

Students' Perceptions during Integration of Computer Games in Primary Education: QoE Analysis

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ABSTRACT

The integration of computer games in the primary school program is a challenging task which requires changes in the pedagogical approach and teaching practices. Since it is important to understand students, this study follows student-centered approach while evaluating different variables in computer game enhanced classes, which impact the overall students' Quality of Experience (QoE). We involved a total of 114 students in several primary schools in Macedonia which participated in traditional and game-based learning environment. Students' feedback was collected through surveys and the data set was analyzed with a path analysis model that illustrates relationships between relevant variables which influence students' QoE in classes enhanced with computer games. We found that students' motivation mostly influenced students' QoE, which was also determined by the increased effectiveness and simplified way of learning. The research results correlated students' QoE and learning outcomes during integration of computer games in primary schools, which were altogether increased against the traditional environment.

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1. INTRODUCTION

Games have been played for fun and entertainment through the human history, but were also recognized as a potential learning tool [1], [3]. The social activities and collaboration during game-play can be used in the educational environment to increase students' involvement in learning process, since sharing one's ideas and responding to others' reactions sharpens thinking and deepens understanding [2], [4]. Furthermore, the active engagement of the student through learning by doing, goal-oriented and constructivist learning activities creates an experiential learning environment which increases the level of students' achievements [5].

On the other hand, the rapid development of the emerging technologies in the last decade has increased their implementation in different areas of modern society. Information and Communication Technology (ICT) provides resources and different tools, which extend opportunities for creation, management and distribution of information among involved parties. Therefore ICT may highly contribute in the field of education, where communication of knowledge and information is extremely relevant, while creating a powerful learning environment which can improve students' learning experience and enhance teaching methods. These new technologies can provide benefits for teachers to increase effectiveness and flexibility, support easier planning and lessons preparation, while adapting the learning content to new ideas. The integration of computer games in the learning environment can combine the positive aspects of learning through game-play incorporated with latest technologies towards higher level of cognitive learning outcomes

[6], [7]. Due to tremendous popularity of computer games, especially among young population, students' motivation can be increased while learning in a technology-enhanced setting and student-centered environment, compared to the traditional classroom.

Still, there are different aspects which are significant while designing and planning technology-enhanced learning systems which can include computer games as an instructional tool. Some of the instructional design issues related to learning goals, like authentic vs. abstract problem solving [9], can influence the final success of the learning process. Furthermore, the real implementation of the technology and game-play in the education demands changes in teaching style, changes in learning approaches, instructional guidelines and access to information [8], [33], [35].

In this study, we explore the utilization of the information technology in primary education, by introducing computer-simulated traditional children games into the learning program, thus enhancing the learning curriculum. These games are implemented through different technological tools, making an interactive learning experience for the young population in their classroom activities. The study's primary goal is to distinct relevant factors which influence positive students' experience and provide relationship among different variables while the game-based learning activities are introduced in the primary school education. We have evaluated this learning approach in several primary schools in cities and villages, so we can provide relevant information when the technology is used in different environments, with students having different experience with the latest technology. In this study, we follow student-centered approach, while exploring social element and students' subjective expectations, in terms of Quality of Experience (QoE) [11]. In recent years QoE [10], [12] has emerged as a full scale evaluation of the technological implementations in terms of end-user expectations, so we believe the provided results can give relevant information for future development and successful integration of technology into the learning process. We have also compared students' learning outcomes between the technology-enhanced game-based learning environment and the traditional classroom, so we can see if students' QoE can be co-related with the learning achievements.

This article is organized as follows: section 2 provides related literature and the novelty of our approach, research methodology and a case study on this topic is presented in section 3, section 4 provides actual results and analyses, while section 5 concludes the article.

2. RELATED LITERATURE

The educational process should be constantly improved to reach higher level of students' perceived knowledge according to their potential. Therefore different approaches, methodologies and teaching practices must be adopted and put into practice so positive results can be achieved at the end. The ICT offers different perspective, but some studies [13], [14], [16] already show that teachers are not integrating technology sufficiently as a teaching/learning tool. Teachers are generally very professional and are committed to provide quality education to their pupils, but these studies show several problems which usually occur when new technologies and changes have to be introduced in the educational process.

On the other hand, the social constructivist theory [22] suggests that unlike the conventional lecturer, the teacher should create a context for learning which will engage the students in interesting activities that encourages and facilitates learning. The constructivist approach stresses that knowledge is constructed by children from their own experiences, such as via problem-solving tasks, games and simulations. Having in mind that the student's knowledge is actively constructed by the student himself, learning outcomes significantly depend on the students' internal motivation to understand and promote the learning process. Since the content that needs to be learned by students is not always motivating to them, it makes sense to merge the content of learning and the motivation of games [5], [17], [18]. The computer-simulated games and learning have increased their mutual connection in the recent years. Different games were developed to provide instructional, problem solving challenges and testing of specific skills [3], [19]. Graphical representation, models and modeling are very helpful to learning [15], [30] because they allow certain aspects of students' experience to be incorporated in the problem solving, making the abstract problem more concrete and understandable to the students. Games possess interesting graphical representation and are usually built on certain models, which makes them appropriate for the learning process. Despite the advantages that game-playing can contribute to the learning process, there is also an important gap between theory and practice for effective integration of games in the educational programs, due to different barriers for implementation [23], [33]. Although certain skills, such as problem-solving ability increase within a game, the real challenge comes when these skills and learned content have to be used outside of the gaming environment [20]. Different studies [20], [21] have shown modest to low evidence, when gamed learning skills or content are transferred outside of the digital environment.

Even though QoE has become popular among researches that focused on the social element and end-users' expectations [10], [24] - [26]; there are lot of inconsistencies regarding identification of factors

which influence actual users' QoE. Furthermore, research studies that evaluate students' QoE during integration of computer games in the educational environment are almost non-existent, which requires additional efforts towards a proper student-centered approach and relevant analyses.

Our study researches implementation of specific technology enhanced games in the certain primary education schools in Macedonia, while evaluating different variables which can influence higher level of positive students' QoE and increase Quality of Learning (QoL). The novelty of our approach is that specific games are selected, which children, their parents or grandparents played without the use of technology, enhanced through proper ICT implementation and adopted accordingly in the everyday learning environment. The research was conducted in several primary schools in different cities and villages in Macedonia. Teachers in these schools found proper way to embrace the new technology and enhance the standard state primary school curriculum with computer games, properly chosen for the specific content.

We believe that the idea of learning through games can improve the learning process, if the computer games are developed to incorporate adequate pedagogical components, based on didactic principals as highly organized and properly guided pupils' activities. We follow this idea in this study, while trying to present research findings that support it. The learned skills and content through such learning activities can be successfully transferred outside of the gaming environment with increased students' motivation and QoE, which inevitably leads to increased learning outcomes.

3. RESEARCH METHOD

The simulations and computer games may deeply contribute in creation of a powerful learning environment in numerous ways. Traditional classroom education, without the utilization of the technology is no longer considered as adequate preparation for future development and successful life in general. Having in mind future challenges we have to analyze different approaches, priorities, obstacles and strategies for integration of computer games into the everyday learning process of primary school children and their teachers. Our study tries to tackle these issues and provide positive example where computer games can be incorporated in the primary school educational program. During the process of planning, organizing and even programming of the games, we focused on proper connection of theory and practice, adaptation of the games according to students capabilities, their school activates, emotional interest and relation to their everyday life routine. Our efforts were especially aligned towards the goals and principles of the educational component of each involved school subject, in respect to the state educational program in Macedonia.

This approach which integrates the computer games in the learning environment offers exclusive possibility to transfer the learning process into maximum mental and physical activity of each student, while the learned skills and content through the games can be successful transferred outside of the digital environment. The traditional classroom learning offers little physical activities and interaction among students. These lessons tend to be static and monotones, which decrease students' focus on the subject's content and motivation to learn.

We have basically chosen to use games which can be adapted to incorporated technological advantages into the pedagogical practice and provide optimal involvement of the student, which can be mentally and physical challenging. Besides focusing on proper pedagogical planning and implementation of the games in the school classes, this study also follows student-centered approach while determining the relevant factors which influence the positive level of students' experience (QoE) during these innovative changes, comparing them to the traditional classroom education on the same subject with similar content.

During the study we have identified several primary education schools in different cities and villages in Macedonia. These schools have the capabilities to transition, from the traditional priorities and conventional learning goals, into an approach that changes the way of teaching, while engaging teachers to use computer games and fulfill the schools' highest ambitions for their students. They worked on similar school subject, while performing one activity enhanced with a computer game and similar activity with the traditional teaching method. The students involved in these activities were from 10 to 12 years of age, which mostly use computers and technology regularly in their everyday life for different purposes.

A survey was developed, which was distributed to students after class, both traditional and with computer games, to gather students' subjective opinion on different subjects. They were able to grade different questions on a scale from 1 to 5, where 1 is strongly disagree and 5 is strongly agree on each question. The surveys were conducted online after class, while the responses from different schools were collected in a central database for further analyses and results. As a result of the students' responses we have identified several variables which illustrate their opinion regarding the traditional and non-traditional class. These variables are: simplified way of learning during the class, motivation to learn, quicker and effective learning, and students' subjective QoE during the learning sessions. Table 1 shows the research variables and their description in the surveys' questionnaire.

Table 1. Input variables from the students' responses

Variable Name	Description in the questionnaire
Simple	Students' think the learning is more simplified this way
Motivation	Students' were motivated to learn through this approach
Quick	Students believe they can learn quicker and more effectively this way
QoE	Student's overall experience from the class

The students' feedback regarding these variables can show how they are connected among each other and results can be compared for differences in the traditional and computer game enhanced class. The research variables provide sufficient information for proper QoE analysis and are used for further research, factor correlations and hypotheses development regarding students' perceptions during integration of computer games in primary education.

Hence, we have formulated the following hypotheses:

- *Hypothesis 1:* The simplified way of learning through computer games influences students' motivation to learn (*H1a*) and increases effectiveness for quicker learning (*H1b*);
- *Hypothesis 2:* The motivation to learn during the class enhanced with computer games increases the level of positive students' QoE during the class;
- *Hypothesis 3:* The effectiveness (*H3a*) and simplified way of learning (*H3b*) also influence students' QoE from the non-traditional class.

Consequently, we have used the observed variables regarding classes with computer games and the proposed hypotheses to construct a path analysis model, which explores the relationships between variables and defines how students' QoE is predicted as a combination of the other observed variables (Figure 1).

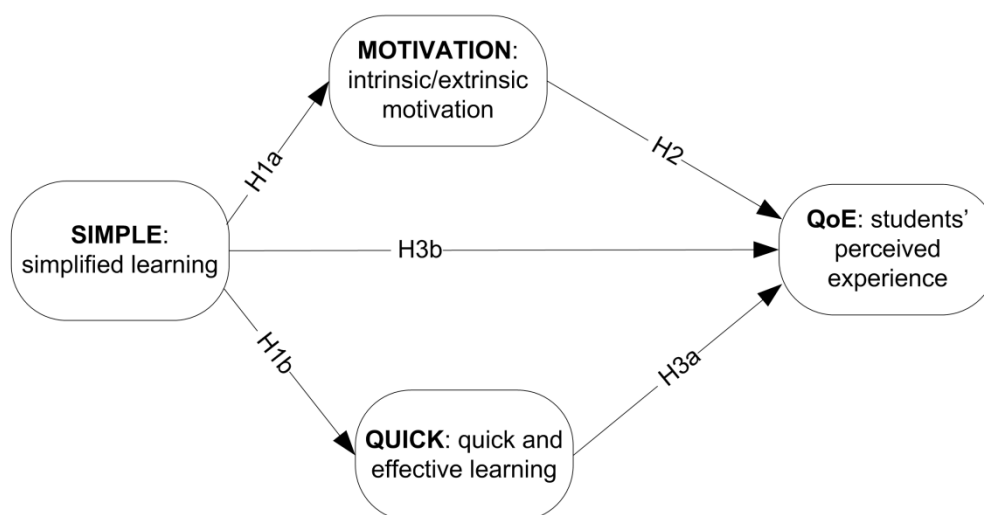


Figure 1. Hypothesized path analysis model with relationships between observed variables

In our methodological approach, we have subjected the researched model to a statistical analyses using Statistical Package for Social Sciences (SPSS) and Analysis of Moment Structures (AMOS) software. The quantitative numbers retrieved from the surveys' database can show the proper model fitting and testing of our path analysis model and explore its relevance in a real environment.

We were also able to analyze if the computer games provided higher level of perceived students' knowledge, through quick evaluations at the end of each class and compare it in both environments.

Further analysis is conducted through a case study on a specific subject and content, which gave us possibility to test our methodology and proposed path analysis model, provide preliminary results on the relations among observed variables and justification of the proposed hypotheses.

3.1. Participants and Case Study Design

Following the methodology of this research study, we have organized a case study while incorporating a specific computer game, for a specific subject in several primary education schools in Macedonia. The schools that participated in this case study are situated in the capital city and two villages,

more precisely OU "Ss. Cyril and Methodius" in Skopje, OU "Mancu Matak" in the village Krivogastani, Prilep and OU "Petar Pop Arsov" in the village Bogomila. Therefore, we were able to sample students from both rural and non-rural environment. The total number of evaluated students was 114, which included children at age 1112, 46% male and 54% female. 92.1 % of these children use computers on daily basis, 7.02 % use computers two-three times a week, while only 0.88 % never used computers. Even though these participants live in different environments, this sample of students can be considered highly familiar with technology, representing the global situation in primary schools in Macedonia.

For the purpose of this case study we have chosen mathematics as a subject for evaluation. The content included lessons on the study of the metric system. During this part of the educational curriculum on this subject, students have to learn how to convert standard units of length, weight, volume, and temperature in the metric system.

We have chosen to use traditional class while teaching students weight metric conversion (kilograms, grams etc.) and a class with computer game for the length metric conversion (meters, centimeters, millimeters etc.). A traditional game named "Zavor", in which participants throw a ball into a distance, measuring each participant's score for the length of the covered distance, was chosen for class for length metric conversion. Special game program according to traditional game was developed for Microsoft Kinetic, which is a motion sensing input device by Microsoft for the Xbox 360 video game console, present at all involved primary schools. With this computer game, students could play "Zavor", by throwing a virtual ball into the distance, while the length of the covered distance is displayed on the screen in different metric, first in meters, centimeters etc. This game was properly aligned to the curriculum, while students were involved in mental and physical activity. During the computer game based class all of the students were completely involved, learning the metric conversion content, which can be totally abstract to children at that age, in an innovative and motivating environment.

Figure 2 illustrates one of the classes where "Zavor" was played with the Microsoft game console.



Figure 2. Game "Zavor" played during a metric conversion class

The first student's impression after the class was their positive experience because new technology and physical activities were involved. Still deeper analyses regarding the learning benefits and the factors for possible increased level of students' QoE have to be conducted. Following our methodology, we have conducted the necessary surveys after the traditional and non-traditional classes in the involved primary schools and gathered students' evaluations data on previously described variables.

The gathered results on all of the variables were compared among the traditional and non-traditional class. Both types of classes were on the same subject and content, so we could provide relevant quantitative analysis and comparative numbers for the different learning methodologies. These results can point out if the computer based class provided better learning experience to the students and does this unique approach really makes a difference in the primary education. Furthermore, the variables listed in Table 1 were subjected as observed input variables in our path analysis model (Figure 1), so we can elaborate the relationships and regression weights among them, test our hypotheses, while defining how students' QoE is predicted in the non-traditional learning environment.

Student's learning outcomes were also measured through quick evaluations after each class, so they can be compared between the traditional and game-based environment. Even though deeper QoL analysis is out of scope of this study, we used this information to correlated learning achievements with students' perceived QoE in the different learning conditions.

4. RESULTS AND ANALYSIS

It is globally accepted that education quality may improve through the promotion of technology integration. Still the technology use in classrooms does not necessary means that it is properly aligned to learning curriculum and teacher's believes as one of the factors for technology integration [27]. Our research study explores the idea of incorporating proper computer games into the primary education classes, while evaluating the students' experience. But this research also tries to generate constructive practices and positive examples where teachers play important role in proper technology integration which should improve the educational quality. The case study was performed according to our methodology and the obtained results are analyzed in the effort to support our claims.

The students' feedback from the questionnaires was analyzed and results were compared among the same children who attended the traditional class and the class where the game "Zavor" was integrated in the learning environment. While participating in both types of classes, on the same subject, these students could express their subjective experience, which gave us relevant information for comparison purposes.

4.1. Descriptive Statistics

Through evaluation of the statistical data from the students' responses we can draw immediate conclusion if the introduction of the computer games provided positive change in the learning environment and influenced higher level of students' perceived QoE.

The summary of the students' responses regarding the researched variables and their reliabilities during the traditional class is represented in Table 2.

Table 2. Statistical information regarding the variables and their reliabilities for the traditional class (n = 114)

Variable Name	Min / Max	Mean	Median	Standard Deviation	Skewness	Kurtosis
Simple	1 / 5	3.25	4.00	1.443	-0.425	-1.155
Motivation	1 / 5	3.25	3.00	1.277	-0.289	-0.815
Quick	1 / 5	3.50	4.00	1.311	-0.455	-0.938
QoE	1 / 5	3.38	4.00	1.376	-0.409	-1.083

Students' responses covered all possible grades from 1 (strongly disagree) to 5 (strongly agree) on different variables, but generally these responses were constructive with low standard deviation. From the statistical point of view, to evaluate the normality of the surveys' data, we need to look at the skewness and kurtosis, having in mind that absolute values of skew > 3.0 are described as "extremely" skewed and kurtosis absolute values > 8.0 suggest a problem [28]. Therefore the surveys' data presented in Table 2 provides relevant information from the traditional class.

Table 3 lists the statistical information regarding variables during the class with the game "Zavor" and the necessary parameters for the normality of the data.

Table 3. Statistical information regarding the variables and their reliabilities for the class which included the game "Zavor" (n = 114)

Variable Name	Min / Max	Mean	Median	Standard Deviation	Skewness	Kurtosis
Simple	2 / 5	4.46	5.00	0.824	-1.488	1.480
Motivation	2 / 5	4.30	5.00	0.849	-1.034	0.286
Quick	1 / 5	4.39	5.00	0.862	-1.442	2.182
QoE	2 / 5	4.40	5.00	0.849	-1.669	3.182

The results show significantly higher students' grades on all observed variables when the computer game was introduced in the learning environment. Therefore it is evident that the game-base learning condition increased the positive level of students' perceptions. The lower values for standard deviation in Table 3 represents lower errors from the mean scores and the skewness and kurtosis values indicate that surveys' data from this approach was relevant too.

4.2. Results of the QoE Path Analysis

The hypothesized model was also subjected to the students' responses and tested to see how closely the model matches the data. Figure 3 illustrates the proposed path analysis model with relationships and regression weights among the observed variables during integration of computer game in the class.

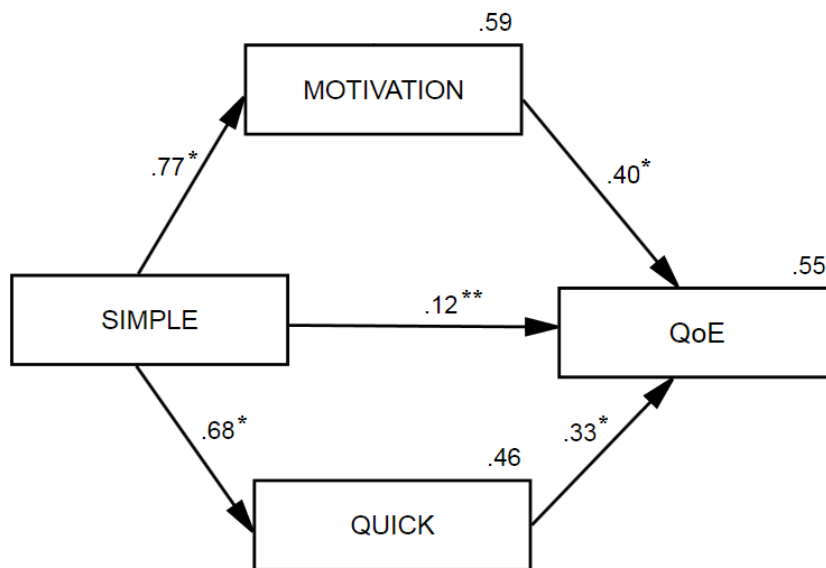


Figure 3. Path analysis model with regression weights among variables (* $p < 0.001$, ** $p < 0.005$, two-tailed)

The produced values for the necessary indicators: CMIN/DF = 0.002 (relative chi-square where smaller values are preferable [29]); CMIN = 0.002; GFI = 1.00 (Goodness of Fit Index which should exceed 0.9 for good model [31]); RMSEA = 0.00 (Root Mean Square Error of Approximation where smaller values below 0.08 are preferable [32]); indicate proper model fit and alignment between the hypothesized model and the collected data. The path between Simple and QoE reported $p < 0.05$, while the rest of them reported $p < 0.001$ which means that all of them are statistically significant (paths with values for $p > 0.05$ are usually considered not relevant).

The results show close connection among Simple and Motivation (0.77) and Simple and Quick (0.68), which fully supports *Hypothesis 1*. The QoE variable is significantly predicted by Motivation (0.40), which leads to conclusion that the students' motivation for learning during the class with included computer game mostly influences positive students' QoE (*Hypothesis 2*). These findings support the outcomes of certain studies which stress the importance of students' motivation during game-based learning [17], [18]. Furthermore, we have found that QoE is also predicted by Quick (0.33) and Simple (0.12) (*Hypothesis 3*). Even though the regression weight between Simple and QoE is low, the model reports high indirect connection among these variables (0.55), due to the close connection between Simple/Quick and Simple/Motivation. The increased level of positive students' QoE is in-line with the social constructivist theory [22], since the integration of computer-simulated traditional children games in the classroom really influenced students' perceptions.

4.3. Learning Outcomes

Having the model for students' QoE prediction during integration of computer games in the classroom environment, in the course of our research activities we have evaluated the results from the quick evaluations after the traditional and game-based classes. The learning outcomes were measured via students' scores after the performed test evaluations and students' interest in the classroom activities. The teachers assessed the students by grading these aspects from 1 (poor) to 5 (excellent), with results listed in Table 4.

Table 4. Descriptive statistical information for students' learning outcomes (n = 114)

Indicator	Traditional Class			Gama-based Class		
	Min/Max	Mean	S. Deviation	Min/Max	Mean	S. Deviation
Test Score	2/5	4.17	1.088	2/5	4.52	0.885
Interest	2/5	4.11	1.103	2/5	4.41	1.020

The descriptive results demonstrate higher mean value on both performance indicators during classes with game-based activities, which correlate with the increased level of positive students' QoE in the same learning conditions. From the pedagogical point of view, we have also found that the students showed

better understanding of the content during the non-traditional class, especially since the practical presentations of the material through the game, enabled students to deeper understand the abstract content and use it outside of the learning environment.

Even though the descriptive statistics illustrate difference in the learning outcomes, we have performed a non-parametric Mann-Whitney U test [34] with SPSS and chose the environment as a grouping variable, while testing students' performance samples to further compare indicators. The test results, with confidence level of 95%, are presented in Table 5.

Table 5. The Mann-Whitney U test statistics while comparing students' performance in both environments

Statistical test	Test Score	Interest
Mann-Whitney U	5351.500	5416.000
Wilcoxon W	11906.500	11971.000
Z	-2.701	-2.490
P-value (Asymp. Sig. two-tailed)	0.007	0.013

The result shows that the p-values for the performance indicators are lower than the alpha value of 0.05, which confirms that the difference in the learning outcomes between the traditional and game-based learning environment is statistically significant. In line with the descriptive performance statistics, the Mann-Whitney U test provided findings that correlate students' QoE and learning outcomes during integration of computer games in primary schools, which are altogether increased against the traditional environment. Therefore it validates the significance of this study, since the QoE analysis and the results provide actual information about the students' subjective factors, which have to be taken in consideration for the improvement of the learning process and suggest incorporation of this new and innovative idea in the primary education practice.

5. CONCLUSION

In this study we have presented a novel approach for integrating computer games in the primary educational program. Following the student-centered approach we have focused on positive students' experience, a key driver of technology acceptance, adoption and usage behavior. We have provided a path analysis model that predicts students' subjective QoE in similar environments, as a combination of the proposed influential factors which were relevant in this research study. The results of the performed case study fully supported our methodology and presented model, while providing relevant information for successful implementation of computer games in the learning process.

Consequently, we have demonstrated that game-based learning environments provide increased level of quality of the learning experience compared to the traditional classroom, influenced by students' motivation, quicker and effective learning. We also found that students' learning outcomes in the different learning conditions correlate with students' QoE, thus validating the importance of the QoE prediction model.

In our future work, we will continue to use the proposed methodology while enlarging the scope of work in different directions. We will evaluate benefits and students' experience when computer games are introduced in primary educational classes with subject like language, arts, science and mathematics, provide comparative analyses and test for the model behavior. Following the technology oriented approach, our future work will include involvement of distance education tools like videoconferencing and streaming media, integrated with properly selected computer games. We will also focus on meaningful QoL analysis in similar learning environments.

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