FACTA UNIVERSITATIS
Series: **Electronics and Energetics** Vol. 31, N° 3, September 2018, pp. 329-342
https://doi.org/10.2298/FUEE1803329R

DEVELOPMENT OF AN IOT SYSTEM FOR STUDENTS' STRESS MANAGEMENT

Branka Rodić-Trmčić[1], Aleksandra Labus[2], Zorica Bogdanović[2], Marijana Despotović-Zrakić[2], Božidar Radenković[2]

[1]Medical College of Applied Studies in Belgrade, Serbia
[2]Faculty of Organizational Science, University of Belgrade, Serbia

Abstract. *This paper shows the development of an IoT system for students' stress management. The IoT system is developed in an open architecture and is an integral part of the educational ecosystem. The system is composed of two elements: the one that enables measurement of vital parameters for identifying stress in students, and the other for stress control. The system for stress control consists of a mobile health application featuring relaxation content. Such system should minimize the excitement and have an impact on reducing future stress. The IoT system for stress management was evaluated in a real environment, during students' thesis defense on Faculty of Organizational Sciences, University of Belgrade. The results show that time spent using mobile health application with relaxing content can reduce students' physiological arousal and excitement during thesis defense.*

Key words: *Internet of Things, wearable computing, stress management, education, students*

1. INTRODUCTION

The Internet of Things (hereinafter: IoT) is the paradigm of the modern world in which people and devices are linked and communicate with each other. The human dimension of the Internet of Things leads to its role in the healthcare sector and it can change the health behavior for the better. Until present, different technological solutions have been developed with the aim of improving healthcare and conducting preventive actions [1], in various areas, including the field of stress management.

Stressful situations can generate arousal and anxiety. When a person is aroused, the body is under the stress. Stress activates the sympathetic nervous system, and its activation causes different reactions in the human body, such as the production of sweat, a heart rate increase and muscle tension. Although stress plays a positive role in performance, too much

Received November 23, 2017
Corresponding author: Božidar Radenković
Faculty of Organizational Science, University of Belgrade, Jovana Ilića 154, 11010 Belgrade, Serbia
(E-mail: boza@elab.rs)

stress or repeated stress can have negative effects. Stress has been recognized as one of the leading problems in healthcare and has a high impact on people's health. Long-term repetitions of stress manifestations in any population can be used as a predictor of other health conditions and disorders.

Research shows that the most pronounced sources of stress are in the domain of self-cognition and school life [2]. There is a frequent occurrence of stress in students during studies. It can be caused by changes in habits, separation from family members, or excitement in taking an exam [3]. Many students face a variety of stressful situations during an exam, which can negatively affect the result of the exam. At the same time, poor results frequently do not mean less intelligence or student knowledge [4]. To cope with stress moments and prevent a repetition of stress, it is important for students to manage the situation that can produce negative arousal. At the same time, providing information of arousal in students in real time to teachers is an important part to prevent stress. Such biofeedback enables teachers to adapt classes or exam method and thus make the environment that is more favorable for the student. Stress management in this domain refers to using different technologies with the aim to measure and control a person's levels of stress.

The presence of stress can be identified through the measurement of different vital parameters of a user's body with various IoT and wearable systems. Commercial IoT systems are not with open APIs, they can hardly be programmed and customized, which makes them hard to integrate with other e-education services. In order to make this integration possible, we have chosen an approach based on open architecture. An open architecture ensures that the developed IoT system for stress management becomes an integral part of an educational ecosystem. In addition, an important part of the developed system for stress management is mobile health application with relaxation content that should minimize the students' excitement and have an impact on reducing future stress.

The pilot project is evaluated in a real environment, at Faculty of Organizational Sciences, University of Belgrade, during students' thesis defense. Besides students' stress management, our motivation for this work is being raised by educational aspect, too. The educational aspect represents advocating for students to be provided with fundamentals of IoT technologies, applications, and devices. Further, an assertion is on introducing the IoT application potential, therefore students should be able to use and further develop the IoT system.

The rest of the paper is organized as follows: Section 2 summarizes previous work in the field of stress management. Section 3 is dedicated to the presentation of the development and implementation of the IoT system for stress management. Section 4 discusses the research methods for experiment setup and data collection. Experimental results and discussion are provided in section 5. Section 6 concludes the paper.

2. Related Work and Motivation

In recent years, IoT technologies were widely applied through many projects in various health areas. Technologies based on IoT, like mobile technologies and wearable computing, are frequently used in the area of self-measuring of health metrics. Those measurements are used for health promotion, well-being, and stress management where they can detect changes in vital parameters and play a role in the improvement of human behavior. Different kinds of wearables and sensors, used individually and in combination, are designed for tracking vital parameters that are indicating stress or arousal symptoms, such as heart rate, GSR, blood pressure, and others.

Heart rate is one of the health status indicators, a manifestation of the presence of an arousal. Heart rate sensor is often used in sport [5][6] and fitness [7] equipment. In everyday life, heart rate sensor can improve identification of stress indicators and help to provide stress management [8] [9].

Smart phones take a big part in stress management. Some devices have embedded sensors for detecting and monitoring behavior indicative of stress or depression [10]. Others have implemented biofeedback, i.e. therapeutic tools for stress and anxiety [11] [12]. Ahtinen proposed a mobile application for stress management that contains four intervention modules for mental wellness-training [13]. The study that recruited 15 participants from a university has shown significant improvements in stress and life satisfaction in respondents.

One commercial solution for stress management is Biosync Technology. Patient's heart rate, galvanic skin response, and movements are measured. Data are automatically processed to determine patient's stress level, and in addition, the patient is provided with preventive measures to have a better life [14].

A number of papers have looked into measuring the psychological state and physical reactions in students [15] and their academic success, as well as calculating their correlation [16] [17], or the improvement of student's mental health [8].

The research carried out by Shen, Wang & Shen [18] used psychological signals to predict emotions. They investigated the presence of different emotions in the studying process and proposed a sensible e-learning model. The data were acquired using three sensors: skin conductivity sensor measuring electrodermal activity, photoplethysmograph sensor measuring blood pressure, and EEG sensor measuring brain activity. Measurements were taken over several weeks on one subject in the natural environment, the closest possible to the everyday environment.

In the study [19], a heart rate sensor was implemented together with a skin conductivity sensor, accelerometer and temperature sensor in a natural context – public appearance of PhD students in front of an audience, where significant variations in the values of measured vital parameters were observed. A feedback to the speaker was implemented in a form of talk assistant that sends information about heart rate to trigger relaxation.

In this research, we want to design and implement a system to identify the psychophysiological signals indicating stress during students' thesis defending. Most of the research uses different kinds of devices to recognize stress in students, but few of them are coping with the stress management in a real environment [20] [21]. Our goal is to provide a solution that would enable monitoring of body manifestation of arousal and help students to manage their stress during thesis defense. A mobile application with the relaxation content should minimize the arousal in students and make an impact on reducing stress during thesis defense. The influences of the mobile application on the presence of stress and anxiety levels, or change the behavior of students in certain contexts will be analyzed.

3. An IoT System for Stress Management

Sensors and smart phones in monitoring health status usually imply: collecting data from the sensors; providing support to the user through a display with the measured values; sharing the information; ensuring the low-power devices, wearability, precision, longevity and reliability of devices.

IoT system architecture for stress measurement consists of three parts: a wearable system for monitor vital parameters, a mobile health application featuring relaxation content and cloud platform. In addition, we have developed services for connecting the components, hosts, and users (see Fig. 1).

The wearable system requires components such as a heart rate sensor, a microprocessor to process obtained data, and a wireless Internet connection that allows the participants to freely move during their activities. The second component, the mobile application featuring relaxation content can be installed on any Android device that has a wireless connection to the Internet. Cloud platform collects sensor data from the wearable system, analyzes collected data, and follows browsing history from the mobile application.

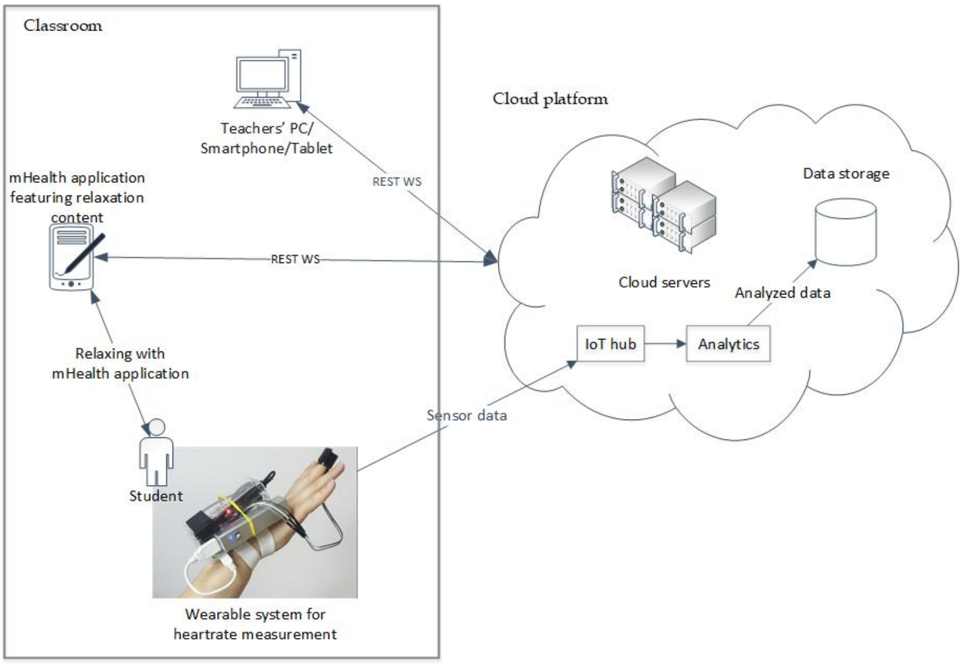

Fig. 1 Components of the IoT system for stress management

3.1. Intelligent devices

One of the main challenges is designing an IoT system that is wearable, low-power, reliable and precise. Commercial solutions often satisfy the above characteristics. One such solution is Xiaomi Mi Band (shown in Fig. 2), which is completely wearable. The device possesses a Bluetooth module that enables communication with appropriate mobile application. As the most of the commercial solutions, it comes with no open APIs and, thus, it is not programmable and customizable. Accordingly, there is no possibility to gather sensor data and store in the database for real-time monitoring, further analytics, biofeedback, nor integration with other educational services.

Fig. 2 Commercial wearable wristband Xiaomi Mi Band 2

The wearable system developed in this pilot project is not completely wearable as commercial solutions, but it provides open APIs that enable adjustment and integration with other systems in accordance with our needs. Fig. 3 shows the components of the wearable system for heart rate measurement.

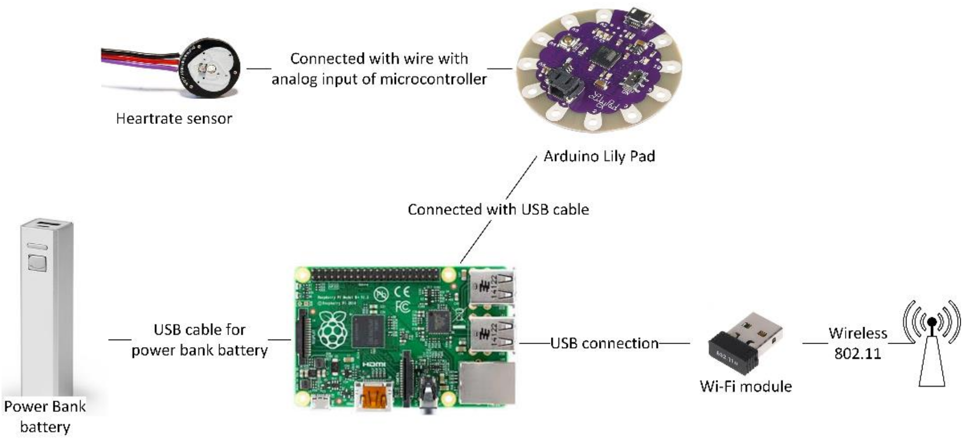

Fig. 3 Schematic view of components of a wearable system for heart rate measurement

In the implementation, we used Pulse sensor Amped, plug-and-play heart rate sensor for Arduino. There is added amplification and noise cancellation circuitry to the hardware of the sensor [22]. It works with either 3V or 5V LilyPad Arduino. A heart rate sensor records the user's heartbeats and is an important parameter in evaluating the arousal or the exposure to stress. The technology of measurement is usually based on two beams of light of different wavelengths that are focused on the human nail tip. The measured signal can then be obtained by a photosensitive element.

Heart rate sensor, on the other side, is connected to Arduino Lily Pad (ATMega32U4), and Raspberry Pi microcomputer. A USB cable was used to connect Raspberry Pi and Arduino Lily Pad. The system is packaged in a plastic box with two bracelets that enable easily wearing the device. Heartbeat sensor is attached on the fingertip that enables more reliable measurement without excess sensor moves (see Fig. 4).

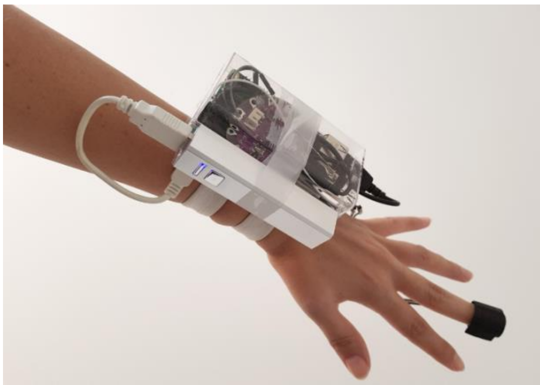

Fig. 4 Position of wearable device during project evaluation

The software was implemented using the Python programming language. In the created prototype, communication layer consists of communication and networking connection with the Wi-Fi access integrated into devices with the support of required software [23]. Obtained sensor data are transmitted to the cloud using the Raspberry Pi with Wi-Fi module (802.11b/g/n). Wi-Fi module and mobile phone with health application are connected to a local secured Wi-Fi network. The mobile application connects to web services on the remote cloud through mobile Wi-Fi access with low power consumption so that user can carry the device for a longer period of time.

The power supply is provided via Power Bank battery attached to the plastic box of the device. The charged battery provides about 2 hours of continuous measurement.

3.2. Mobile health application

The Android application with relaxation content was created in the Android Studio 1.2.1 programming environment, using the Java programming language. Contents that could have a relaxing effect were implemented in the app: funny sports scenes, beautiful nature photos, relax natural sounds [24] [25]. The content was taken from YouTube. The content watched by users is recorded on the cloud platform. Fig. 5 shows some screens of the application content.

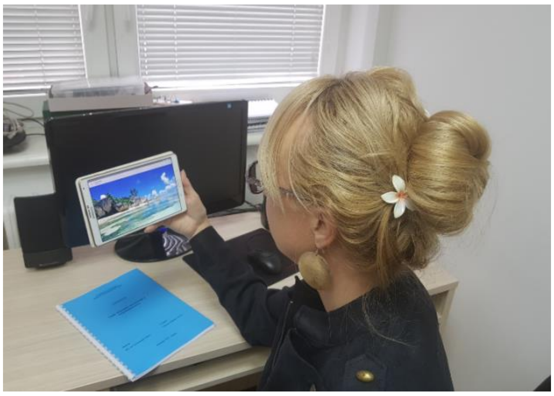

Fig. 5 Respondent relaxing with mobile health application

3.3. Cloud platform

The cloud platform is mainly responsible for data classification and storage. After receiving a piece of data from Arduino, Raspberry Pi has a role to read the data from the Arduino processor through the serial port. In case there are no errors, Raspberry Pi sends data to Microsoft Azure IoT Hub platform. Raw data are analyzed using Microsoft Azure Stream Analytics processing job. The result of the analytics process is a stream of aggregated data, which is stored in MSSQL database on the cloud.

4. RESEARCH METHODS

The aim of this evaluation is to identify the psychological signals indicating arousal during students' thesis defending. In addition, we examine and compare the arousal presence in respondents who used the mobile health application with relaxation content (experimental group) to the respondents who didn't use it (control group). Significance should indicate if the stress during thesis defense can be managed with relaxing content delivered through the mobile application.

4.1. Instruments

For the purpose of evaluation, a general, non-anonymous questionnaire was created. It consisted of demographic questions and it was filled out by students before the first phase of testing.

In order to evaluate anxiety level before testing, after the test, and after relaxation following the completed test, Spielberger's [26] Text Anxiety Inventory (STAI) test is used. The test is a self-report instrument for measuring anxiety and it consists of 20 questions. The answers were provided in the form of a 4-point Likert scale, namely: 4 – very much so, 3 – moderately, 2 – a little, 1 – not at all and respondents rated the extent to which each statement is true for them. The instrument was referred to the student's state at the given time, not an earlier period. The students' STAI test scores were categorized into low (20 to 40), moderate (41 to 50) and high (51 to 80) [17].

4.2. Participants

The evaluation sample consists of students of Faculty of Organizational Sciences, University of Belgrade. The participants were students of the master studies of the Department of E-business. All participants had previously attended theoretical and practical courses in E-business, Internet technologies, Mobile technologies, and IoT, so they were familiar with sensors and usage of wearable devices.

In total, 26 students successfully finish the evaluation of the pilot project. All of the participants were informed about the testing and they signed a consent form.

The participants were from 23-30 years old. There is evidence that health-risk behaviors (smoking cigarettes, lack of physical activity, etc.) influence higher levels of stress in students [27]. In the sample, most of the respondents were physically active regularly or at least occasionally (couple times a week, at least half an hour) and they were non-smokers at most. The half of the students had a job.

Table 1 shows descriptive statistics of the sample.

Table 1 Descriptive statistics of the sample

Characteristic	Gradation	Frequency	Percentage (%)
Sex	Male	10	38
	Female	16	62
Smoker	Yes	2	8
	No	24	92
Physical activity	Regularly	12	46
	Occasionally	12	46
	Never	2	8
Employed	Yes	14	54
	No	12	46

4.3. Experimental design

Experiment session lasted approximately 45 minutes for each participant. Each respondent was situated in a pleasant classroom and connected to the wearable system after arrival. Respondents wore the wearable device on the left hand and the pulse sensor was placed on the index finger. There were no sensors on the right hand and writing was enabled.

At the beginning, respondents filled out a general questionnaire, an STAI test and signed a consent to participate in testing. The sample was divided into two groups: experimental and control. After completing the questionnaires, respondents from experimental group were given a tablet with a pre-installed Android application with relaxation content and short instructions on how to use it. The respondent had 15 minutes to relax and use the application content. During the use of the mobile application, the duration of the use and the browsed content were tracked and saved in the cloud. Also, the obtained values of vital parameters for the respondent were recorded. The respondents from the control group had the same procedure, except they were relaxing without content on the mobile application. Scheme of experimental protocol is shown in Fig. 6.

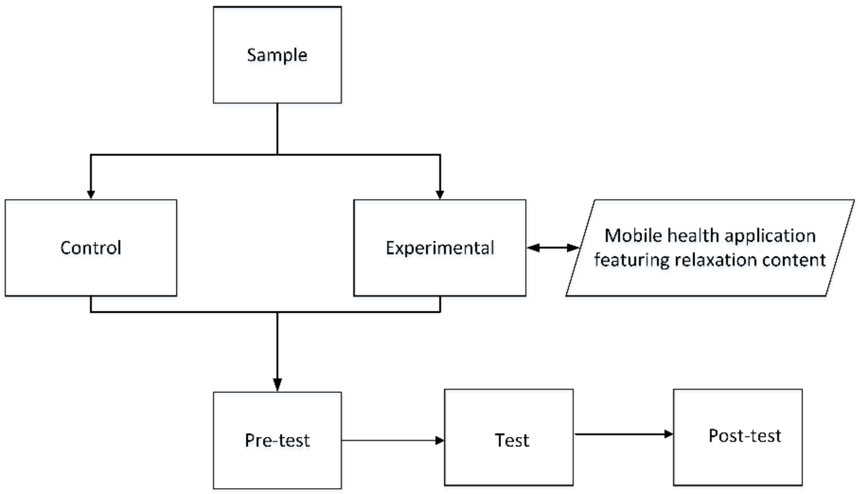

Fig. 6 Protocol and testing phases

4.4. Statistical analysis

Measured and obtained data from the heart rate sensor were averaged for all three phases individually. Thus, we got three values of heart rate for each respondent.

For further analyses, totaled averaged measures on the pre-test were then subtracted from totaled averaged measures on the post-test, determining the difference between the two measures.

Data analyses were performed using SPSS (v20.0). In all analyses, results were considered statistically significant at the $p \leq 0.05$ level or $p \leq 0.001$.

In the first step of the analysis, we tested differences between arousal occurrences in students' heart rate through three phases: pre-test, test and test phase. Differences between two phases of measurement, regardless of group, were tested with Wilcoxon signed-rank test.

In the second step, we tested statistical differences in heart rate difference between control and experimental group through phases. For that purpose, we used Students T-test. When testing for normality, Shapiro-Wilk test was used, and Levene's Test for Equality of Variances. In case that normality or equality of variances was not met, data were tested with Mann-Whitney U test [28].

5. Results and Discussion

5.1. Arousal through testing phases

We have investigated if there was a statistical difference in students' heart rate from pre-test phase and test phase in which they defended their thesis. The results have shown that heart rate in the test phase is significantly higher ($Z=-2.66$, $p<0.05$) than in pre-test phase. This is an expected result, as a defense is a stressful event.

It was expected that after increased arousal during pre-test and test phase, respondents' heart rate became lower in post-test phase, as a stressful event was finished. There is a strong statistical significance that measured values of heart rate at post-test phase are lower than heart rate values in pre-test phase ($Z=-3.92$, $p<0.001$) as well as in test phase ($Z=-4.01$, $p<0.001$). Post-test phase can be considered as the most calming phase from the beginning of the test. Figure 7 shows the distribution of differences of averaged heart rate between pre-test and post-test phase among experimental and control groups. Mean value (shown as a vertical line in a box) is higher in the control group (-9.46) than in the experimental group (-5.92).

5.2. Stress management in experimental and control group through testing phases

There were statistical differences ($t_{(24)} = -3.72$, $p<0.05$) in arousal, measured by subtraction of heart rate between pre-test and test phase, between the control and the experimental groups, regarding the use of the mobile health application with relaxation content in pre-test phase. According to the results, an arousal of the experimental group was decreased, probably because they were treated with relaxation content during pre-test phase.

Also, there is a strong statistical difference (Mann–Whitney $U=17.5$, $p<0.05$) in heart rate during the test and post-test phase, between control and experimental groups. Distribution of averaged heart rate values between two phases is shown in Fig. 8. The experimental group's values do not deviate from test to post-test phase as they deviate in the control group (shown as the difference on the figure). The greater deviation, shown as difference, points to higher arousal in the test phase.

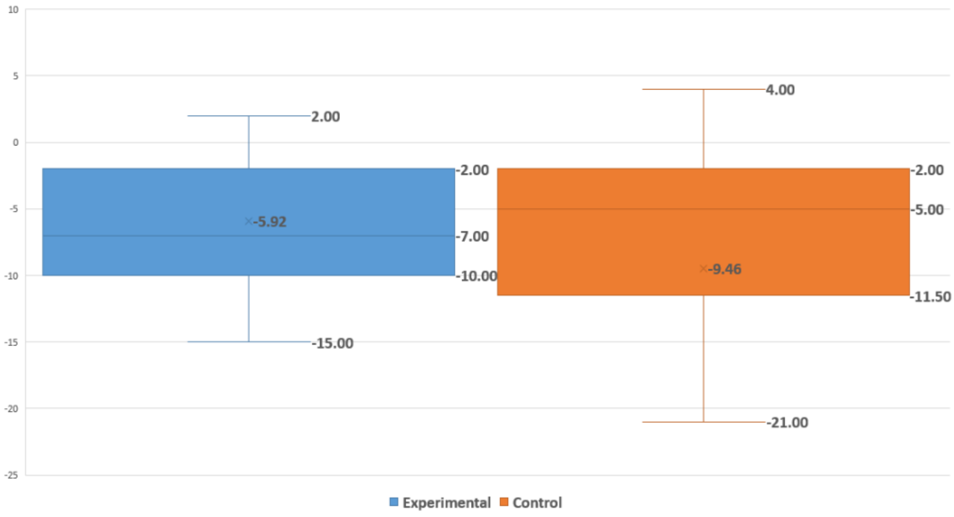

Fig. 7 Distribution of differences in measured averaged heart rate values between pre-test and post-test phase

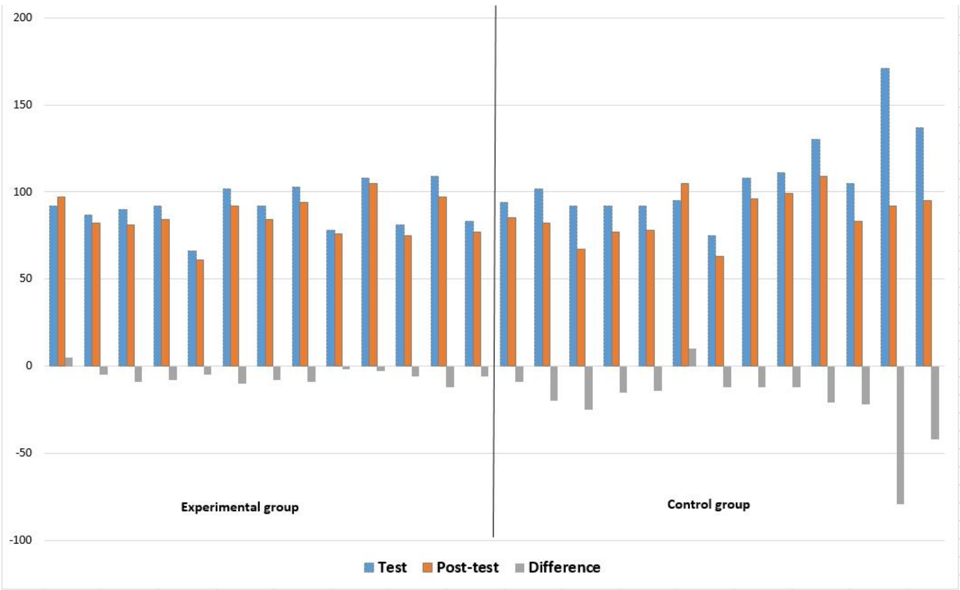

Fig. 8 Distribution of averaged heart rate values during test and post-test phase and difference between them in experimental and control group

Since students used the mobile health application with relaxation content in the post-test phase, it could be an explanation for the significant difference in arousal between the two groups.

Students' heart rate values were significantly lower in post-test phase than during the pre-test phase but there is no statistical significance in differences between the two phases among groups. Regardless of the relaxation content on the mobile health application, students' arousal were decreased in the post-test phase.

Table 2 presents the participants' average time spent at different contents of the mobile health application with relaxation content. Before and after defense, participants spent the longest time watching fun sports clips in total, and the longest average time they kept in continuously was watching fun sports clips and then listening to relax music.

Table 2 Distribution of time spent at different contents of the mobile health application with relaxation content

Content	Total of time spent on content (hh:mm:ss)	Average time on content (hh:mm:ss)
Fun sport	05:46:18	00:06:56
Relax music	04:10:21	00:04:49
Relax photo	03:02:31	00:04:21

5.3. The results of the STAI test

Table 3 shows participants distribution by STAI test points in both experimental and control groups.

Table 3 Participants distribution by STAI test results

	Anxiety gradation		
Test phase/group	Low	Moderate	High
Pre-test – total	**20**	**5**	**1**
Experimental	12	1	0
Control	8	4	0
Test – total	**22**	**3**	**1**
Experimental	12	1	0
Control	10	2	1
Post-test – total	**25**	**1**	**0**
Experimental	12	1	0
Control	13	0	0

Almost 20% of students reported moderate anxiety in pre-test phase, e.g. a moment before thesis defense. After the test, only 11.5% of respondents reported moderate anxiety, and after relaxation after defense, in post-test phase, just one respondent (3.8%) had moderate anxiety. High anxiety was present in pre-test and test phase in 3.8% of the sample from the control group.

In pre-test and test phase there were more respondents with moderate and high anxiety in the control group than in the experimental group.

There is a statistically significant change in STAI pre-test scores that are lower than STAI post-test scores ($Z=-3.902$, $p<0.001$). Also, STAI post-test scores are lower that

STAI test scores (Z=-3.137, p<0.05), but there is no significant change in scores between STAI pre-test and STAI test scores. Figure 9 shows the distribution of STAI scores in pre-test, test and post-test phases. Median of STAI scores (shown as a horizontal line in boxes) and mean (X mark in the box) is the highest in pre-test phase and the lowest in post-test phase.

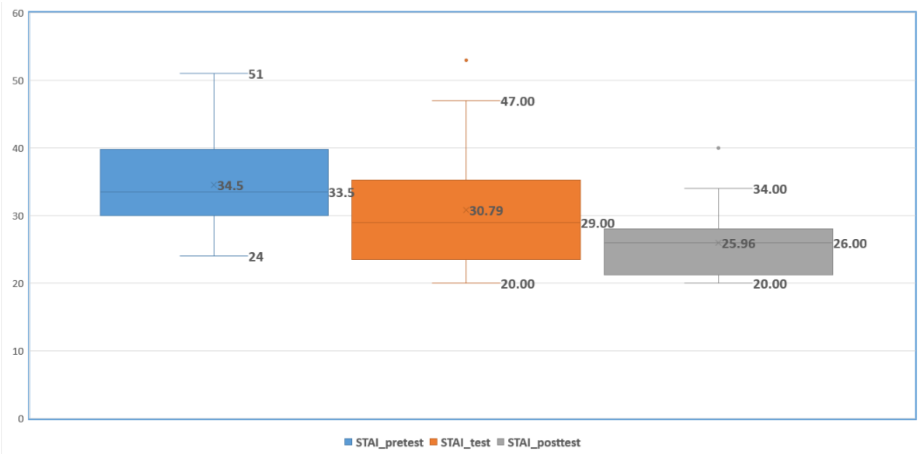

Fig. 9 Distribution of scores of STAI test through three phases

There was no correlation between STAI test results and the level of heart rate through phases. Low anxiety in participants during thesis defense could be explained either with too subjective answers on STAI test because the test wasn't anonymous or by the fact that the students are well prepared and relaxed with their professors.

6. CONCLUSION

The solution proposed in this paper demonstrates one of the ways of integrating the concepts of electronic health, mobile health, Internet of Things and wearable computing. The implemented IoT system allows monitoring respondents' vital parameters. Mobile health application with relaxation content can have an impact on reducing arousal in respondents during the defense of the thesis. The proposed solution is applicable in education environments. Unlike the conventional educational system, the proposed solution enables biofeedback. Information about students' arousal is sent to professors on which they can change the exam flow. In addition, the IoT solution proposed in this paper can be successfully applied for stress monitoring in different life situations.

The values obtained in the research indicate that the use of a mobile health application with relaxation content had a significant effect on decreasing students' arousal before and during thesis defense. There is no evidence that the application can help students to calm down after they defend their thesis.

The major contributions of this paper can be summarized as follows:

- The way of the realization of stress measurement and stress control through IoT concept and mobile health in an education environment.
- Development of the IoT infrastructure for stress measurement and control.
- Introducing a new smart healthcare service into the education system, providing biofeedback to subjects involved in the education process.

The main limitation of the study is the small and homogeneous sample. Also, there is no evidence whether the students were feeling stressed before the test for both the control and the experimental group that could have an effect on their baseline heart rate. In addition, the future work should include students from different departments where there is a different attitude towards professors.

Acknowledgement: *The authors are thankful to Ministry of education, Science and Technological Development, Republic of Serbia, grant 174031.*

REFERENCES

[1] B. Rodic-Trmcic, A. Labus, S. Mitrovic, V. Buha and G. Stanojevic, "Internet of things in E-health: an application of wearables in prevention and well-being," in *Emerging Trends and Applications of the Internet of Things*, IGI Global, 2017, pp. 191-197.

[2] Q. Li, Y. Xue, L. Zhao, J. Jia and L. Feng, "Analyzing and Identifying Teens Stressful Periods and Stressor Events from a Microblog," *IEEE Journal of Biomedical and Health Informatics,* vol. PP, no. 99, pp. 1-1, 2016.

[3] N. Sohail, "Stress and Academic Performance Among Medical Students," *Journal of the College of Physicians and Surgeons Pakistan,* vol. 23, no. 1, pp. 67-71, 2013.

[4] M. S. Ali and M. N. Mohsin, "Test Anxiety Inventory (TAI): Factor Analysis and Psychometric Properties," *IOSR Journal Of Humanities And Social Science (IOSR-JHSS),* vol. 8, no. 1, pp. 73-81, 2013.

[5] Y. Fu and J. Liu, "System design for wearable blood oxygen saturation and pulse measurement device," in Proceedings of the 6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015, 2015.

[6] Suunto, "SUUNTO Foot Pod Mini," 01 November 2015. [Online]. Available: http://www.suunto.com.

[7] BASIS Science, 02 November 2015. [Online]. Available: http://www.mybasis.com/.

[8] A. Millings, J. Morris, A. Rowe, S. Easton, J. K. Martin, D. Majoe and C. Mohr, "Can the effectiveness of an online stress management program be augmented by wearable sensor technology?," *Internet Interventions,* vol. 2, no. 3, pp. 330-339, 2015.

[9] A. Parnandi and R. Gutierrez-Osuna, "Physiological Modalities for Relaxation Skill Transfer in Biofeedback Games," *IEEE Journal of Biomedical and Health Informatics,* vol. 21, no. 2, pp. 361-371, 2017.

[10] S. Saeb, M. Zhang, C. Karr, S. Schueller, M. Corden, K. Kording and D. Mohr, "Mobile Phone Sensor Correlates of Depressive Symptom Severity in Daily-Life Behavior: An Exploratory Study," *J Med Internet Res,* vol. 17, no. 7, p. e175, 2015.

[11] H. Al Osman, H. Dong and A. El Saddik, "Ubiquitous Biofeedback Serious Game for Stress Management," *IEEE Access,* pp. 1274-1286, 2016.

[12] M. A. Zafar, B. Ahmed and R. Gutierrez-Osuna, "Playing with and without Biofeedback," in Proceedings of the IEEE 5th International Conference on Serious Games and Applications for Health (SeGAH), 2017, Perth, 2017.

[13] A. Ahtinen, E. Mattila, P. Välkkynen, K. Kaipainen, T. Vanhala, M. Ermes, E. Sairanen, T. Myllymäki and R. Lappalainen, "Mobile Mental Wellness Training for Stress Management: Feasibility and Design Implications Based on a One-Month Field Study," *JMIR Mhealth Uhealth,* vol. 1, no. 2, p. e11, 2013.

[14] S. Falan, "Wearable Technology: Examples from Sweden," 2016. [Online]. Available: http://salusdigital.net/wearable-technology-examples-sweden/.

[15] F. Arriba-Pérez, M. Caeiro-Rodríguez and J. M. Santos-Gago, "Towards the use of commercial wrist wearables in education," in Proceedings of the 4th Experiment@International Conference (exp.at'17), 2017, Faro, 2017.

[16] T. Dragon, I. Arroyo, B. P. Woolf , W. Burleson, R. Kaliouby and H. Eydgahi, “Viewing Student Affect and Learning through Classroom Observation and Physical Sensors,” in *Intelligent Tutoring Systems*, Berlin, Springer Berlin Heidelberg, 2008, pp. 29-39.
[17] L. T. Ping, K. Subramaniam and S. Krishnaswamy, “Test anxiety: state, trait and relationship with exam,” *Malaysian Journal of Medical Sciences,* vol. 15, no. 2, pp. 18-23, 2008.
[18] L. Shen, M. Wang and R. Shen, “Affective e-Learning: Using “Emotional” Data to Improve Learning in Pervasive Learning Environment,” *Educational Technology & Society,* vol. 12, no. 2, pp. 176-189, 2009.
[19] M. Kusserow, O. Amft and G. Tröster, “Monitoring Stress Arousal in the Wild,” *Pervasive Computing, IEEE,* vol. 12, no. 2, pp. 28-37, 2013.
[20] R. Kocielnik, M. Pechenizkiy and N. Sidorova, “Stress Analytics in Education,” in Proceedings of the 5th International Conference on Educational Data Mining, Chania, Greece, 2012.
[21] A. Joshi, R. Kiran and A. N. Sah, “An experimental analysis to monitor and manage stress among engineering students using Galvanic Skin Response meter,” *Work,* vol. 56, no. 3, pp. 409-420, 2017.
[22] World Famous Electronics llc., “Pulse Sensor Amped,” 2017. [Online]. Available: https://pulsesensor.com/.
[23] M. Chen, Y. Zhang, Y. Li, M. M. Hassan and A. Alamri, “AIWAC: affective interaction through wearable computing and cloud technology,” *IEEE Wireless Communications,* vol. 22, no. 1, pp. 20-27, 2015.
[24] J. J. Alvarsson, S. Wiens and M. E. Nilsson, “Stress Recovery during Exposure to Nature Sound and Environmental Noise,” *Int J Environ Res Public Health,* vol. 7, no. 3, p. 1036–1046, 2010.
[25] W.-C. Wang, “A study of the type and characteristics of relaxing music for college students,” in Proceedings of Meetings on Acoustics, Providence, Rhode, 2014.
[26] D. C. Spielberger, “Test Anxiety Inventory: Preliminary Professional Manual,” *Consulting Psychologists Press,* 1980.
[27] M. Y. Kwan, K. P. Arbour-Nicitopoulos, E. Duku and G. Faulkner, “Patterns of multiple health risk–behaviours in university students and their association with mental health: application of latent class analysis,” *Health Promot Chronic Dis Prev Can,* vol. 36, no. 8, p. 163–170, 2016.
[28] E. Saperova and D. Dimitriev, “Effects of smoking on heart rate variability in students (545.6),” *The FASEB Journal,* vol. 28, no. 1, pp. 545-6, 2014.