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An ANFIS model of quality of experience prediction in education

Tatjana Vasileva-Stojanovska*, Marina Vasileva, Toni Malinovski, Vladimir Trajkovik

Faculty of Computer Science and Engineering, Ss. Cyril and Methodius University, Skopje, Rugjer Boshkovik bb, PO Box 574, 1000 Skopje, Republic of Macedonia

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ABSTRACT

This paper presents a Quality of Experience (QoE) prediction model in a student-centered blended learning environment, equipped with appropriate technologically enriched classroom. The model uses ANFIS technique to infer the QoE from the individual subjective factors and the objective technical factors which altogether influence the perceived QoE. We explored the influence of subjective personality traits extroversion and neuroticism, as well as the learning style on QoE. The objective factors included in the model are technically measurable parameters latency, jitter, packet loss and bandwidth affecting Quality of Service (QoS) of the underlying technology. The findings presented in this paper are obtained from a case study which involved 8 teachers and 142 students from second and sixth grade in five primary schools in the Republic of Macedonia. The teachers involved in the project introduced game-based learning strategies in classes, including on-line videoconferences, streamed video content and classical face to face gaming. We constructed three ANFIS systems with seven and four input variables and compared their performances using the RMSE, MAPE and R^2 measurements. The results showed that perceived QoE can be reliably predicted by the student's personality traits and learning style as subjective factors and network jitter as an objective factor.

1. Introduction

Education is an interactive process during which students gradually adopt knowledge, develop intelligent reasoning, judgment and skills needed for successful mature life. The subjective perception of the process by the involved participants can be expressed as a level of satisfaction. The student satisfaction with the educational process directly influences his academic performance [34]. Therefore, constant efforts are made to approximate and adapt the educational process and environment to the student's preferences, in order to ensure optimal performance for each individual. From the pedagogical point of view, the shift from classical teacher-centered toward student-centered educational models, brings the individual preferences and learning style at the center of the educational process and creates optimal environment for learners to develop their real potential.

When the educational process is aided by technology or product, the subjective measure of satisfaction is expressed as "Quality of Experience" (QoE). According to ITU-T P.10/G.100, QoE is defined as the overall acceptability of an application or service, as subjectively perceived by the end-user. Therefore, QoE derives from the complete system's effect on the user, influenced by the underlying technology as well as the user expectations and context. Having in mind the subjective nature of QoE, it is understandable why its quantification and measurement is not trivial. The literature reports multiple efforts attempting to approach the concept of QoE in terms of user perception, expectation and experience [33,35]. Classical example is the approach described by ITU-T Focus Group on IPTV in 2008 [16] which measures QoE through appropriate user tests and surveys while expressing QoE values in terms of Mean Opinion Score (MOS).

Even though the MOS method delivers the goal of subjective quality measurement, its major drawback is the low cost effectiveness. Therefore various attempts are made to "objectify" i.e. to correlate the QoE with certain parameters that can be objectively measured [25]. These parameters are classified and referred as the quality of network while delivering the service to the users (jitter, delay, packet loss, etc.) and the quality of delivered content (visual quality, audio quality, audio delay etc.). The first class of parameters quantifies a measure known as Network Quality of Service (NQoS)

* Corresponding author at: Rugjer Boshkovik bb, PO Box 574, 1000 Skopje, Republic of Macedonia. Tel.: +389 75 599 536.
E-mail addresses: tatjanav@nbrm.mk (T. Vasileva-Stojanovska), vasileva_marina@yahoo.com (M. Vasileva), tmalin@nbrm.mk (T. Malinovski), trvlado@finki.ukim.mk (V. Trajkovik).

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Table 1
QoS provisioning for interactive and streaming video.

	Interactive video	Streaming video
Packet loss	<1%	<5%
Latency (one way)	<150 ms	<4–5 s
Jitter	<30 ms	No significant requirements
Bandwidth	Overprovision the minimum-priority bandwidth guarantee to the size of the videoconferencing session plus 20 percent	Depends on the encoding format and rate of the video stream

and the second class of parameters quantifies the Application Quality of Service (AQoS). Together NQoS and AQoS comprise an overall objective measure of the network performance known as Quality of Service (QoS).

According to ITU-T E.800 [16], QoS is defined as the collective effect of performance which determines the degree of satisfaction of the end-user of a certain service. By contributing to the improvement of overall performance of the network, the QoS management improves the end-user experience with the system. System vendors provide various mechanisms for QoS management and provision, assuring that QoS in given network setup can be controlled and guaranteed in advance.

Earlier studies on QoS to QoE correlation have shown that the network level QoS parameters have bigger impact on perceived QoE than the application level QoS parameters [21,35]. Therefore in our research activities we have mainly focused on the NQoS provisioning parameters, as objective factors which influence student's QoE.

The recommendations given in the guidelines for QoS provisioning for interactive and streaming video [15] are summarized in Table 1.

Following the study of Calyam et al. [3], the values of the NQoS parameters are mapped to MOS values as given in the Table 2.

Besides the delivered QoS, the personal affinities have strong impact on the perceived QoE as well. In attempt to identify the main subjective factors affecting QoE in a blended educational environment, we found strong support in literature reporting the personality and learning style as leading factors on the student's academic performance in the classical education [2,5,7]. Personality factors (Extroversion, Neuroticism) as given in Eysenck theory [10] and certain learning styles (Reflector, Pragmatist) were statistically significant predictors of rated performance in the study of Furnham et al. [12]. Furthermore, the literature reports strong relationship between student satisfaction and academic performance [6,32], which gives a solid reason to explore the effect of personality traits and learning style on the student satisfaction as well.

The main goal of this paper is to explore the objective and subjective factors influencing and predicting the perceived student's QoE in a blended educational environment, particularly in technology aided classrooms involving videoconference (VC) and video streaming (VS) sessions in the educational process. Furthermore, having in mind the importance of satisfaction on the overall academic performance, our aim is to identify stereotypes of students depending on their personality and preferences, and offer adaptive educational scenarios to the different stereotypes, thus ensuring optimal learning environment for each particular individual. For that purpose, in our case study we involved eight teachers and 142 students from second and sixth grade in five primary schools in Republic of Macedonia. We created educational scenario in which certain parts of Math, Nature/Society and Art curricula were held in inverted student-centered manner in which students were playing games, participating in videoconference sessions and watching streamed video lessons. The choice of the sample of students to participate in this study was based on few criteria: the age of the children had to be appropriate to apply the personality tests (8–18 years old); having in mind that the resulting sample should explain QoE for a broader range of primary school students and the game based learning scenarios are considered to motivate mostly the younger children, we decided to include children from different ages yet young enough to be motivated by the given scenario. The teachers involved in the project had to be properly trained to apply the given educational scenario on the classes. The schools were chosen from both rural and non-rural areas of the country. The participants were able to express themselves through the game, to collaborate with the other students in order to complete some task, and even participate in the process of evaluation. The teacher's role was to present the objectives and to mediate, support and motivate participants. The students were learning curricula topics by playing two social games for Nature/Society classes, two logical games for Math classes and two visual games for Art classes. Every game was played in three subsequent school classes having different educational setup appropriate for each class. First class was held in a traditional face to face manner, second class involved videoconference session with peers from another school, and in the third class the students were completing tasks following instructions given previously in a streamed video session. At the end of the study, the students have completed total of 18 Math, Nature/Society and Art classes, by playing six different games in three different educational setups: a classical face to face classroom class, a videoconference session class and a video streaming session class. At the end of each class students filled a questionnaire rating the aspects of satisfaction, content, simplicity, technical setup, approach and eagerness to repeat the class experience [29].

The videoconferencing infrastructure used in our case study is based on a Polycom videoconferencing platform, which connects different locations in several primary, high schools and universities in Macedonia, with Skopje as a central site. These sites are interconnected through the MARNET (Macedonian Academic and Research Network) networking infrastructure which connects university campuses and other state educational institutions, including most of the involved primary schools. Since the schools in rural areas did not have access to this network, they used the Internet as a

Table 2
NQoS parameters to MOS mappings for VC and VS.

	Videoconference (VC)			Video streaming (VS)		
	Good	Acceptable	Poor	Good	Acceptable	Poor
MOS	4–5	3–4	<3	4–5	3–4	<3
Latency	0–150 ms	150–300 ms	>300 ms	0–3 s	3–5 s	>5 s
Packet loss	0–0.5%	0.5–1.5%	>1.5%	0–3%	3–5%	>5%
Jitter	0–20 ms	20–50 ms	>50 ms	0–1 s	1–4 s	>4 s