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THE IMPACT OF DISTANCE LEARNING ON STUDENT'S ATTENTION DURING THE COVID-19 PANDEMIC: A SOCIAL EXPERIMENT

The aim of the paper is to analyze the students' visual attention during online classes in the context of the COVID-19 pandemic. In order to detect visual attention and gather insights into user behavior, we used eye-movement tracking technology on a mobile phone. The paper presents a repeated social experiment involving students from the Faculty of Information Technologies at Slobomir P University in Bijeljina. The research involved an experimental design with two groups of students of the same generation. Students were assigned to the experimental and control groups randomly. During the experiment, data were collected automatically and stored in a database, which we used to conduct statistical analysis. We started from the assumption that various situational factors can distract students' attention during online classes. Five out of the six external attention indicators exhibited statistically significantly higher values in the group of students who were instructed to listen carefully to the lesson (the experimental group) when compared to the group that did not receive such an instruction (the control group). The research revealed that, despite numerous "distracting factors" in the home environment that can diminish students' attention during distance learning, a teacher's emphasis on the importance of the presented instructional material positively influences an increase in students' visual attention.

Keywords: distance learning; Covid-19; visual attention; face detection; eye tracking

INTRODUCTION

The Corona virus pandemic, as an unprecedented event in human history after World War Two, has led to redefining all aspects of modern life – socio-political, cultural, intimate, daily routines and life styles. All our acquired habits and living patterns have been put under testing and reshaping. They have been under the influence of emergency circumstances and strong health measures taken by both world organizations and local authorities. In pandemic times, they establish new models within which individual and social life modes are organised in the newly created situation (Trninić, Janković 2022).

According to the postmodern sociological paradigm, contemporary social relations are based on *uncertainty* and *insecurity,* which is why every person has to learn how to live without a clear vision of the future consequences of the decisions that an individual makes in the present. On the one hand, it is important to *trust* expert knowledge and abstract systems. On the other hand, individuals must act strategically in order to position themselves properly in the new living environment (Giddens 1991; Beck 1992). As for the former, it is about collective acting, whereas the latter relates to the social acting of an individual, in other words, proper social and personal positioning, with conscious risk-acceptance of all life-related choices.

If we apply the principles of the aforementioned theory to the current state of affairs when the humankind and contemporary world are facing a great world crisis caused by the pandemic, it becomes clear that the decisions we are making are going to overwhelming affect our future. From our response to the pandemic crisis, the direction, that is, the very trend of changes in which the future development of society, politics, economy, and culture will be reflected is going to depend on (Trninić, Janković, Romić 2021). "Although the newly-created situation requires instantaneous decisions, without any prior analysis, theoretical knowledge, and wider social consensus, it is important to take into consideration the consequences, as well as possible changes to the domains of personal and collective life, they are going to leave in the future. As it is, what has been introduced as a 'short-term emergency measure' is going to become a part of daily routine" (Harari 2020).

PANDEMIC AND DISTANCE LEARNING

The Covid-19 pandemic has brought about significant changes in the field of education, particularly in the way teaching is delivered. It happened at all levels of

education – from primary and secondary education to universities and research centers. A large number of countries around the world were forced to close educational institutions as part of their efforts to control the spread of Covid-19 during the pandemic. More than 1.5 billion students worldwide have been affected by school and university closures during the Covid-19 pandemic (UNESCO 2023). Many universities and higher education institutions adapted swiftly to the challenges posed by the Covid-19 pandemic. They rapidly transitioned to distance learning or provided a combination of online and in-person learning, where theoretical teaching is conducted online, and practical or experimental teaching is carried out in person.

The tools for conducting online classes were developed and used before the onset of the pandemic (Selimović, Blatnik 2023). The pandemic, however, had a significant impact on the rapid adoption and evolution of these tools, as well as the shift towards more versatile multilateral online communication and digital content sharing between participants. Due to the outbreak of the coronavirus pandemic, many IT companies recognized the need to enhance existing tools or develop new ones to support online teaching. There is a range of tools and technologies used in the online education landscape, and their capabilities can vary significantly. Some of the older tools are used only to distribute learning materials such as tutorials and quizzes, while more advanced tools are designed to stream live classes. Teaching conducted in real-time offers several advantages, one of the most prominent being direct and prompt communication between instructors and students.

Transitioning to online teaching and using digital tools requires some effort and adaptation from lecturers, who must convert their traditional lecture materials into digital formats suitable for online use. Some of them have to make an extra effort to learn how to use ICT, especially teachers who relied more on traditional, face-to-face teaching methods. An additional challenges for lecturers can be the lack of physical presence, which makes it difficult for lecturers to monitor students' activities during online classes and refocus them if they get distracted in the same way hey might in a traditional classroom.

On the other hand, students may have problems maintaining attention and motivaton during distance learning because they are not in traditional classroom settings but in home environments which can be less structured and more comfortable, making it easier for students to get distracted. The presence of distractions like family members or roommates, social networks, chat applications, video games and many other activities can make it very challenging for students to concentrate during online classes.

By consulting a wide range of scientific papers dealing with the advantages and disadvantages of distance learning, we have concluded that there is a consensus among different authors. Due to lack of space, we will present the most frequently mentioned positive and negative factors in the most cited scientific papers. One of the most cited papers (162 citations in October 2023) is a research paper by three Brazilian authors. This highly-cited paper, published before Although it was published before the outbreak of the covid pandemic, it seems to identify well fundamental issues of distance learning. As highlighted by the authors, the institutional advantages of distance learning are: larger number of students, cost efficiency, no need for physical infrastructure, reduction of administration, content reusability. The disadvantages for institutions seem to be more numerous: lower teaching quality because students do not have the opportunity to contribute to discussions (they are less likely to ask questions), they often do not have the opportunity to interrupt the lecturer and ask a question, most lecturers are trained in traditional forms of teaching, in some countries and cultures, there may be a strong preference for the traditional form of teaching. The benefits for students are significant and should not be overlooked. Firstly, there is the flexibility of listening to classes (which allows you to study and work simultaneously), the availability of study materials, the lower cost of studying, a wide range of courses, and learning from home 24/7. The disadvantages of distance learning are problems with students' attention, self-discipline challenges, the inability to ask questions or seek clarification at all times (De Oliveira, Penedo, Pereira 2018). Another study (90 citations in October 2023), conducted in Turkey during the pandemic, emphasize similar disadvantages of distance learning. We will rank them in order of importance (from the most to the least important). Teachers point out: lack of time spared for live courses, excessive workload due to homework, implementation's inadequacy for major area courses, uncertain evaluation system, lack of time spared for homework, limited access to registered courses, lower interaction. On the other hand, students emphasize: Inability to communicate with friends, Inability to focus, Not feeling the classroom atmosphere, Being not accustomed to the system, Lack of knowledge, skills and attitudes, Feeling the need to socialize, Remaining passive (Özüdoğru 2021).

The scientific paper describing the situation of distance learning in India (89 citations in October 2023) provides very valuable insights. Organizing distance learning in a country as vast and diverse as India, especially during a global pandemic, was challenging given a wide range of socio-economic conditions, regional variations, a large number of educational institutions, and a diverse student population. Several

key challenges in this context include: for many students it was difficult to suddenly change their mindset and adopt digital education, although they have advanced a lot in technological perspective, it was not clear how far they have been able to adopt technology for constructivism ("distance education is not simply real life"), rural and low-income communities have less internet access in compare with urban counterparts, differencies in preparedness of faculties to deliver distance learning lectures (Dubey, Pandey 2020).

THE SUBJECT AND GOAL OF THE EXPERIMENT

Attention is a fundamental cognitive function that enables a person to direct and focus psychic energy on specific contents-stimuli from the environment. It can manifest in various forms and can be categorized based on different aspects of its expression. External or visual attention can often be recognized by the posture of the body, particularly the direction of the head and eyes towards the object or area of interest. Internal manifestations of a lack of attention can be recognized by specific indicators – slowed digestion and breathing, increased cerebral circulation, changes in the psychogalvanic reflex, or blockade of the alpha rhythm in the EEG (Marić 2001).

In neuroscience and cognitive psychology, various classifications of attention are presented, differing among authors (Goldstein 2014; Pashler et al. 1998; Posner & Petersen 1990). For the purposes of our work, it is essential to analytically and experimentally distinguish between visual and cognitive attention, despite the acknowledgment that these two forms of attention cannot be entirely separated in practice, as they rely on complex neural networks. Visual attention is confined to information originating from the visual field, while cognitive attention is a broader concept encompassing the processing of information and the regulation of internal mental processes. Visual attention can influence cognitive processes; for example, selectively focusing on a specific object can enhance the processing and memory of information related to that object. Conversely, cognitive attention can support the maintenance of visual focus, particularly during tasks that require sustained concentration (Carrasco 2011; Knudsen 2007; Styles 2005).

Based on our teaching experience, we observed that one of the main disadvantages of distance learning is the challenge of maintaining high levels of students' attention due to many "distracting factors" from their home environment. Some students don't have access to private spaces or dedicated computers, or they may face home distractions; others are inclined to turn off the camera and "leave the lecture" for a while,

while some students engage in other online activities that distract them during the lecture (social networks, chat, YouTube, video games, etc.). The issue of maintaining students' visual attention on virtual platforms has been studied by researchers even before the outbreak of the pandemic and significant findings on this topic are available (Chen, Lai, and Chiu 2010). Considering the advantages and disadvantages of distance learning (from the previous chapter) and personal experiences during teaching, we decided to conduct an experiment to compare the effectiveness of distance learning in two different contextual situations. Setting up such an experiment involved creating two groups of students:the experimental group – where we emphasized the importance of careful lesson attendance and that their smartphone cameras would be used for attention measurements; and the control group – where students were told that some measurements would be taken via their smartphone cameras but without the emphasis on attentiveness. All students, without exception, agreed to participate in the study.

The experiment aimed to determine whether a lecturer's verbal warning (as one of the many contextual factors) could affect students' visual attention during online classes. If it demonstrates that it can, it is reasonable to assume that the above-mentioned contextual factors can influence students' attention in the online learning environment.

The independent variables (indicators) which we used to monitor attention are: left eye detection, right eye detection, eye blink, face detection in the camera's field of view, right eye open probability and left eye open probability.

METHOD OF CONDUCTING THE EXPERIMENT

This experiment is a repeated experiment conducted under identical conditions as the first one. We have already published detailed results from the first experiment (Gavrić, Minović, Mišković 2022). Both experiments were conducted in the same classrooms on two different campuses (Doboj and Bijeljina), covered the same course (.NET basics), and it was led by the same teacher as the experimenter. The one-year gap between the two experiments, conducted in November 17, 2020 and November 19, 2021, was thought to be a significant factor in minimazing the potential so-called "halo effect" or any carryover effects from the students who participated in the first experiment to those in the second experiment. Another precaution to avoid the "halo effect" were not informed about the specific data being collected during the experiment.

We used the consistent sample size of 15 students in both the experimental and control groups for both experiments. The limited number of students attending the .NET basics course posed a constraint when it came to conducting the experiment on a larger group of students.

The students who took part in the experiment were all in their final (fourth) year of study, and they had already gained fundamental programming knowledge in previous years of their education. This approach was implemented to eliminate the possibility that their prior knowledge might be lacking or insufficient, ensuring that they had a solid understanding of the teaching content presented to them during the experiment. In other words, the material presented during the experiment was designed to be accessible even for students with weaker backgrounds in the subject. Additionally, the amount of information shared was not overwhelming, making it easy for the students to understand and remember. We achieved this by selecting straightforward materials and by condensing the delivery of the educational content.

The video presentation that both groups of students watched had a duration of 25 minutes. The experiment started with the students being given instructions on how to utilize the smartphone application, i.e. they were instructed to create a user profile, join the course, initiate the lecture video, and watch it through to the end. All the students were able to start the video without encountering any issues, and watched it from their respective homes simultaneously.

Following the review of the instructional material, the data regarding visual attention during the monitoring of the educational content is recorded in the database. Subsequently, this data is exported and subjected to further analysis.

EYE TRACKING AND VISUAL ATTENTION DETECTION SOFTWARE

In recent years, there have been numerous efforts to automate the detection of inattention using various technologies (EEG data, heart rate, mouse pressure, wristbands for measuring skin conductivity, etc.). Such technologies and solutions can mostly be implemented in controlled laboratory settings. Our goal is to use technology available outside the laboratory.

Eye tracking is the process of determining the position of the eye relative to the position of the head. Eye tracking is utilized in various fields, such as psychological assessments, medical diagnostics, driver assistance systems, and many other applications.

For the experiment, the software described in the paper (Gavrić, Minović, Mišković 2022) was utilized. This software was developed by the authors of the paper. The software was designed as a mobile application, compatible with both Android and iOS platforms. The selection of mobile platforms for the software aligns with the research findings presented in the paper (ibid.), which indicates that more than 85% of students prefer to attend online classes using mobile platforms.

The eye detection and tracking application uses the ML Kit API. ML Kit is a machine learning package for mobile applications developed by Google. By using this kit, the application is capable of:

- Recognizing and locating facial features (coordinates of the eyes, ears, cheeks, nose, and lips for each detected face);
- Obtaining contours of facial features (detected faces, eyes, eyebrows, lips, and nose);
- Recognizing facial expressions (detecting whether the person is smiling or has their eyes closed);
- Tracking faces through video frames (assigning a unique identifier to each detected face);
- Processing video frames in real time.

The software we use enables the delivery of online lessons through pre-recorded or live video presentations, organized by grade level and subjects. Each academic year can encompass multiple courses, and each course can further include a variety of teaching materials. To access the teaching materials, students are required to enroll in the respective course. Students can view teaching materials and engage in communication with both their peers and instructors. The primary functionality of the application revolves around the detection of visual attention by analyzing the image of the face and eyes of the user while they are watching video content. For the tracking of visual attention to occur, it is necessary for students to enable access to the front camera of their smartphone. The images captured from the smartphone's front camera are not transmitted to any remote location, but the processing of these images is conducted locally on the user's device. This approach is privacy-conscious and does not compromise user privacy. From each photo taken by the camera, the application extracts data related to face detection, eye detection, and eye opening. The collected data is stored in a remote database and accessible for further analysis. Once the video material begins, the application automatically switches to a "laid-back mode."

The following image shows a screenshot of the running application used for the experiment.

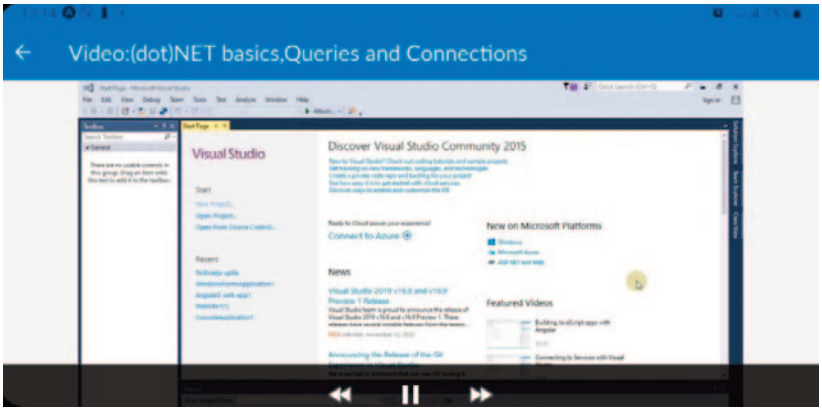

Figure 1: A screenshot of the application with a running video presentation

RESULTS AND DISCUSSION

The strict rules established before the experiment were essential prerequisites for its successful execution. Given that the independent variables represent various aspects of visual attention, there are high correlations between them. They provide us insights into the validity of the methodological concept being measured. In this section, we will discuss the fundamental differences in correlations observed between the experimental and control groups. The most substantial differences in correlations are associated with two specific variables: left and right eye openness. In the experimental group,there is the negative correlations between the variables "eye blinking" (for the left eye the correlation is -0.650 and for the right eye it is -0.680) and the the openness of the left and right eye. This observation makes logical sense because when a person blinks more frequently, it's natural for their eyes to be less open, which aligns with common physiological expectations. However, this correlation is not observed in the control group. The openness of the left and right eyes (v5 and v6) correlate with the presence of a face (v4) and the presence of the left (v2) and right eye (v1) in the camera field of view. All correlation coefficients show high values - above 0.7 (Tables 1 and 2).

The following section will provide more details about the similarities in correlations between variables in the experimental and control groups. We have

observed high high correlations in the body's responses to left and right eye sensations. The correlations between the presence of the left and right eyes in the camera field of view (v1 and v2) are high in both groups- 0.845 in the experimental group and 0.994 in the control group. Similarly, the probability of both eyes being open (v5 and v6) is also high in both groups. The correlation coefficient in experimental group is 0.932, while in the control group, this correlation value is 0.989. (Tables 1 and 2).

Table 1. Pearson's correlations among independent variables in control group

Variables		1.	2.	3.	4.	5.
Right Eye Detected	*r*					
	p					
Left Eye Detected	*r*	**0.994****				
	p	0.000				
Eye Blink Detected	*r*	-0.013	-0.025			
	p	0.963	0.930			
Face Detected	*r*	**0.971****	**0.974****	0.030		
	p	0.000	0.000	0.916		
Right Eye Open Probability	*r*	**0.743****	**0.759****	-0.190	**0.754****	
	p	0.002	0.001	0.498	0.001	
Left Eye Open Probability	*r*	**0.758****	**0.765****	-0.190	**0.757****	**0.989****
	p	0.001	0.001	0.498	0.001	0.000

Note(s): *r* - Pearson's coefficient of correlation; *p* - Sig. (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

Table 2. Pearson's correlations among independent variables in experimental group

Variables		1.	2.	3.	4.	5.
Right Eye Detected	*r*					
	p					
Left Eye Detected	*r*	**0.845****				
	p	0.000				
Eye Blink Detected	*r*	-0.055	-0.129			
	p	0.845	0.647			
Face Detected	*r*	**0.952****	**0.892****	-0.197		
	p	0.000	0.000	0.481		
Right Eye Open Probability	*r*	0.018	0.175	**-0.680****	0.171	
	p	0.948	0.534	0.005	0.534	
Left Eye Open Probability	*r*	-0.044	0.045	**-0.650****	0.086	**0.932****
	p	0.877	0.872	0.009	0.760	0.000

Note(s): *r* - Pearson's coefficient of correlation; *p* - Sig. (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).

In this section, we will analyze the scores indicating the level of visual attention in the experimental and control groups. Tables 3 and 4 present the average scores (in the form of percentages) for the experimental and control groups, for all six variables we measured (from v1 to v6). The data are presented for each individual student as well as overall scores for the entire group. Group results show that all indicators of visual attention are higher in the experimental group than in the control group. When interpreting these results, one should bear in mind the inverse meaning of variable v3, where a higher score indicates a higher number of eye blinks per unit of time, which, in turn, reflects a lower level of attention. The average scores for the detection of the left and right eyes (v1 and v2) are above 98.6 (on a scale of 1 to 100) in the experimental group, and, in the control group, these results are around 91.1 (Tables 3 and 4). The results of the t-test, as presented in Table 5, demonstrate that the students in the experimental group had a higher detection of both the left and right eyes in the field of view of the smartphone camera compared to students from the control group (for the right eye t=14.647 at the significance level sig. 0.000; and for the left eye t=14.892 at the significance level sig. 0.000) (Table 5).

The "eye blink" variable (v3) is the only variable that doesn't show any statistically significant difference between the experimental and control groups (t= -

1.632; sig=.114) (Table 5). Face detection in the camera field of view (v4) shows the significant difference between the experimental and control groups, as indicated by the t-test result (t=15.842; sig=0.000). This result suggests that the experimental group exhibited higher levels of face detection than the control group (98.6 vs. 91.3) (Tables 3, 4 and 5). The remaining two variables (v5 and v6) show similar results. The experimental group has greater openness of the left and right eyes compared to the control group, with the greatest disparities seen when comparing the two groups directly. The results indicate the substantial difference of 8.9 points in the openness of the left eye (v6) between the experimental and control groups (93.4 in the experimental group and 84.5 in the control group). The substantial difference of 11.4 points in the openness of the right eye (v5) between the two groups (93.7 in the experimental group and 82.3 in the control group) is even more pronounced than the difference observed for the left eye. The t-test reveals that the differences in eye openness for both the left and right eyes are statistically significant, given as follows: the openness of the right eye t=7.712; at the significance level sig. 0.000 and the openness of the left eye t=10.401; at the significance level sig. 0.000. It is evident that, in all dimensions of visual attention (except for "eye blinking"), the experimental group had higher scores, indicating greater attention, compared to the control group.

Table 3. Average data for the eperimental group.

	Right Eye Detected	Left Eye Detected	Eye Blink Detected	Face Detected	Right Eye Open Probability	Left Eye Open Probability
1.	98.547%	98.313%	.246%	98.412%	92.402%	94.275%
2.	98.989%	98.112%	5.089%	98.522%	83.522%	88.829%
3.	99.403%	99.345%	.511%	99.235%	99.235%	94.669%
4.	99.212%	99.567%	1.180%	98.890%	98.890%	96.424%
5.	99.001%	99.511%	1.134%	99.510%	99.510%	96.873%
6.	97.786%	97.589%	3.459%	97.786%	87.786%	87.776%
7.	97.312%	97.303%	.913%	97.534%	99.534%	98.989%
8.	99.541%	99.589%	.899%	99.578%	95.578%	95.259%
9.	99.112%	99.578%	4.673%	98.905%	89.905%	90.121%
10.	99.538%	99.458%	3.897%	99.454%	90.450%	90.711%
11.	97.370%	97.890%	1.126%	97.760%	97.760%	95.056%
12.	98.788%	98.156%	2.390%	98.689%	98.689%	97.100%
13.	97.078%	97.890%	4.111%	97.258%	88.298%	90.134%
14.	98.212%	98.677%	.698%	98.501%	94.414%	94.429%
15.	99.246%	99.023%	.235%	99.204%	89.244%	89.656%
Average	98.609%	98.667%	2.037%	98.616%	93.681%	93.353%

Table 4. Average data for the control group.

	Right Eye Detected	Left Eye Detected	Eye Blink Detected	Face Detected	Right Eye Open Probability	Left Eye Open Probability
1.	92.012%	92.200%	2.045%	92.125%	83.134%	83.445%
2.	91.989%	91.522%	4.179%	92.030%	84.309%	84.980%
3.	90.443%	90.355%	.911%	90.858%	82.240%	81.997%
4.	90.102%	89.996%	3.187%	91.011%	81.387%	81.789%
5.	93.001%	92.955%	1.134%	92.877%	85.209%	84.970%
6.	87.496%	87.559%	3.459%	88.009%	77.249%	78.010%
7.	92.312%	92.311%	.913%	92.128%	82.748%	82.937%
8.	91.541%	91.589%	2.709%	91.234%	83.749%	84.000%
9.	94.500%	94.578%	4.673%	95.100%	84.482%	84.199%
10.	91.938%	91.458%	3.897%	91.323%	79.023%	80.010%
11.	89.300%	89.288%	3.118%	90.006%	82.396%	82.478%
12.	88.748%	88.606%	5.390%	89.020%	79.078%	79.302%
13.	92.278%	92.391%	6.111%	92.248%	84.287%	83.898%
14.	91.222%	91.227%	2.898%	91.112%	82.112%	82.232%
15.	90.236%	90.123%	.997%	89.997%	83.090%	83.091%
Average	91.141%	91.077%	3.041%	91.272%	82.299%	84.489%

Table 5. Differences in Indicators of Attention (Experimental vs. Control Groups) (T test for Equality of Means; p<0,05)

Variables	Groups	Number of students	Mean	Standard Deviation	Standard Error Mean	T value	Sig. (2 tailed)
Right Eye Detected	Experim.	15	98.60900	.849986	.219465	14.647	.000
	Control	15	91.14120	1.782324	.460194		
Left Eye Detected	Experim.	15	98.66673	.816746	.210883	14.892	.000
	Control	15	91.07720	1.796919	.463962		
Eye Blink Detected	Experim.	15	2.03740	1.725557	.445537	-1.632	.114
	Control	15	3.04140	1.644003	.424480		
Face Detected	Experim.	15	98.61587	.747374	.192971	15.482	.000
	Control	15	91.27187	1.678292	.433333		
Right Eye Open Prob.	Experim.	15	93.68113	5.244201	1.354047	7.712	.000
	Control	15	82.29953	2.273166	.586929		
Left Eye Open Prob.	Experim.	15	93.35340	3.494117	.902177	10.401	.000
	Control	15	82.48920	2.038768	.526408		

When comparing the results of the first (Gavrić, Minović, Mišković 2022) and second experiments, we can conclude that differences at the level of individual students were more pronounced in the first experiment than in the second. Specifically,

the difference between the most attentive student in the experimental group and the least attentive student in the control group ranged between 14.8% and 23.5% in the first experiment. In the second experiment, this range (for the eighth student from the experimental group and the twelfth student from the control group) was between 10.6% and 16.5% across the five statistically significant indicators.

However, at the group level, the differences in paired indicators between the experimental and control groups were more pronounced in the second experiment. This is evident when comparing the *t* values for the indicators "probability of left eye openness" and "probability of right eye openness" (Table 5).

CONCLUSION

In this paper, we presented the results of an experiment aimed at detecting and quantifying differences in the external manifestations of students' attention during distance learning. This relatively new form of teaching has both advantages and disadvantages but also holds immense potential for widespread adoption. A recent study conducted in Taiwan in the post-Covid19 pandemic period yielded important findings: a *shared screen* displaying teaching materials on an online learning platform attracts the most visual attention, *highlighted portions* of teaching materials have the greatest capacity to sustain attention, and the shared screen exerts a *stronger influence* on visual attention compared to any other area on the platform (Wang, Chen, Hsueh 2023). In other words, the *shared screen* positively impacts students' visual attention; however, the *visualization* of teaching materials should be improved by experts in the field, and efforts should be made to reduce the *impact of "distracting factors"* due to the different context in which this type of learning is conducted (e.g., a home environment).

We hypothesized that various situational factors might (though not necessarily) disrupt students' attention during online learning. Experimental results indicate that one such situational factor – a verbal prompt by the instructor to increase attention - can enhance visual attention. Of the six indicators of external attention, five showed statistically significant increases in the group of students who were prompted to listen carefully to the lecture (the experimental group) compared to those who did not receive such a prompt (the control group). One indicator ("eye blinking") did not show statistical significance either in the initial experiment (Gavrić, Minović, Mišković 2022) or in the repeated experiment.

Various factors might have influenced this outcome. An eye blink lasts only 0.1 seconds, which is a very short duration that older smartphone cameras likely cannot

accurately capture. From a medical perspective, eye blinking is an involuntary reflex that may increase in individuals wearing contact lenses or in those with certain neurological conditions. Conversely, during activities such as driving, working on a computer, or performing other precise tasks, the blink rate tends to decrease compared to the norm (Knudsen 2007). Thus, we believe the "eye blinking" variable demonstrates non-discriminative properties in both experiments, which should be considered when reconstructing and improving the measurement instrument in future research. Nonetheless, the instrument's overall measurement properties cannot be disputed.

The experiment confirmed that the findings align with our expectations: students' visual attention increases when they are explicitly directed to focus on the importance of the material being presented. However, a separate question arises regarding whether frequent "attention-raising" interventions, such as verbal prompts or other pedagogical measures, could lead to counterproductive effects. This remains a potential topic for future research.

BIBLIOGRAPHY

1. Beck, Ulrich (1992), *Risk society: Towards a new modernity*, Sage Publications.
2. Carrasco, Marisa (2011), ″Visual attention: The past 25 years″, *Vision Research*, 51(13), 1484-1525.
3. Chen, Hsueh Chih , Hwei Der Lai, Fa Chung Chiu (2010), ″Eye tracking technology for learning and education″, *Research in Education Sciences*, 4, 39-68.
4. De Oliveira, Mayra Martins Santana, Antonio Sergio Torres Penedo, Vinícius Silva Pereira (2018), ″Distance education: advantages and disadvantages of the point of view of education and society″, *Dialogia*, 29, 139-152.
5. Dubey, Pushkar, Deepak Pandey (2020), ″Distance learning in higher education during pandemic: challenges and opportunities″, *International Journal of Indian Psychology*, 8(2), 43-46.
6. Gavrić, Željko, Miroslav Minović, Vanja Mišković (2022), "Tracking Students? Visual Attention During E-Learning in the Time of COVID-19". *International Journal of Engineering Education*, Vol. 38, No. 5(B), 1550-1561.
7. Giddens, Anthony (1991), *Modernity and self-identity: Self and society in the late modern age*, Stanford University Press
8. Goldstein, Bruce (2014), *Cognitive, Psychology: Connecting Mind, Research and Everyday Experience* (4th ed.), Wadsworth Publishing;

9. Harari, Yuval Noah (2020), ″The world after coronavirus″, *Financial times*, 20(03).
10. Janković, Aleksandar, Duško Trninić (2022), ″Fear and distrust towards social institutions in the beginning of the coronavirus pandemic (SARS-COV-2): Research carried out in the Republic of Srpska / Bosnia and Herzegovina″, In: *Political and Economic Self-Constitution: New Forms of Political, Economic and Social Resilience During Pandemic Times*: *Proceedings of the X International Scientific and Practical Seminar*, Federal University of Santa Catarina, Brasil, 33-38.
11. Knudsen, Eric I. (2007), ″Fundamental components of attention″, *Annual Review of Neuroscience*, 30, 57-78.
12. Marić, Jovan (2001), *Klinička psihijatrija*, Megraf, Beograd
13. Özüdoğru, Gül (2021), ″Problems faced in distance education during Covid-19 Pandemic″, *Participatory Educational Research*, 8(4), 321-333.
14. Pashler, Harold (ed.) (1998), *Attention,* Psychology Press. London
15. Posner, Michael I., Steve E. Petersen (1990), ″The attention system of the human brain″, *Annual Review of Neuroscience*, 13(1), 25-42.
16. Selimović, Sanja, Stanko Blatnik (2023), ″Past, present and future of distance learning″, *Research in Education and Rehabilitation*, 6(1), 9-16.
17. Styles, Elizabeth A. (2005), *Attention, Perception and Memory: An Integrated Introduction.* Psychology Press. Routledge
18. Trninić, Duško, Aleksandar Janković, Ranka Perić Romić (2021), ″Socio-political changes in mode of living of and social relationships between citizens of the Republic of Srpska during COVID-19 pandemic″, In: *Political Consequences of the Pandemic: The 2020 Serbian Political Science Association Annual Conference*, Serbian Political Science Association and Faculty of Political Science, Belgrade, 109-128.
19. Unesco (2023), *UNESCO's education response to COVID-19*, 21 June 2023. Available at: https://www.unesco.org/en/covid-19/education-response/initiatives [Accessed 15 September 2023].
20. Wang, Chun-Chia, Hsuan-Chu Chen, Cheng-Yu Hsueh (2023), ″Tracking Learners' Visual Attention of a Virtual Platform during the COVID-19 Pandemic: Evidence from Eye Movements″, *14th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI)*, Koriyama, Japan, 206-211.

UTICAJ UČENJA NA DALJINU NA PAŽNJU STUDENATA TOKOM PANDEMIJE COVID-19: SOCIJALNI EKSPERIMENT

Sažetak:

Cilj rada je istražiti vizuelnu pažnju studenata kod online nastave tokom pandemije Covid-19. Za detekciju vizuelne pažnje korištena je tehnologija za praćenje pokreta oka na mobilnom telefonu. U radu je prikazan ponovljeni socijalni eksperiment sa studentima završne godine Fakulteta za informacione tehnologije Slobomir P Univerziteta iz Bijeljine. U eksperimentu su učestvovale dvije grupe studenata iste generacije. Jedna grupa studenata svrstana je u eksperimentalnu, dok je druga grupa svrstana u kontrolnu grupu. Podaci tokom eksperimenta su prikupljani automatski i čuvani u bazi podataka iz koje su kasnije rađene statističke analize. Pošli smo od pretpostavke da različiti situacioni činioci mogu narušiti pažnju studenata prilikom izvođenja online nastave. Od šest indikatora spoljašnje pažnje, pet indikatora su pokazali statistički značajno veću vrijednost u grupi studenata koja je bila upozorena da pažljivo sluša nastavu (eksperimentalna grupa), u odnosu na grupu kojoj nije dato takvo upozorenje (kontrolna grupa). Istraživanje je pokazalo da, bez obzira na brojne „ometajuće činioce" u kućnom ambijentu koji mogu smanjiti pažnju studenata prilikom učenja na daljinu, upozorenje nastavnika na važnost nastavnog gradiva koje se prezentuje utiče na povećanje vizuelne pažnje studenata.

Ključne reči: učenje na daljinu; Covid-19; vizualna pažnja; detekcija lica; treptanje oka

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