Use of Cloud Gaming in Education

Sužnjević, Mirko; Homen, Maja

Chapter

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Mirko Sužnjević and Maja Homen

Abstract

The use of digital games in education has been the subject of research for many years and their usefulness has been confirmed by many studies and research projects. Standardized tests, such as PISA test, show that respondents achieved better reading, math and physics results if they used the computer more for gaming-related activities. It has been proven that the application of video games in education increases student motivation, improves several types of key skills—social and intellectual skills, reflexes and concentration. Nevertheless, there are several challenges associated with the application of video games in schools and they can be categorized as technical (network and end device limitations), competency (teachers' knowledge in the area), qualitative (lack of educational games of high quality), and financial (high cost of purchasing games and equipment). The novel architecture for delivery of gaming content commonly referred to as "cloud gaming" has the potential to solve most of the present challenges of using games in education. A well-designed cloud gaming platform would enable seamless and simple usage for both students and teachers. While solving most of the present problems, cloud gaming introduces a set of new research challenges which will be discussed in this section.

Keywords: cloud gaming, education, video games, quality of experience, optimization

1. Introduction

It is very important that the establishment of ICT infrastructure in schools be supported by the introduction of services that will use this infrastructure, which is shown on the example of Turkey [1, 2], which introduced such infrastructure to schools without innovative services and has not yielded significant results in the improvement of the educational process. Using games in schools is one of the innovative services that can drive motivation of students for better participation and make the schools happier places for all children.

The use of digital games in education has been the subject of research for many years and their usefulness has been confirmed by research [3–6]. Although the potential for learning through video games is great, the instances of application of this learning methodology so far have been rare. The basic challenges associated with the application of video games in schools are divided into technical (e.g., end device limitations), competency (e.g., teachers' knowledge in the area), qualitative (e.g., few educational games of high quality), and financial (e.g., high cost of purchasing games) [7]. Besides the listed issues, for games to be adopted and incorporated in formal education, policies would have to be made by the key stakeholders

in all sections of the society, such as in education, government, independent and standardization bodies, and the game industry.

Cloud gaming provides a new concept of online games organization, where the game is completely stored and played on a server located on a cloud. A high-definition video is sent to the client, and user commands are sent to the server. The cloud gaming concept has the potential to solve most of the above problems because it does not require a powerful client device (mobile devices are sufficient), does not require any additional competency from the teachers (games are located in the cloud), enables the use of the newest and most graphically advanced games, and reduces the number of required licenses. Therefore, the use of cloud gaming for delivering gaming content in educational environment could be a solution which would enable all the benefits while removing the major downsides and challenges. Nevertheless, this concept brings a series of research challenges related to optimization of interactive video streaming based on available computing and network resources with the goal of maximizing overall Quality of Experience (QoE). Also, there is always a question of appropriate content for each of the educational units defined by the curriculum, as well as the problem of adapting the existing and designing new games while bearing in mind the diversity of delivery platforms on which they can be played (primarily tablets and mobile phones). The interdisciplinary nature of this research area requires an approach that will combine technical research with social research in the field of educational application of advanced technical tools.

The remainder of the chapter is organized as follows. In Section 2, an overview of advantages and current issues of using video games as a teaching tool is presented. Cloud gaming is described in detail in Section 3. Section 4 presents the discussion on the problems of using games in schools and how cloud gaming could solve these problems, also discussing which research problems need to be overcome if cloud gaming is to be used as a platform for games as a teaching tool. Section 5 presents the roadmap of research efforts needed to solve the identified research problems.

2. Using games as a teaching tool: an overview of advantages and issues

The use of digital games in education has been the subject of research for many years and their usefulness has been confirmed by research [3–6]. Standardized tests, such as PISA test, show that respondents achieved better reading, math and physics results if they used the computer more for gaming-related activities [8]. Newest research [9, 10] also confirmed that digital games can improve communication skills, adaptability and resourcefulness in elementary school students and even in university students [11]. Social games in education are becoming increasingly relevant because they can provide solutions to certain problems seen in traditional school environments, for example, lower cognitive outcomes and poor attitudes towards learning. Video games require students to challenge themselves, collaborate and interact with peers and they promote critical thinking. All of those skills are necessary for students to thrive in today's digital world [12]. Previous research showed that with collaborative games students can learn and practice social skills and the games can improve their engagement in the classroom. Social skills are important because they are tied to peer and teacher acceptance as well as academic achievement [13]. Social games embed various communication possibilities and levels of interaction between students; thus, different types of learners can enjoyably engage with contents of learning in a familiar and fun way. Digital game-based learning and academic achievement are closely related: students who are more

motivated to perform better at games are also more motivated to achieve better academic results. There is a connection between skill mastery, progression and rewards both in gaming and in education contexts [14].

There is a special field of research regarding serious (learning) games. Serious games are designed for other purposes than pure entertainment. They are used in many areas such as; education, healthcare, marketing, engineering etc. Serious game-based approach to learning can be used in many different curricular areas and newest research showed that it promotes better learning and students' motivation and enjoyment [15, 16]. Serious games proved to be an especially great tool when it comes to general problem-solving skills [17], language learning [18–20], history and physical education [20] as well as science education [18, 21, 22]. Games have also been researched in special needs education students and research showed that using serious games in education enhances students' cognitive outcomes as well as social behavior [23–25].

Like every other method, the usage of serious games for learning has some advantages and disadvantages. Combination of the relative novelty of the whole field and the general breakneck pace at which the gaming industry is developing produces various difficulties in evaluation of results. The lack of methodological standards when it comes to using digital games in education also makes it hard to directly compare the results of different studies. Additionally, research in the field is often focused more on the effects in specific fields of education (health industry, military or corporate training, etc.) and less on the impact on formal education as such.

With the soaring costs and complexities of developing digital games at large, such educational projects are also in great danger of being abandoned unfinished; with the tendency of modern video games to be in perpetual development cycles, sometimes it is hard to even get a finished product in this field. That level of constant change can make it impossible to properly evaluate the educational impact of a game and isolate important factors for research purposes.

The research into negative sides of digital games is also a contentious subject, which can make it hard to filter out the potential bias in available results. So, while the positive side of serious games as an educational tool is unquestionably promising, further research into potential disadvantages is certainly warranted.

Large number of research projects in the area of using games as a teaching tool was conducted in the recent years, which was summed up and evaluated in a European Schoolnet study [7]. The main conclusions of the study were that the application of video games in schools increases student motivation, improves several types of key skills—social and intellectual skills, reflexes and concentration. Several analyzed projects also show increased knowledge about the subjects taught. Increased mathematical knowledge was demonstrated in DANT and The Consolarium projects [26]. Through its research institute, the Joint Research Centre, the European Union has studied the possibility of using video games in education as well as reducing the risk of exclusion of vulnerable groups [7, 11], and it finances projects related to the use of video games in education. The Gaming Horizons project studied the role of digital games in culture, education and economy. The final report stated that video games can create new learning opportunities that are more focused on the student, thanks to their motivational capacity and motivational strength [27]. The objective of the InLife project was to create a new gaming framework in education that would exploit the new concept of the Internet of things as well as educational digital games. The current phase of research in this field in the European Union is medium and large studies in schools funded through projects of the member states or the European Union.

3. Cloud gaming

3.1 Technical overview

Cloud gaming provides a new concept of online games organization, where the game is delivered from a server located in a cloud. According to [28], the most important and currently most implemented model for cloud gaming is "Remote Rendering Gaming as a Service", in which the multiplayer server, the game logic, and the rendering are all located on the server, while the only main functionality left to the client is the input module. In this model a high-definition video is sent to the client and user commands are sent to the server. The cloud gaming concept is illustrated in **Figure 1**. The user commands are sent from the user devices and the high definition video stream is sent from the cloud gaming server to the users. The traffic is highly asymmetrical as the high definition video flow is much more demanding in terms of network bandwidth than the user commands.

The advantage of this approach is that only video content is displayed on the client's device and that all games are played through the same client application. This computationally less demanding functionality is generally supported by mobile devices, and it is independent of the operating system of the client's device. Therefore, the client does not have to employ the most recent, expensive hardware equipment to be able to play the newest, often very resource hungry games. The most conspicuous disadvantage is that the client has to be connected to a network that has a very high bandwidth (one stream goes up to 50 Mbit/s) and very low network latency (less than 70 ms of Round-Trip Time). Conventional methods of reducing the effects of poor network conditions on the multi-media content streaming (such as temporary storage of data in buffer until they are ready for display or precoding the video in different formats) cannot be applied in this case, because they introduce additional latency into the system and due to the fact that the video does not exist before the user defines it with their controls. Latency in the cloud gaming system reduces its interactivity and the Quality of Experience (QoE) of the end user. There are a number of studies focusing on the impact of latency on the QoE of the user, but in general cloud gaming systems require less than 70 ms on Round Trip Time network latency (e.g., GeForce NOW).

The estimated net worth of global cloud gaming market in 2018 was $ 802 million, while it is estimated to reach up to $ 6.944 billion in the year 2026 according to

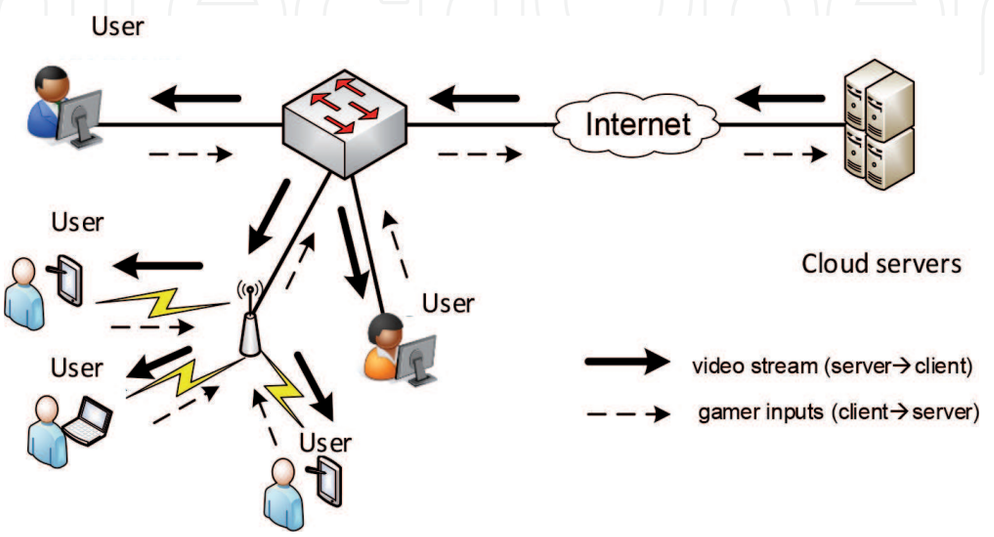

Figure 1.
Cloud gaming architecture.

the Zion market research [29]. The market is very competitive and the first services Gaikai and OnLive were unsuccessful on the market and were acquired by Sony in 2012 and 2015 respectively. Some of the main technical issues that led to shutting down of the pioneers of cloud gaming were problems with the virtualization of the Graphics Processing Unit (GPU) and insufficient penetration of the high broadband Internet connections (10 Mbit/s and more). Sony's PlayStation NOW is powered by the technology developed by Gaika. There are currently several commercial platforms for cloud gaming on the market, such as GeForceNOW, G-Cluster, PlayKey.net, Parsec, Vortex, etc. This field is very propulsive and even some of the largest companies on the ICT market, such as Microsoft and Google, announced their Xcloud and Stadia platforms.

3.2 Research challenges in the area of cloud gaming

The research field is very dynamic and deals with the following key issues: (1) virtualization of graphic resources [30–32], (2) new video encoding methods adapted to the needs of highly interactive applications [33–35] and (3) the optimization of the QoE based on available resources, whether they are network related [36, 37], related to the game type [38] or related to the distribution of virtual machines [39]. One of the main research problems in cloud gaming is optimization of the end user's QoE taking into account the available server, client, and primarily network resources. For that to be done, the first QoE models need to be derived from detailed user studies. We describe in detail the related work in this area.

User studies are the first and basic step in the modeling of the QoE of any service. The factors affecting the QoE can be divided into systemic, user and contextual [40]. Most of the studies in this field focused on the impact of network latency and loss of package on the QoE [41–48]. In general, the results show that cloud gaming is highly sensitive to network latency and that package losses of less than 1% caused significant degradation of the players' QoE [40], as confirmed by a commercial platform study [49], but also by a study of an open-source platform GamingAnywhere [50]. The research clearly recognized the sensitivity of this service to network degradation and it is therefore necessary to dynamically adjust the service to network condition on the basis of optimization of algorithms in order to avoid congestion that causes latency and package losses. Although various media is sent in the concept of cloud gaming, most of the network traffic is generated by video streaming [51], which is the key optimization medium. One of the video encoding methods that exploits the specific features of cloud gaming is the cooperative encoding of videos of different users in the same session to take advantage of the established redundancy between their videos [52]. This method has the potential for application in the educational environment, because in this scenario all the students in a class play the same video game. Defining the players' area of interest within the scene and the different encoding of scenes detail at macroblocks level is a method by which significant savings can be achieved in the used network traffic, while retaining a high level of the QoE [53]. A similar principle of interest field analysis is used in [54], but by using virtual scene rendering information, which enables acceleration of the video encoding process, especially the calculation of the motion vector and selection of the macroblock mode, which reduces encoding time by as much as 72%. Although compression can reduce the amount of data being sent, the variable state of the network can lead to instability of the service and the decrease of the QoE. For the system to be adaptable to network parameters variations (primary bandwidth and latency), optimization mechanisms and adaptive video streaming are required. The basic principle in such optimizations is that interactivity is the most important component of video games and that video quality is secondary, within certain limits of course,

as well as that video encoding parameters can be adapted to enable adaptive video streaming [55]. The optimization of video streaming based on the network latency is presented in [56] and a special package distribution scheme for the transmission of cloud video streams is presented in [34]. A review article [57] sums up research in this field and open research problems. All reviewed papers deal with the issues of using cloud gaming in an entertaining context. The scenario of application in the educational environment opens up many new research questions and optimization opportunities; to the best of our knowledge, there have been no studies dealing with education as a specific case study so far.

4. How cloud gaming solves issues in using games as a teaching tool?

Like in many other countries, in Croatia the problem of outdatedness of the teaching methodology applied in schools has been recognized, and the Strategy of Education, Science and Technology defines that it is necessary to "develop digital educational contents, tools and methods of using ICT in learning and teaching." [58]. The increase in the number and availability of mobile devices has created predispositions for introducing digital education through gaming in schools, and mobile tablet devices have recently often been mentioned as a potential replacement for paper textbooks in schools. Some of the advantages of mobile tablet devices over the textbooks include: faster learning [59], reduction of physical load on children who are overloaded with the weight of textbooks [60], the availability of a large number of textbooks in digital form, new approaches to learning and more. Using games in schools can be one of the steps on the road towards the goal of reaching advanced digital education. Nevertheless, for this step to be taken in practice, significant challenges need to be overcome.

As we previously stated, the basic challenges associated with the application of video games in schools are divided into ***technical, competency, qualitative and financial*** [7].

- One of the main **technical problems** in the integration of contemporary video games in classrooms is that newer games require that the graphics processor performs a large number of demanding computing operations in real time, and most of the graphics processors built into mobile devices do not have enough processor power to achieve this task. The heterogeneity of tablet devices in terms of operating systems and technical features (e.g. display size, storage, processor speed) is also a problem. Additionally, games today require a lot of storage space on the hard disc (e.g., the newest Call of Duty Modern Warfare requires 175 GB of disc space), which severely limits the number and quality of the games which can be played.

- **Competency problems** relate to teachers and the lack of information on using video games in teaching and the question of which games to use in relation to which teaching material. Additionally, in "classic" computer classrooms, teachers have the major burden of maintaining the ICT structure in both hardware and, especially, software aspect—for which teachers do not have quality competencies or sufficient time.

- The **quality problems** are related to the lack of appropriate educational games, which are mostly significantly inferior to games that are developed exclusively for entertainment purposes [61]. Also, the technical aspect of games being developed for a particular platform and operating system fragments the pool

of existing educational games with high quality to further extent. For example, a game developed for PC and therefore usually Windows operating system cannot be played on a tablet.

- **Financial problems** include the cost of purchasing one game per device, which could be a major burden to school budgets. The cost could be very high if multiple games could only be used in a single course. Additionally, there are rather weak financial justifications for the development of serious games—the market is far smaller and harder to reach, while the lack of information and sorry design of the games are hindering market development. In order to support as many mobile devices as possible, game developers need to develop multiple versions of a game for different platforms (e.g. *ios* and Android operating systems), which increases costs, and they are further limited by the heterogeneous technical features of devices.

Cloud gaming concept has the potential to solve most of the above problems by the way it is designed. Here we list how the major problems in introducing games in classrooms are completely solved or partially alleviated:

- Technical problems:
    - *Processing power*—this issue is completely solved because only reproduction of the video stream and capturing of the user's input is required, and those functions impose very low processing load.
    - *Heterogeneity of user devices* and their processor power are solved as the overwhelming majority of smartphones and tablets in the market are capable of reproducing a video stream with no issues. Therefore, any of these devices is capable of serving as a cloud gaming client device.
    - *Storage space*—the games are stored on the cloud and the video stream received on the client side is discarded after being displayed. The client application which displays the streaming video and captures the input from the user has relatively low storage requirements (e.g., installation package for open source cloud gaming platform GamingAnywhere is a bit smaller than 8 MB).
- Competency problems:
    - *Maintaining the IT infrastructure*—teachers do not have to maintain the IT infrastructure because games are stored on a cloud, so only one application per user device needs to be installed. Therefore, problems can only arise with running one application and not multiple ones, so any troubleshooting would require much less effort;
    - *Appropriate games*—This issue is not solved by the cloud gaming approach per se, but a centralized nature of the cloud gaming system enables the implementation of a recommended system for a particular lesson. The more details on what such a solution would require is given in the next section.
- Quality problems:
    - *Fragmentation of the appropriate educational games*—cloud gaming approach enables playing the games which are designed for any platform on any other

platform. If a game is developed for Windows, the virtual machine in the cloud on which the game is run needs to have a Windows operating system, but the client machine can run any operating system, for example Android or iOS.

- *Lack of high-quality educational games*—cloud gaming system enables the use of high-quality games which were designed for entertainment purposes in educational context (e.g., using one of the games from Civilization series to teach history).

- Financial problems:
  - *Cost of game purchasing*—the cloud gaming platform allows for a large number of students to use the same game license under the conditions negotiated with the game developer, of course.
  - *Costs of developing educational games*—the cost for developers is reduced because they need to develop the game for only one platform.
  - *Market size*—deploying a cloud gaming platform which would serve as a country-wide enabler of games in schools opens up a large market, which would be an incentive for game developers. If successful, such approach could be followed by other countries or stakeholders, which would further expand the market.

As presented, cloud gaming offers the potential to completely or partially solve listed problems, but also brings a series of challenges for application in schools in order to make it successful. In the next section we describe the research challenges which need to be overcome for this goal to be achieved.

4.1 Cloud gaming in teaching: research problems

The case study of using cloud gaming in classrooms has its own specific user and technical requirements and limitations (e.g., the number of users sharing wireless network, background traffic, same game etc.). In order to solve them, the cooperation of researchers in the technical and educational field is necessary. It is necessary to evaluate the knowledge and expectations of students as well as teachers, identify technical characteristics of traffic and traffic infrastructure, create models that optimize the QoE depending on dynamically changing network resources, study the existing games that can be used for educational purposes and define the methodology for adding new games, optimize video streaming on the server side, evaluate the system and refine it based on feedback from end users – teachers and students. An additional challenge is that the data transfer in the last step is performed via wireless networks that have lower performance than wired networks. **Figure 2** illustrates the functionality of the cloud gaming concept with application in education as well as open research questions in both technical and educational area.

4.2 Technical research problems

The technical research problems are mostly related to the infrastructure constraints on the server and the network side, as well as how to enable best possible QoE of end users given the said constraints. Besides that, on the user side there is a problem of designing an appropriate interface or interface modifications which would enable playing a game.

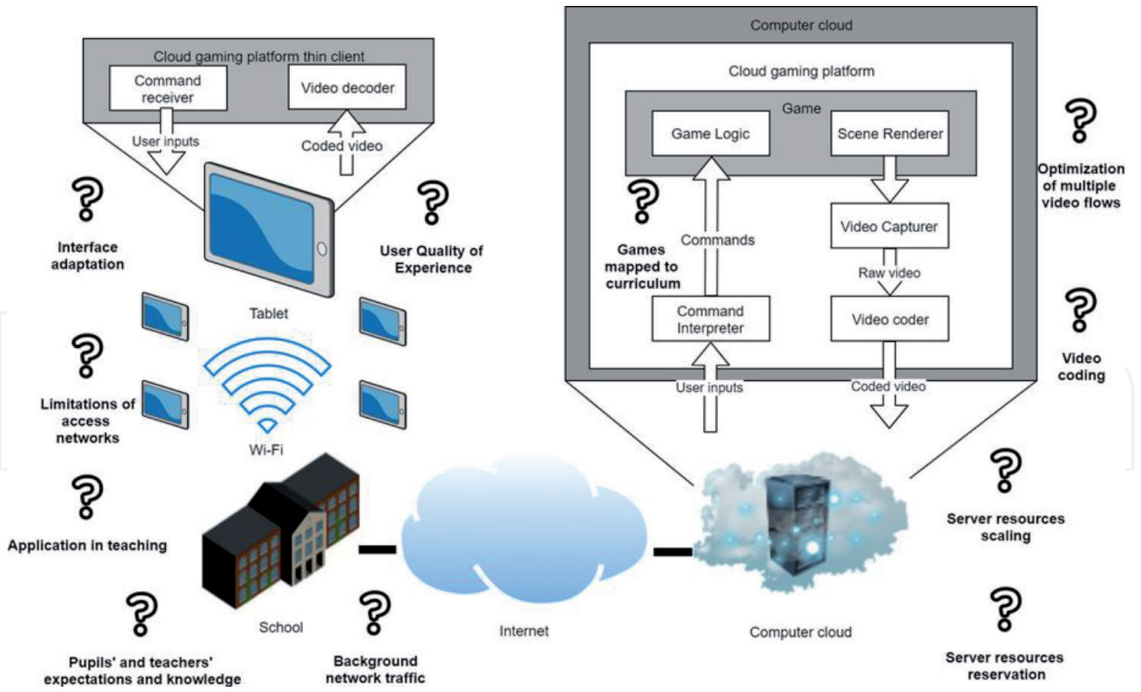

Figure 2.
Research questions related to the cloud gaming concept with application in education.

In the ideal scenario a whole class would be able to play a game which their teacher has instructed them to. With 30 students in class and 30 Mbit/s of generated traffic per game stream this yields 900 Mbit/s of overall traffic load. All this traffic must first go through a wireless network (preferably WiFi) and through the school network towards the cloud in which the servers are stored. In Croatia the schools which were connected to the Internet within the e-schools project are connected with the main Carnet network via high speed optical links and those backbone links should not be a problem for cloud gaming traffic. Nevertheless, the problem might arise if these links get overloaded with other types of background network traffic; therefore, an overall **analysis of network traffic** traversing these links is needed. The results of such analysis are needed to properly dimension the cloud gaming network flows depending on the number of users. The bigger network issue is the WiFi connectivity as a bottleneck. The latest WiFi standard IEEE 802.11ax [62] is promised to have speeds up to 10 Gbit/s, which might solve the issues of bottleneck on this section, but the current most popular standard offers up to 1.3 Gbits/s in theory, which is in practice limited up to a half of the value depending on the strength of the signal, the number of devices connected, other networks etc. Therefore, an **analysis of capabilities of current WiFi standard 802.11ac for serving multiple cloud gaming flows** is needed. Previous standards showed little potential for such application as the QoE of the end user was severely degraded when only five users were using the service [63].

Because of the limitations of the infrastructure and fluctuating background traffic, there is a need for an **optimization algorithm for adapting the characteristics of video streams** in a way which would maximize the end users' QoE under the current constraints. For the optimization to be possible, first the **QoE models for the games** which are used in the educational settings need to be devised. There has been significant research in the QoE of games used in entertainment context for cloud gaming and "regular" network gaming. These results can serve as a basis for devising the QoE models for games in educational context, but further research is needed because of a different context which may have a significant impact on the QoE.

Finally, the current generation of general-purpose video codecs has not been developed with a cloud gaming in mind. Bandwidth and especially latency constraints of cloud gaming impose additional requirements on the video codec, but specifics of the application offer possibilities for **advanced video coding methods**, which could speed up the coding process, lower the bandwidth required, or even lower the latency by pre-coding different outcomes, which can happen based on user input, and basically "predicting the future" [35].

4.3 Educational research problems

First and foremost, in order to make the system useful to end users, it is necessary to examine the opinions and attitudes of teachers and students on the use of videogames in classroom and determine their need for such a system for the sake of its optimal implementation. Teachers should be familiar with the system and know how to make the best of it in class. The system should not be complicated to use.

Regarding videogames, there is a problem that the market lacks serious games, while the existing games should be studied and categorized in detail. Such games could be categorized according to the genre, but the most important categorization would be done according to learning outcomes in specific areas, i.e. mathematics, science, language learning, etc. It is also important to connect the games to the public curriculum in order to make them practical.

As mentioned, there is a significant lack of serious games that could be used in class; therefore, it would be wise to create own games, which would be created for the existing teaching curriculum and in the local language. It would be crucial to include teachers and students in the very process of making of serious games. The needs and demands of end users (students) of serious games ought to be met during the process of their making. The attitudes of educators towards serious games have a significant impact on their adoption in teaching [64]; that is why their inclusion in the process of making of games is of vital importance. In order to make that happen, it is necessary to study different processes of game designing, while giving teachers and students a role in the process of game creation. This could be done through a process of co-creation of games, meaning that all representative members would have their say in the design. This could be realized through various workshops, where teachers and students would participate in the process of game design with the help of different creative tools such as collage, clay, various painting techniques, making of prototypes, storyboards, etc., with game designers and programmers guiding the entire process of game design. Many teaching education faculties have ICT departments that work on the creation of educational packages, which creates a possibility for a productive cooperation.

Mutual design made by teachers and students could transform serious games in education, both through innovation of game content with the examples from teaching curriculum and with the acceptance of games as part of the teaching process. This would make end users co-owners of such games by giving them an important role in their design, creation and, eventually, their use.

5. Cloud gaming in teaching: roadmap of required research

The interdisciplinary nature of the research problem requires an approach that will combine technical and social research in the field of educational application of advanced technical tools. The goal of the presented roadmap is to create a SErver Platform for ClOud Gaming (SEPCOG) with specific purpose for streaming games

in the classroom, as well as to devise a methodology for adding appropriate content to the platform. The content may be newly developed, or the existing content could be adapted. We propose an approach composed of the sets of basic research activities illustrated in **Figure 3**.

The first step in this research would be to define a system specification based on the information collected from teachers and students. This data can be collected through surveys of students and teachers. Data collected by surveys may be in the form of responses to questions, as well as free responses. Likert scale might be used to measure the opinions and attitudes of teachers and students and such data would be analyzed by statistical methods.

The second step is to identify the test games which can be used. Available educational or entertainment games could be reviewed with a special emphasis on games in the native language of the country or those that can be localized. The research question is how to identify an educational game and a commercial game that could be used in the educational context, as defined in [61, 65].

A possible scenario for creation of test games would be a joint developing of the game between teachers and students. Such a scenario may be based on a game development system that would be simple enough for children to use. The games for e.g. understanding physical phenomena, mathematical games and the like could be generated under this scenario. For all these approaches in games creation, a methodology for mapping the games according to the units of the existing curriculum ought to be created. The methodology needs to be based on the identification of the learning outcomes of gaming scenarios and the establishing of non-unique relations to the teaching units. This is a major research question that requires careful consideration, which is highly dependent on the country and its educational process. To achieve this objective, a research related to educational content—games that would be streamed as video content to students—needs to be conducted. Available video games of various categories ought to be analyzed. First, test video games that can be used in laboratory research need to be defined. At this point, teachers and their expertise in didactics will be crucial for the success, as well as cooperation between teachers and researchers from technical areas.

The third step needs to be an iterative subjective laboratory testing of the QoE depending on the network parameters and video encoding parameters, as well as the adjustment of the developed system based on the results of these tests. For this research to be carried out, characteristics of the network in schools and the network

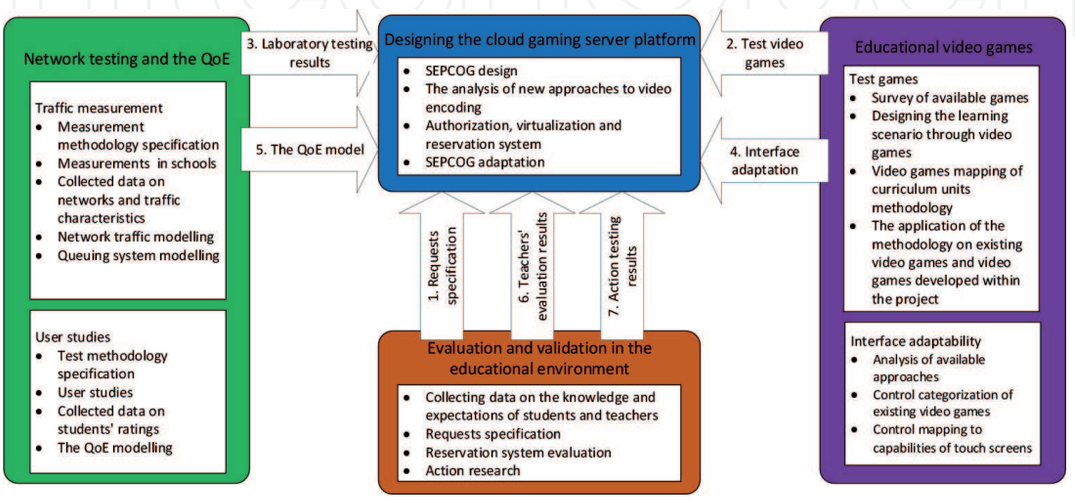

Figure 3.
Research methodology.

traffic have to be identified. Also, the methodology for measuring network traffic in schools has to be specified.

The fourth step needs to be the research of the adjustment of the games' interface to the limitations of the tablet interface (that neither has a keyboard nor a mouse). Today's mobile devices host different types of games, even games that are highly demanding in terms of interaction, such as shooting games. The control methods used in these games can be directly replicated for the needs of cloud gaming, but for that approach a detailed review of the field has to be performed, all valid control methods have to be identified, and the appropriate ones have to be selected. In addition, it is necessary to make a general classification of the interaction of games on PCs and to copy it to touch screen capabilities. Such a research effort needs to be done in accordance with both teachers and students. To achieve this, a methodology for the adaptation of video games to the limitations of mobile device interfaces is needed. The study of methodologies for learning via games development as well as developing own games in cooperation with students is also needed. The development of a methodology for mapping the educational content to the units of the existing curriculum and grouping the educational content according to the teaching units of target subjects is required.

The fifth step which is needed for the validation of the approach is action research—deployment of the developed system in testing schools for teachers and students to use it. Questionnaires have to be specified to identify the main advantages and disadvantages of the developed system by using text encoding and statistical analysis. The aim of the teachers' evaluation is to ensure easy use of the system, while experimental action research is an activity within which the system is handed over to users (teachers and students) in their own environment (classroom) with instructions. At the end of use, researchers should collect data from teachers and students through questionnaires and interviews. Data analysis can be done by statistical and text encoding methods to identify key challenges in the functioning of the system. Once all of these research steps have been conducted, the results implemented in practice could enable a happier and more motivated school attendance of students.

6. Conclusion

In this chapter we have presented a literature review proving the advantages of using digital games in schools, discussed the problems of using games as a teaching tool in practice, and presented the solution based on cloud gaming. We showed that while the advantages are clear, there are significant challenges in applying the use of digital games in schools in practice. We present a possible solution based on the concept of cloud gaming—streaming of live game video to end users' devices, whose video is created in real time based on the results of user commands. We showcase how the cloud gaming approach solves the number of current issues, but we also define research problems which this approach poses. We present a detailed roadmap of the research which needs to be conducted in cooperation of educational and technical research.

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Author details

Mirko Sužnjević[1]* and Maja Homen[2]

1 Faculty of Electrical Engineering and Computing, University of Zagreb, Zagreb, Croatia

2 Faculty of Teacher Education, University of Zagreb, Zagreb, Croatia

*Address all correspondence to: mirko.suznjevic@fer.hr

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