, *opposition*, *interaction*, and *representation* or *story* is useful. The concept of *cooperation* is also an important aspect of games and playing games and indeed there are many games that do not focus on competitive elements or winning. Some examples are simulation games such as The Sims (thesims.com) or the open sandbox of Minecraft (minecraft.net).

Serious games, which we perceive as an umbrella term, include different types of educational games as well as games for other purposes such as: *training, rehabilitation, marketing and social improvement.* The term serious games has been defined by Zyda [6] as follows: "Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives." This definition is fairly inclusive but its focus on entertainment sometimes clash with what is marketed as serious games. Marsh [7] defines serious games in terms of a continuum between games for purpose and experiential environments for purpose. As an example, many serious game applications are utilizing the technologies typically associated with computer games rather than the game play component. These applications are referred to as virtual environments and digital media with no traditional gaming characteristics [7]. For our work, we define serious games as games that engage the user, and contribute to the achievement of a defined purpose other than pure entertainment (irrespective of whether the user is consciously aware of this). A game's purpose may be formulated by the user her/himself or by the game's designer, which means that also a commercial off-the-shelf (COTS) game, used for non-entertainment purposes, may be considered a serious game. It is worth noticing that the utilization of game and visualization technologies, simulations and virtual worlds for purposes beyond entertainment can be included under this definition as well. While this definition includes non-digital games, it should be noticed that most references to serious games are in fact to digital serious games.

A number of recent reviews of computer game research have been carried out. As the topic has become more and more popular the number of studies is increasing and as indicated by Tobias et al. [1] it is no longer possible to carry out an extensive review covering the whole area. By necessity, reviews will have to focus on different topics and employ inclusion criteria. We have identified some recent reviews by Hays [8], Vogel et al. [2], Egenfeldt-Nielsen [9], Ke [10] and Tobias et al. [1] which we shortly introduce below.

Tobias et al. [1] present an extensive review of research on computer games, which examines research evidence for the effectiveness of games for instruction. 95 studies are categorized into groups with respect to their intention and knowledge claim. The following categories are identified:

- Transfer of knowledge, skills and attitudes from games to real world tasks.
- Effects on cognitive processes such as visual attention, spatial visualization and problem solving.
- Facilitating performance & learning in various topics.
- Uses of games in instructional situations.
- Effects of playing games on school learning.
- Effects on aggression, hostility and motivation.
- Attitude change.

Tobias et al. [1] conclude that the research reviewed indicate a promise for educational games. However, these promises are deemed as tentative as they identified a number of areas where there is still a need for further research and theoretical development. Tobias et al [1], conclude that "there is considerably more enthusiasm for describing the affordance of games and their motivating properties than for conducting research to demonstrate that these affordances are used to attain instructional aims, or to resolve problems found in prior research." One interpretation of this critique is the will within the community to develop and evaluate prototypes rather than spending more efforts on the actual usage in teaching.

Egenfeldt-Nielsen [9] presents an overview of the educational use of computer games by examining their underlying learning theories. There is a lack of knowledge about the implications of using games in educational contexts as this particular area has its unique problems in terms of methods, focus, and relevant research questions. Egenfeldt-Nielsen [9] points out that the different learning approaches (behaviourism, cognitivism, constructionism and socio-cultural) all have something to offer in the realm of educational game design and there are indeed titles to be found that represent all of them. Hence, there is no silver bullet and the field of educational games is not homogenous.

Hays [8] presents a review of 48 empirical research articles, published between 1982 and 2005, on the effectiveness of instructional games and concludes that empirical studies of the instructional effectiveness of games are fragmented and not always methodologically sound. Furthermore, there is no evidence that games are the preferred instructional method in all situations. This implies that the teaching context ant the pedagogical activities surrounding the game are important.

Vogel et al. [2] present a meta-analysis of computer games and simulations for learning. They claim that it is difficult to determine the nature of the relationship between games and learning as there is no common ground with respect to what skills and domains are analysed. To remedy this, they focus their review on studies on the gain of cognitive skills or attitudinal change. Furthermore, they only include studies that report statistics, assessing the difference between traditional classroom teaching and computer gaming or interactive simulation teaching. This shows the diversity of the field.

According to Ke [10] empirical research on instructional games is fragmented. Furthermore, Ke [10], referring to Dempsey et al. [11] indicates that much of the evaluation of games has been anecdotal, descriptive, or judgmental. Ke [10] presents an analysis of which methods have been used and what the results of these empirical studies are. Interestingly, no analysis is made of the evaluator, i.e. whether the evaluator is independent or a stakeholder in the development of the game.

III. METHOD

No survey of game research can list every study that has been made as they have increased dramatically over the last couple of years and the field has evolved rapidly. Hence, in order to give an accurate overview of the current state of the research, we limit our survey with respect to a number of criteria. This review has three major limitations:

1. It covers the time 2002 – first half of 2012.
2. It focuses on studies that have empirically evaluated the learning effect in some way.
3. It only includes papers published in scientific journals, hence excluding conferences.

The literature search was carried out in May and June 2012 and the following computerized bibliographic databases and search engines were selected as the most appropriate for the topic: *Academic search elite (Ebscohost), arXiv, LibHub, Inspec, ScienceDirect, ERIC, PsyhINFO, SAGE Online, Emerald, ACM Portal, SocINDEX, Google Scholar, Springer Link, IEEEXplore, CiteSeer* and *Scopus*.

Only peer reviewed journals were included in the results. We excluded conferences and unpublished reports in order to focus on empirical studies with well documented research approaches which we expect to find in journals. Furthermore, we expect that studies of high quality that have been presented at conferences will appear in elaborated versions in journals. The database searches were carried out using the following key words, and combinations of them:

- Video game
- Computer game
- Education
- Training
- Evaluation
- Empirical evaluation
- Effectiveness and Game based learning/training.

Key words were combined in order to reduce the number of relevant hits. In particular, we looked for empirical studies with some kind of effect measurements. The data bases were divided between the two authors and the searches yielded 120 hits that were deemed relevant based on an inspection of titles, keywords and abstracts. After sorting out duplicates between the different databases, 99 papers remained to be more carefully inspected. Each of these was independently inspected by the two authors, which resulted in the final selection of 40 papers which the authors could agree on, i.e. both authors had identified them as relevant to the review. The final selection only included papers that presented empirical data on the learning effect of computer games in formalized school contexts, i.e. pre-school, elementary school, secondary school, high school and higher education. We excluded the military, business and vocational training domains as the many games in these fields would distract from our focus on formalised classroom education. We also excluded studies about the relationship between video games, violence, aggression, and social behaviour. Finally, the papers selected were divided between the authors to be summarized.

IV. RESULTS OF THE LITERATURE SURVEY

The final selection of papers included 40 papers covering the following topics: *mathematics*, *cancer treatment*, *computer science*, *conceptual learning*, *bullying*, *engineering*, *fire fighting*, *language*, *geography*, *history*, *health*, *natural sciences*, *nutrition*, *physics*, *problem solving*, *social sciences*, *software development* and *surgery*. The classification is summarized in Table 1. The table also indicates the educational context, whether the evaluator was independent or a stakeholder in the development of the game, the evaluation method used and the result of the evaluation.

Mathematics lends itself well to game-based learning, at least if we judge by the number of studies (13/40 studies selected) in that particular field. However, the survey shows somewhat mixed results in terms of learning effect. 7/12 evaluations indicate positive results for learning effect; 5/12 are neutral and 1/12 is negative (at least for some groups). In general, positive effects are found for motivational aspects. There seem to be a fondness for classroom experiments and trials in the realm of mathematics games, seven of the studies selected carried out some form of controlled experiment. One interesting exception, which tells us a bit more about the broadness of the application of games and simulations in mathematics teaching, is [12]. Kim and Chang [12] analysed empirical data from the US database called National Assessment of Educational Progress (NAEP) on the effects of playing computer games on mathematics achievements for 4th graders. This database contains data about school achievements in various subjects and stores data about study results as well as the frequency of computer game use in class as indicated by the teachers. The results are somewhat mixed with respect to background and gender. English-speaking students who played computer mathematics games in school every day displayed significantly lower mathematics achievement than those who never played. On the other hand, positive effects of daily computer use were noted among male students whose first language was not English. Male language minority students who daily played computer games in mathematics demonstrated higher mathematics performance compared to male English-speaking students who never played.

Kim and Chang [12] conclude that the amount of time spent on playing mathematics games in class may be an important variable to consider. When male students played mathematics games every day they showed low mathematics performance. In contrast, when they played computer games with lower frequency in mathematics class, they outperformed male students who did not play computer games at all. Furthermore, according to Kim and Chang [12] the results should be interpreted with care as the study used a secondary database that records no details about which games were used.

Language learning is another popular topic taught with serious games with four out of 40 studies selected. Three of the selected studies employ specifically designed language learning games, whereas the last one utilises a

TABLE I. SUMMARY OF PAPERS INCLUDED IN THE SURVEY

Author	Educational context	Evaluator	Method	Result	Topic
Rub11 [13]	Elementary	Developer	Mixed-method	Positive	Bullying
Kato08 [14]	General	Independent	Experiment	Positive	Cancer treatment
Pap09 [15]	Secondary School	Developer	Experiment	Positive	Computer Science
Sind09 [16]	Higher Education	Developer	Experiment	Neutral	Computer Science
Rou06 [17]	Elementary	Unclear	Experiment	Neutral	Conceptual learning
Ebn07 [18]	Higher Education	Developer	Experiment	Positive	Engineering
Chu07 [19]	Elementary	Independent	Experiment	Positive	Fire fighting
Vos11 [20]	Elementary	Independent	Experiment	Positive	First language
Asa12 [21]		Independent	Experiment	Positive	Geography
Tüz09 [22]	Elementary	Independent	Mixed-method	Positive	Geography
Vir05 [23]	Elementary	Developer	Experiment	Positive	Geography
Tüz07 [24]	Elementary	Developer	Mixed-method	Unclear	Health
Hui09 [25]	Elementary	Independent	Quasi-experimental	Positive	History
Kenn11 [26]	Higher Education	Independent	Single instance trial	Positive	History
Conn11 [27]	Secondary School	Developer	Experiment	Negative	Language
Cho11 [28]	Higher Education	Independent	Case study	Positive	Mathematics
Kim10 [12]	Elementary	Independent	Survey	Negative	Mathematics
Kab10 [29]	Higher Education	Developer	Experiment	Neutral	Mathematics
Ke06 [30]	Elementary	Independent	Experiment	Positive	Mathematics
Ke08 [31]	Elementary	Independent	Mixed-method	Neutral	Mathematics
Kord11 [32]	Elementary	Developer	Pilot-study	Positive	Mathematics
Lia11 [33]	Elementary	Developer	Pilot-study	Positive	Mathematics
Main11 [34]	Elementary	Independent	Pilot-study	Positive	Mathematics
Pan12 [35]	Elementary	Independent	Experiment	Neutral	Mathematics
Sung08 [36]	Pre-school	Developer	Experiment	Positive	Mathematics
Ros03 [37]	Elementary	Developer	Experiment	Neutral	Mathematics
Wil06 [38]	Elementary	Developer	Trial	Positive	Mathematics
Liu09 [39]	Elementary	Developer	Quasi-xperimental	Positive	Natural Sciences
Wang08 [40]	Elementary	Developer	Experiment	Positive	Natural Sciences
Mun08 [41]	Elementary	Developer	Mixed-method	Positive	Nutrition
Rav02 [42]	Secondary School	Unclear	Mixed-method	Positive	Physics
Hua10 [43]	High School	Developer	Quasi-experimental	Mixed	Problem solving
Liu10 [44]	Elementary	Developer	Quasi-experimental	Positive	Second language
Piir09 [45]	Unclear	Independent	Qualitative	Positive	Second language
Yang12 [46]	Unclear	Independent	Quasi-experimental	Positive	Social Sciences
Hain11 [27]	Higher Education	Developer	Experiment	Positive	Software development
Wangen09 [47]	Higher Education	Developer	Experiment	Neutral	Software development
Gom07 [48]	Higher Education	Independent	Experiment	Positive	Surgery
Gom08 [49]	Higher Education	Independent	Experiment	Positive	Surgery
Qin10 [50]	Higher Education	Developer	Pilot-study	Positive	Surgery

commercial entertainment game. Perhaps the popularity of games for language learning can be explained by the fact that learning language requires being able to read and write but also being able to listen and talk. Teaching listening and talking via written texts is very difficult and therefore the use of audio and video is very popular. Games are more active than videos and can require both passive and active command of the language, making them well suited to language learning. Furthermore, any game may provide (first and second) language learning opportunity as many are published internationally in English. Piirainen-Marsh and Tainio [45] present and an interesting example, both methodologically and as an example of spontaneous learning. They report on a qualitative study which uses a social-interactional to analyse learning from playing games. They analyse two 13-year-old Finnish boys playing a fantasy role-playing game. Data was drawn from 13 hours of interactions from teenagers playing computer games. The study does not attempt to "measure" the learning effect but rather provides deep analyses of how the participants engage and interact when playing the game. These activities and interactions provide many opportunities to both read and use English and it is these learning situations that are analysed. Transcripts of the dialogues between players were analysed to study how they used the English language.

The results show how the players frequently repeated voice-overs and texts aloud as well as borrowed terms and concepts from the game while discussing game events with each other. Another interesting observation is how the players anticipate the dialogue of the game and co-construct their own versions as the play. To summarise, Piirainen-Marsh and Tainio [45] conclude that they demonstrate how a wide range of interactional opportunities for using English are available in the game. The analysis shows how players pay detailed attention to the textual and vocal resources in the game and how they adopt gaming vocabulary when they memorize chunks of game dialogue and reproduce or adapt these in appropriate contexts. However, we can't draw any evidence of longitudinal changes or development of language expertise from this data.

Several studies look at using game-based learning for teaching higher cognitive skills such as collaboration, argumentation and problem solving (three studies) and behavioural change (three studies). Huang et al. [43] developed a system called the Idea Storming Cube (ISC), which aims to support and engage students in divergent thinking in the problem-solving process. Specifically, the system was developed to support problem solving in relation to debris flow problems, which is considered an urgent problem as they occur frequently in Taiwan. The system is inspired by a Rubrik's cube, used to combine and associate ideas. As the activity continues the participants will generate and exchange ideas. The system asks them to generate ideas and describe them in natural language. The ideas are validated by the system and all new and unique ideas will generate points and as a return, the users can rotate the cube and see ideas from their peers. The results are positive however, while game-based training seems to have a positive impact on collaborative argumentation and problem solving in relation to civic and society based topics, for problem solving with regards to debris flow problems this is less clear. Students that were taught using the game generated more and more valid ideas, but comparing test-scores reveals that the control group actually learnt more [43].

Yang [46] studied the difference in effectiveness between a game-based learning approach and traditional learning in a quasi-experiment carried out over a full semester (23 weeks) in two ninth-grade Civic and Society classes (44 students, ages 15-16). The aim of the study was to compare problem solving skills, motivation and academic achievement between an experiment group (using digital game based learning) and a control group (using traditional learning). The control and experiment groups received the same instruction and learning materials during the first two classes of the week, but different instruction for the last class of the week, which is referred to as the intervention time. During the intervention time the control group received lectures for 50% of the time and spent the rest of the time asking questions, completing hand-outs, reporting results, and receiving feedback. The experiment group spent 50% of the intervention time playing digital games. Some examples of games played are: Tycoon City: New York and SimCity Societies. Teaching was organized so that the instructor began by clarifying the gaming tasks and provided time for students to design their strategies before playing.

Problem solving abilities were evaluated using a standardized test examining the ability to find causes, find solutions, and avoid problems. The game based strategy was clearly effective in promoting students' problem solving skills, while the control group showed no improvement. Furthermore, the game based learning approach resulted in better learning motivation for students in the experimental group. Finally, the academic achievement tests showed no statistically significant difference between the two groups. To conclude, Yang [46] showed that the quantitative improvement in problem-solving and learning motivation suggest that digital game based learning may be a useful and productive tool to support students in effective learning.

In addition to increasing knowledge, serious games are increasingly being used with the intention to change behaviour (three studies). The topics being taught are usually not directly related to the school curriculum, but centre around problem behaviours such as bullying, medication adherence, emergency evacuation and health related behaviour. Munguba et al. [41] carried out a study to evaluate the effect of using interactive games in an occupational therapy nutrition education programme for obese children. The goal was to compare a video game and a board game, both specifically designed to improve the subjects' eating habits. Both quantitative and qualitative techniques were used to study learning of concepts in nutritional education. The results indicate that play activities promoted learning of nutritional concepts. The extent to which eating behaviour was actually changed is unclear even though the secondary goal, after learning about nutrition, is to change eating behaviour. This may be attributed to the fact that changing eating habits is a long term commitment and thus hard to evaluate unless using a longitudinal study. Another factor may be the influence of parents over the eating habits of especially younger children.

Computing is also a topic that is popular with serious game developers (four studies selected). This may be partially due to the fact that many serious game developers themselves are computing teachers of practitioners. It is also a very exact topic making assessment within a game easy. The studies selected are mainly positive. However the approach seems more suitable to university students than school students and one of the studies presented concludes that there is a positive effect based on student's opinions despite the scores not showing a significant difference. Interestingly, we note that teaching computing via games includes both 'hard' and 'soft' topics from computer fundaments and software measurements to relatively more fuzzy topics such as requirements collection and analysis. Hainey et al. [51] argue that traditional educational techniques such as role-play, live-through case studies and paper-based case studies are insufficient and that other approaches are required. One proposed approach is game based learning and the authors present a prototype game which teaches the different roles in a software engineering project, such as project manager, systems analyst, systems designer or team leader. The general idea of the game is that the team (played by one or more players) should manage and deliver different software development projects. Players can interact with non-player characters (NPC) and with each other through a text-based interface. Answers from NPCs are in the form of written transcripts which contains general background information as well as requirements which the player has to identify and document. At some stage the analyst has to send the list of requirements to the designer to produce an outline high-level design.

Surgery is a different type of topic to most other topics being taught with serious games in that it is only taught to university students. Even so, three studies were included in this survey as we perceive medical training of particular interest. Medical training is quite unique in that surgical practice is very costly and carries a risk to human health. Therefore successful simulation and game-based technique can save significant amounts of money and reduce patient risk. This means that the emphasis lies not on comparing these simulations and games with the traditional methods, but more on assessing whether they are useful training tools in their own right and whether performance on these tools correlates with real world performance. The latter means that the tools are useful in assessing whether a student can safely progress to real patients.

Natural sciences teaching has seen an increase in the use of technology either mobile out in the field, or behind the computer, even though only two studies were selected for this survey. These environments offer the opportunity for students to explore environments and the selected studies about teaching natural sciences show an increase in motivation and learning gains. The use of digital technology in geography is popular, and is expected to increase with devices such as GPSs and smart phones with maps. For this survey three studies that represent more traditional 3D games for learning were selected and they show that geography is a popular topic for the application of game-based learning. The papers on this topic found in this survey, show that serious games for teaching geography can be very effective and they are especially effective with students who are struggling with traditional methods of teaching geography.

In addition to the categories presented above, there are several studies of games teaching a variety of topics such as occupational therapy, orienteering, civil engineering, fire-fighting, first-aid, the history of Amsterdam and historical disease epidemics. We included five such studies as they fit our selection criteria.

V. Conclusion and Discussion

In this report, we have summarized the current state of the research on the effect and effectiveness of serious games. Using a structured method we identified papers from a number of databases. Papers were selected based on a number of criteria. As figure 1 shows, the identified research shows a fair amount of evidence that serious games have a positive effect on learning. 29 out of our selected 40 studies show positive results, seven out of 40 neutral and only two out of 40 negative results. For two studies the results are somewhat unclear. From this we can conclude that if they are not always superior to other types of learning material, the evidence that serious games can be effective learning materials in their own right is quite strong.

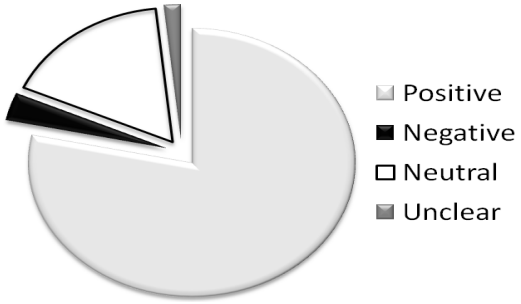

Fig. 1. Evaluation results of identified emperical studies

We notice some interesting examples of using commercial entertainment games in teaching. Even though the major reference to serious games refers to specifically designed games, there seems to be a potential for using entertainment games in education. Piirainen-Marsh and Tainio [45] provide an interesting example of language learning, even though not in a formal teaching situation. Yang [46] showed that a game based strategy using commercial entertainment games was clearly effective in promoting students' problem solving skills, whereas the control group showed no improvement. Furthermore, the game based learning approach resulted in better learning motivation for students in the experimental group. Finally, the academic achievement tests showed no statistically significant difference between the two groups. These results are interesting in that they suggest some benefits from using entertainment games without any detriment in academic achievement.

In 21 cases the developer was also one of the main evaluators. 14 out of these 21 studies show a positive result, four studies show a neutral result, one is negative and two are unclear. In 17 studies the evaluation is carried out by independent evaluators. 14 of these studies show a positive

result, one a negative result and two a neutral result. It seems that there is a tendency towards more positive evaluation results overall. There is a clear trend towards evaluations by a stakeholder in development of the game; furthermore, these studies have a tendency to have positive results (14/21). This trend can be compared to Garg et al. [52] who analysed the development and evaluation of clinical decision support systems and found a strong trend towards positive evaluation results when the developer was also the evaluator, compared with studies in which the authors were not the developers (74% success vs. 28%; respectively). Even though there are some signs of a slight bias in our survey, the effect is not as strong as in other fields [52]. Interestingly, the presence of studies with unclear findings increases when the evaluator is a stakeholder in the game development. It is not clear why this is the case, but it could be due to over ambitious evaluation setups of stakeholders aiming to provide a much proof as possible for their game.

Notably, not much research has been done on how games are actually used in teaching. This includes user acceptance (teachers, students and parents), technological restrictions as well as questions concerning curricula and content (see e.g. [53], [3]). According to Egenfeldt-Nielsen [9], other barriers include the fact that the educational setting uses short lessons in a particular physical space, variations in gaming skills between students and practical issues such as installation and teacher preparation costs. With regards to user acceptance Egenfeldt-Nielsen [9] notes a certain amount of scepticism among students and teachers. There are also reports of practical problems and according to Kirriemuir and McFarlane [3] it is unlikely that entertainment games will be integrated into the curriculum due to a number of reasons: it is hard for a teacher to identify how a particular game might be relevant with respect to the curriculum; the difficulty to persuade other school stakeholders of the benefits of using games as educational tools, especially entertainment games; the lack of time for teachers to learn how to use games as teaching tools; the high amount of irrelevant content and functionality (with respect to the teaching situation) in entertainment games; technology barriers in the IT equipment in many schools. We find that practical pedagogical problems like these are the next step to be addressed in research once we have established the potential of using games in teaching. This is, however, a different strand of research that calls for longitudinal studies in actual teaching situations, which has both practical and ethical implications beyond what we have experienced so far.

The diversity of the field, as indicated by previous reviews [2], [9], [10] probably calls for a diversity of scientific methods to study it. However, within the body of evidence identified in this study, there is a distinct lack of so called longitudinal empirical studies of actual use of games for learning. These are studies that assess the effect over time. Hence does learning with a game have any medium to long term positive effects on students? Can games be effective teaching tools in schools over a longer period of time? If so, how should teaching with games be organized? And do benefits of learning with a game remain if the game becomes an established form for teaching certain parts of the curriculum or is some of its effect due to students (and perhaps teachers) reacting to the novelty factor?

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