Enabling Video Games in Education Through Cloud Gaming

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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. In cloud gaming, the game is completely stored and played on a server located on a cloud with a high-definition video sent to the client, and user commands sent to the server. 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 paper. These challenges include Quality of Experience based optimization for video coding based on network constraints, simplification of procedures for usage of the platform for students and teachers, and methodology for content adaptation and creation. This paper presents a roadmap of research which needs to be conducted in order to develop a cloud gaming system which can be used in education.

***Key words**: cloud gaming; education; video games; quality of experience; optimizations*

Introduction

The use of digital games in education has been the subject of research for many years and their usefulness has been confirmed by research Squire (2003); Van Eck (2006); Charsky, D. & Mims, C. (2008); Duncan, I., Miller, A., & Jiang, S. (2012). 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 (Biagi & Loi 2013). Newest research done by Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016) and Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016) also confirmed that digital games can improve communication skills, adaptability and resourcefulness in elementary school students and even in university students (Barr, 2017). This field has been the subject of a large number of research projects in the recent years, which have been summed up and evaluated in a European Schoolnet study (Wastiau, P., Kearney, C., & Van den Berghe, W., 2009). 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 analysed projects also show increased knowledge about the taught subjects. Increased mathematical knowledge has been demonstrated in DANT and The Consolarium projects (Groff, J., Howells, C., & Cranmer, S. (2012). Through its research

institute 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 [8][9], and it finances projects related to the use of video games in education. The Gaming Horizons project has been studying the role of digital games in culture, education and economy. The final report states that video games can create new learning opportunities that are more focused on the student, thanks to their motivational capacity and motivational strength (Bleumers, L., All, A., Mariën, I., Schurmans, D., Van Looy, J., Jacobs, A., ... & de Grove, F. (2012). The objective of the InLife project was to create a new gaming framework in education that will exploit the new concept of 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. The Croatian Academic and Research Network – CARNET has been implementing an e-Schools project in Croatia, with the aim of increasing the digital maturity of schools.

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, competency, qualitative and financial (Wastiau et. at. 2009). One of the main technical issues 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 process such a large number of operations and show virtual scenes of video games in real time. The heterogeneity of tablet devices in terms of operating systems and technical features (e.g. display size, storage, processor speed) is also a problem. Competency issues relate to teachers and the lack of information on using video games in teaching and the question 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 – computers and games – for which teachers do not have quality competencies. The qualitative group of problems is related to the lack of appropriate educational games, which are mostly significantly inferior to games that are developed exclusively for entertainment purposes (Stewart, J., Bleumers, L., Van Looy, J., Mariën, I., All, A., Schurmans, D., ... & Misuraca, G. (2013). Financial problems include financial justifications for the development of serious games – the market is far smaller and harder to reach, and the lack of information and bad 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. Additionally, the cost of purchasing one game per device can be a major burden to school budgets.

The aim of this paper is to present a research roadmap to a possible solution for all of these problems based on the concept of cloud gaming. We present the concept of cloud gaming and how it could tackle many of these problems. Besides briefly explaining the technical concepts and solutions, we focus especially on the issue of content creation and its application in the educational environment. We also focus and present in detail the existing research challenges which need to be solved before such a solution is set to be deployed.

Cloud gaming

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 advantage of this approach is that only video content is displayed on the client's device. This computationally less demanding functionality is generally supported by mobile devices, and it is independent of the operating system of the client's device. The most important disadvantage is that the client has to be connected to a network that has a very high bandwidth (one stream goes up to 50Mbit/s) and very low network latency (less then 70ms 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) cannot be applied in this case because they introduce additional latency into the system, i.e. they reduce its interactivity and the Quality of Experience (QoE).

There are currently several commercial platforms for cloud gaming on the market, such as GeForceNOW, PlayStationNOW, Vortex etc. This field is very propulsive, so even some of the largest companies on the ICT market, such as Microsoft and Google, announced their Xcloud and Stadia platforms. The research field is very dynamic and deals with the following key issues: 1) virtualization of graphical resources (Shea, R., & Liu, J. (2013), Zhao, Z., Hwang, K., & Villeta, J. (2012); Qi, Z., Yao, J., Zhang, C., Yu, M., Yang, Z., & Guan, H. (2014), 2) new video encoding methods adapted to the needs of highly interactive applications (Shi, S., Hsu, C. H., Nahrstedt, K., & Campbell, R. (2011); Wu, J., Yuen, C., Cheung, N. M., Chen, J., & Chen, C. W. (2015); Lee, K., Chu, D., Cuervo, E., Kopf, J., Degtyarev, Y., Grizan, S., ... & Flinn, J. (2015) and 3) the optimization of the QoE based on available resources, whether they are network related (Jarschel, M., Schlosser, D., Scheuring, S., & Hoßfeld, T. (2011); Lee, Y. T., Chen, K. T., Su, H. I., & Lei, C. L. (2012), related to the game type (Jarschel, M., Schlosser, D., Scheuring, S., & Hoßfeld, T. (2013), or related to the distribution of virtual machines Hong, H. J., Chen, D. Y., Huang, C. Y., Chen, K. T., & Hsu, C. H. (2013). One of the main research problems in cloud gaming is optimisation of the end user's QoE taking into account available server, client, and primarily network resources.

Cloud gaming in teaching – research problems

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." (Vlada R.H., 2013. Strategija obrazovanja, znanosti i tehnologije). 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 the potential replacement for paper textbooks in schools. Some of the advantages of mobile tablet devices over the textbooks include: faster learning (Perotta, 2018), reduction of physical load on children who are overloaded with the weight of textbooks (Federal Communications Commission, 2012), the availability of a large number of textbooks in digital form, new approaches to learning and more.

The cloud gaming concept has the potential to solve most of the above problems: the heterogeneity of user devices and their processor power are not a problem, because only video streaming is shown to the clients; teachers do not have to maintain the IT infrastructure because games are stored on a cloud; the platform allows a large number of students to use the same game license, and the developers gain a unique platform for which they develop one version of the game and gain access to a large number of potential users. Previous research in optimizing the QoE of cloud gaming (Jarschel et. al., 2013; Hong et. al. 2013; Slivar, I., Skorin-Kapov, L., & Suznjevic, M. 2019M; Slivar, I., Sužnjević, M., Skorin-Kapov, L., & Ilić, V. 2016) has not taken into account the specific characteristics of the educational environment, but was

based only on the case study of using games in the entertainment context. Cloud gaming offers the potential to solve these problems, but also brings a series of research challenges. The case study of using cloud gaming in classrooms has its own specific user and technical requirements and limitations (e.g., 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 1 illustrates the functionality of the cloud gaming concept with application in education as well as open research questions.

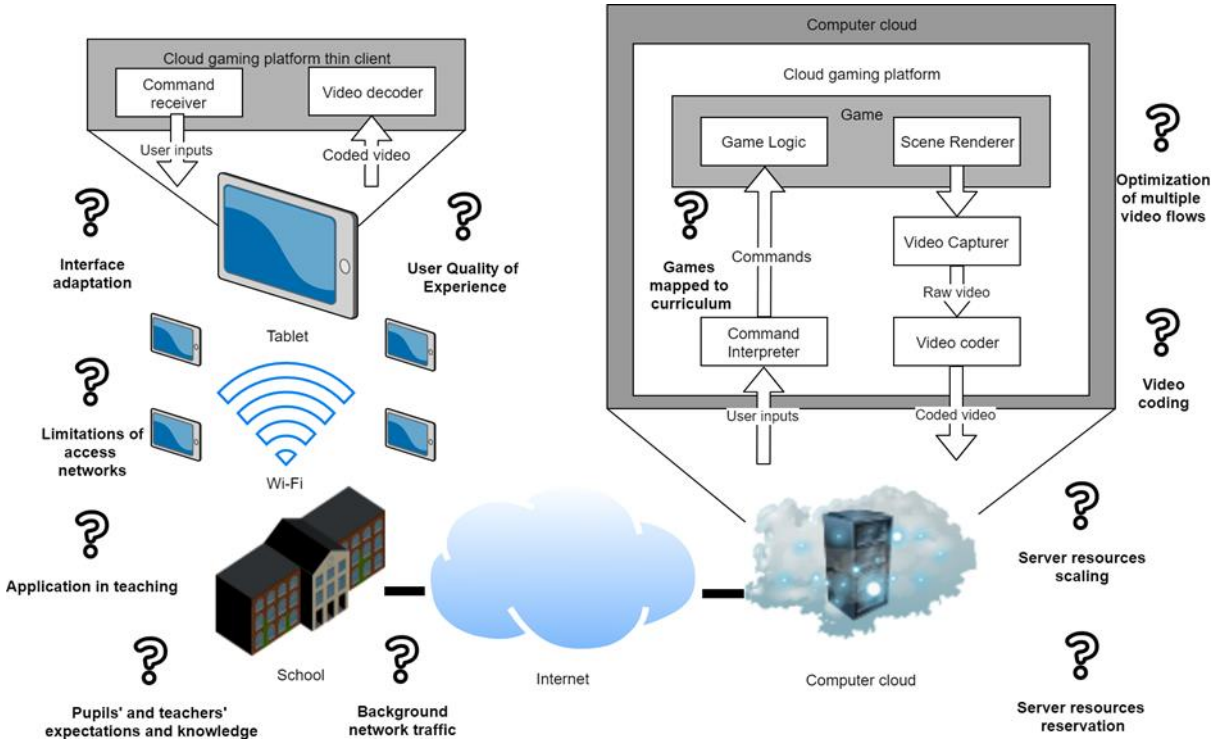

Figure 1 Research questions related to the cloud gaming concept with application in education

Cloud gaming in teaching - methodology of the proposed solutions

The interdisciplinary nature of the research problem requires an approach that will combine technical research with social research in the field of educational application of advanced technical tools. The goal of the methodology is to create cloud gaming platform with specific purpose for streaming games in the classroom as well as devise a methodology for adding appropriate content to the platform. The content may be newly developed, or existing content could be adapted. We propose an approach composing of the groups of basic research activities illustrated in **Error! Reference source not found.**.

The first step in this research would be to define a system specification based on the information collected from teachers and students. This data would be collected through surveys in cooperation with UNIZG-UF and their mentoring schools. Surveys specification has to be performed for these activities. 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 this data would be analyzed by statistical methods. The design and development of the first version of the system could be based on the defined specification.

The second step is to identify the first test games. Available games could be reviewed with a special emphasis on games in Croatian or those that can be localized. The research question is how to identify an educational game and a commercial game that can be used in the educational context, as defined in Bleumers et.al. (2012) and Stewaer et.al. (2013).

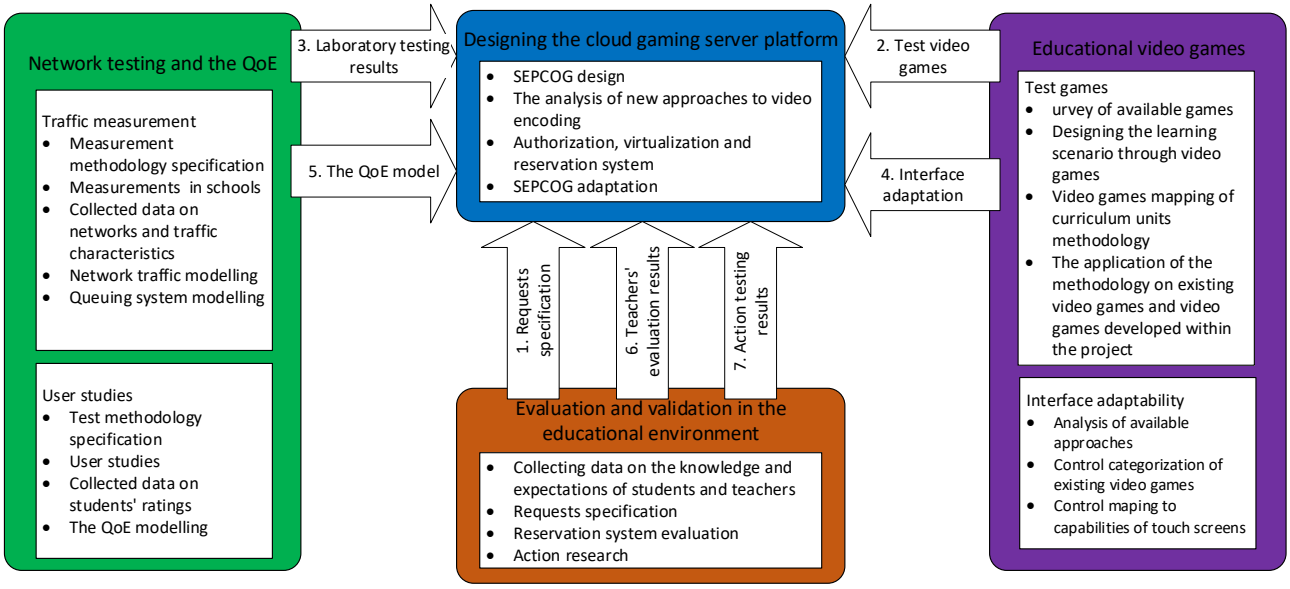

Figure 2 Research methodology

A possible scenario would be a joint developing of the game between teachers and students. Such a scenario may be based on a game development system would be simple enough for children to use. The games for, e.g. understanding physical phenomena, mathematical games and the like, could be generated through this scenario. For this, a methodology for mapping 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 and the establishing of non-unique relations to the teaching units. This is a major research question. 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 have to be analyzed, and the availability of content in Croatian has to be investigated. 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.

The third step would be the iterative subjective laboratory testing of the QoE depending on the network parameters and video encoding parameters, as well as 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 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. The development of a methodology for mapping educational content to the units of the existing curriculum and grouping the educational content according to the teaching units of the targeted subjects is required.

The fifth step which is needed for the validation of the approach is action research. 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. It is very important that the establishment of ICT infrastructure in schools is supported by the introduction of services that will use this infrastructure; this is shown on the example of Turkey (Isci, T. G., & Demir, S. B., 2015), which introduced infrastructure to schools without innovative services and has not yielded significant results in the improvement of the educational process.

Conclusion

In this paper we have presented a literature review proving the advantages of using digital games in schools. 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. 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 researches with the focus on the methodology for content creation – which games can be used and how to adapt their interfaces for use on mobile devices. It is important to note that teachers will play a crucial role here, because this potential project could succeed only with their expert help and didactic knowledge.

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Uvođenje videoigara u obrazovanje s pomoću računalnog oblaka

Sažetak

Primjena videoigara u obrazovanju već je godinama predmet istraživanja, a njihova korisnost potvrđena je brojnim studijama i znanstvenim istraživanjima. Standardizirana ispitivanja, poput PISA-testa, pokazala su da su ispitanici ostvarili bolje rezultate u čitanju, matematici i fizici ako su se više služili računalom za igranje videoigara. Dokazano je da primjena videoigara u obrazovanju povećava motivaciju učenika i poboljšava nekoliko ključnih vještina – društvenost, intelekt, reflekse i koncentraciju. Unatoč tomu, postoji niz zapreka u primjeni videoigara u obrazovanju, a one se mogu kategorizirati kao tehničke (mrežna ograničenja i ograničenja krajnjih uređenja), kompetencijske (znanje nastavnika u tom području), kvalitativne (manjak visokokvalitetnih edukativnih igara) i financijske (visoki troškovi nabavke igara i opreme). Računalna arhitektura novog doba koja omogućava igranje videoigara, kolokvijalno znana kao „igranje putem računalnog oblaka“, ima potencijal za rješavanje većine postojećih zapreka u primjeni videoigara u obrazovanju. Kod igranja videoigara putem računalnog oblaka, videoigra je u potpunosti pohranjena i igra se na serveru smještenom u računalni oblak; korisnik pritom prima video visoke razlučivosti, a server prima korisnikove naredbe. Dobro osmišljena platforma za igranje u računalnom oblaku omogućila bi besprijekornu i jednostavnu uporabu učenicima i nastavnicima. Igranje videoigara putem računalnog oblaka riješilo bi većinu postojećih problema, ali i donijelo nove istraživačke izazove, kojima se ovaj rad bavi. Među te izazove ubraja se optimizacija videokodiranja temeljena na kvaliteti usluge s obzirom na mrežna ograničenja, pojednostavljivanje procedure uporabe takve platforme za učenike i nastavnike te metodologija stvaranja i prilagodbe sadržaja.

Ključne riječi: *igre temeljene na računalnom oblaku, iskustvena kvaliteta, obrazovanje, optimizacija, videoigre*