

DOCUMENT

Name and surname	Ing. Marek Šimon, PhD.
Document type:	Characteristics of the submitted research/ artistic/other output
The name of the university	University of Ss. Cyril and Methodius in Trnava
The seat of the university	Nám. J. Herdu 2, 917 01 Trnava
The name of the faculty	Faculty of Natural Sciences
The seat of the faculty	Nám. J. Herdu 2, 917 01 Trnava

OCA1. - Surname awarded to the assessed person

Šimon

OCA2. - Name awarded to the assessed person

Marek

OCA3. - Degrees awarded to the assessed person

Ing., PhD.

OCA4. - Hyperlink to the entry of the person in the Register of university staff

<https://www.portalvs.sk/regzam/detail/14374>

1st evaluated output

OCA5. - Area of assessment

Applied informatics

OCA6. - Category of the research/ artistic/other output

scientific output

OCA7. - Year of publication of the research/artistic/other output

2019

OCA8. - ID of the record in the Central Registry of Publication Activity (CRPA) or the Central Registry of Artistic Activity (CRAA)

ID = 137742

OCA9. - Hyperlink to the record in CRPA or CRAA

<https://app.crepc.sk/?fn=detailBiblioFormChildQOK4T&sid=652C531D78969B52945580470C&seo=CREPČ-detail-Článok>

OCA10. - Hyperlink to the record in another publicly accessible register, catalogue of research/ artistic/other outputs

<https://www.webofscience.com/wos/woscc/full-record/WOS:000484444100063>

OCA13. - Hyperlink to the webpage where the output is available (full text, other documentation, etc.)

<https://www.mdpi.com/2076-3417/9/16/3269>

OCA14. - Characteristics of the author's contribution

As stated in the article itself in the "Author Contributions" section, the author's contribution (30%) to solving the problem consists of the following parts: software, validation, and visualization.

OCA15. - Annotation of the output with contextual information concerning the description of creative process and the content of the research/artistic/other activity, etc.

Heuristics for Spreading Alarm throughout a Network [electronic] / Marek Šimon, Ladislav Huraj, Iveta Dirgová Luptáková, Jiří Pospíchal, 2019. DOI DOI 10.3390/app9163269. In: Applied sciences. - ISSN 2076-3417 (online), Roč. 9, č. 16 (2019), s. [1-12] [online].

OCA16. - Annotation of the output in English

This paper provides heuristic methods for obtaining a burning number, which is a graph parameter measuring the speed of the spread of alarm, information, or contagion. For discrete time steps, the heuristics determine which nodes (centers, hubs, vertices, users) should be alarmed (in other words, burned) and in which order, when afterwards each alarmed node alarms its neighbors in the network at the next time step. The goal is to minimize the number of discrete time steps (i.e., time) it takes for the alarm to reach the entire network, so that all the nodes in the networks are alarmed. The burning number is the minimum number of time steps (i.e., number of centers in a time sequence alarmed from outside) the process must take. Since the problem is NP complete, its solution for larger networks or graphs has to use heuristics. The heuristics proposed here were tested on a wide range of networks. The complexity of the heuristics ranges in correspondence to the quality of their solution, but all the proposed methods provided a significantly better solution than the competing heuristic.

OCA17. - List of maximum 5 most significant citations corresponding to the output

1. J. García-Díaz, J. C. Pérez-Sansalvador, L. M. X. Rodríguez-Henríquez and J. A. Cornejo-Acosta, "Burning Graphs Through Farthest-First Traversal," in *IEEE Access*, vol. 10, pp. 30395-30404, 2022, doi: 10.1109/ACCESS.2022.3159695.
2. Kenzin, M., Bychkov, I., & Maksimkin, N. (2021). Emergency broadcasting strategies for distributed robotic groups under limited communication. Paper presented at the Journal of Physics: Conference Series, , 1864(1) doi:10.1088/1742-6596/1864/1/012043 Retrieved from www.scopus.com
3. Gautam, R. K., Kare, A. S., & S, D. B. (2021). Faster heuristics for graph burning. *Applied Intelligence*, doi:10.1007/s10489-021-02411-5
4. Gupta, A. T., Lokhande, S. A., & Mondal, K. (2021). Burning grids and intervals doi:10.1007/978-3-030-67899-9_6 Retrieved from www.scopus.com
5. Kamali, S., Miller, A., & Zhang, K. (2020). Burning two worlds: Algorithms for burning dense and tree-like graphs doi:10.1007/978-3-030-38919-2_10 Retrieved from www.scopus.com

OCA18. - Characteristics of the output's impact on socio-economic practice

The article belongs to a series of research tasks solved within the VEGA and APVV project, which uses soft computing methods to increase the security of computer networks. A common problem in networks is the selection of a subset of advantageously located central nodes, which are subsequently able to spread an "alarm" (eg an antivirus notification) to surrounding nodes. The article offers an algorithm to solve this difficult problem, thus contributing to increasing network security in the future.

OCA19. - Characteristics of the output and related activities' impact on the educational process

The problem addressed in the article (research related to both security and graph theory) has an indirect impact on the subject of research in computer science, the teaching of which the evaluated person participates. The topic of the article corresponds to the content of this subject, from the methodological point of view it shows the connection between theory and practice and will positively influence the educational process. The impacts can also be seen indirectly in the subject of graph algorithms and their applications, which is taught in applied informatics the workplace, as well as in the subject of computer networks, which the evaluated person teaches.

2nd evaluated output**OCA5. - Area of assessment**

Aplikovaná informatika/ Applied informatics

OCA6. - Category of the research/ artistic/other output

scientific output

OCA7. - Year of publication of the research/artistic/other output

2016

OCA8. - ID of the record in the Central Registry of Publication Activity (CRPA) or the Central Registry of Artistic Activity (CRAA)

ID: UCM.Trnava.PC022192

OCA9. - Hyperlink to the record in CRPA or CRAA

http://www.crepc.sk/portal?fn=*review&uid=1956753&pageId=resultform&full=0

OCA10. - Hyperlink to the record in another publicly accessible register, catalogue of research/ artistic/other outputs

<https://www.webofscience.com/wos/woscc/full-record/WOS:000388890000001>

OCA14. - Characteristics of the author's contribution

The evaluated person, as the main author (50%), participated in all phases of the output creation, from the initial design of the solution concept, through experimental testing, analysis of the achieved results, to the writing process of the article and the incorporation of review recommendations.

OCA15. - Annotation of the output with contextual information concerning the description of creative process and the content of the research/artistic/other activity, etc.

Neural Gas Clustering Adapted for Given Size of Clusters / Iveta Dirgová Luptáková, Marek Šimon, Ladislav Huraj, Jiří Pospíchal, 2016. In: *Mathematical Problems in Engineering*. - ISSN 1024-123X, 2016, pp. 24793-24793 [7 s.]

OCA16. - Annotation of the output in English

Clustering algorithms belong to major topics in big data analysis. Their main goal is to separate an unlabelled dataset into several subsets, with each subset ideally characterized by some unique characteristic of its data structure. Common clustering approaches cannot impose constraints on sizes of clusters. However, in many applications, sizes of clusters are bounded or known in advance. One of the more recent robust clustering algorithms is called neural gas which is popular, for example, for data compression and vector quantization used in speech recognition and signal processing. In this paper, we have introduced an adapted neural gas algorithm able to accommodate requirements for the size of clusters. The convergence of algorithm towards an optimum is tested on simple illustrative examples. The proposed algorithm provides better statistical results than its direct counterpart, balanced k-means algorithm, and, moreover, unlike the balanced k-means, the quality of results of our proposed algorithm can be straightforwardly controlled by user defined parameters.

OCA17. - List of maximum 5 most significant citations corresponding to the output

1. Hanuliak, P., Hanuliak, M., Zelinka, I., Unified Deterministic Model of Parallel and Distributed Computers, (2018) *International Review on Modelling and Simulations (IREMOS)*, 11 (3), pp. 166-175. doi:<https://doi.org/10.15866/iremos.v11i3.13020>
2. Siladi, V., Povinsky, M., Trajtel, L., & Satymbekov, M. (2018). Adapted parallel quine-McCluskey algorithm using GPGPU. Paper presented at the 2017 IEEE 14th International Scientific Conference on Informatics, INFORMATICS 2017 - Proceedings, , 2018-January 327-331. doi:10.1109/INFORMATICS.2017.8327269 Retrieved from www.scopus.com
3. Rajnák, C., Varga, F., Titiš, J., Moncol, J., & Boča, R. (2018). Octahedral-tetrahedral systems [co(dpmm O, O)3]2+[CoX4]2- showing slow magnetic relaxation with two relaxation modes. *Inorganic Chemistry*, 57(8), 4352-4358. doi:10.1021/acs.inorgchem.7b03193
4. Tang, W., Yang, Y., Zeng, L., & Zhan, Y. (2020). Size constrained clustering with MILP formulation. *IEEE Access*, 8, 1587-1599. doi:10.1109/ACCESS.2019.2962191

OCA18. - Characteristics of the output's impact on socio-economic practice

The article is part of a series of research tasks carried out within the VEGA and APVV projects, which utilize soft computing methods to optimize computer networks. A common issue in networks is the division of a network into subnets of equal size, which can then be managed more efficiently. The article presents an algorithm that addresses this problem using a cutting-edge approach, thereby contributing to the future improvement of network management efficiency.

OCA19. - Characteristics of the output and related activities' impact on the educational process

The problem addressed in the output (research related to networks, computational intelligence, and graph theory) has an indirect impact on the subject of research in computer science, in whose teaching the evaluated person is involved. The topic covered in the output aligns with the content of this subject, demonstrating a methodological connection between theory and practice, thereby positively influencing the educational process. The impact can also be indirectly observed in the course *Artificial Intelligence and Its Applications*, taught within applied informatics at the institution, as well as in the *Computer Networks* course, which the evaluated person teaches.

3rd evaluated output

OCA5. - Area of assessment

Aplikovaná informatika/ Applied informatics

OCA6. - Category of the research/ artistic/other output

scientific output

OCA7. - Year of publication of the research/artistic/other output

2023

OCA8. - ID of the record in the Central Registry of Publication Activity (CRPA) or the Central Registry of Artistic Activity (CRAA)

ID = 1073189

OCA9. - Hyperlink to the record in CRPA or CRAA

<https://app.crepc.sk/?fn=detailBiblioForm&sid=D778A95F77782A999145AA26890E>

OCA13. - Hyperlink to the webpage where the output is available (full text, other documentation, etc.)

https://www.researchgate.net/publication/372731859_A_Comparative_Analysis_of_High_Availability_for_Linux_Container_Infrastructures

OCA14. - Characteristics of the author's contribution

The evaluated person, as the lead author (40%), contributed to all phases of the output creation, from the initial design of the solution concept, through experimental testing, analysis of the achieved results, to the writing process of the article and the incorporation of review recommendations.

OCA15. - Annotation of the output with contextual information concerning the description of creative process and the content of the research/artistic/other activity, etc.

A Comparative Analysis of High Availability for Linux Container Infrastructures. / Šimon, M.; Huraj, L.; Búčík, N.
In: *Future Internet* **2023**, 15, 253. <https://doi.org/10.3390/fi15080253>

OCA16. - Annotation of the output in English

In the current era of information technology, high availability and reliability of services are crucial. This paper focuses on the comparison and analysis of different high-availability solutions in Linux container environments. The aim is to identify the strengths and weaknesses of each approach and determine the optimal solution for common use cases. Through a series of experiments, key performance metrics were collected, including average service recovery time, average transfer rate, and the total number of failed calls. The tested container platforms included Docker, Kubernetes, and Proxmox. Based on a comprehensive evaluation, it can be concluded that Docker with Docker Swarm is the most effective high-availability solution for commonly used Linux containers. However, in specific scenarios, such as when fast data transfer is required or when load balancing is not a priority, Proxmox stands out as a superior alternative.

OCA17. - List of maximum 5 most significant citations corresponding to the output

1. Chou, J.; Chung, W.-C. Cloud Computing and High Performance Computing (HPC) Advances for Next Generation Internet. *Future Internet* **2024**, *16*, 465. <https://doi.org/10.3390/fi16120465>
2. D. Ristovski and M. Gusev, "Evaluating Azure Container, Backend, and Function as a Service," **2024 32nd Telecommunications Forum (TELFOR)**, Belgrade, Serbia, 2024, pp. 1-4, doi: 10.1109/TELFOR63250.2024.10819127.
3. H. Zhou and C. H. Yong, "Implement HPA for Nginx Service Using Custom Metrics Under Kubernetes Framework," in *IEEE Access*, vol. 12, pp. 189722-189734, **2024**, doi: 10.1109/ACCESS.2024.3509876.
4. Bhattacharya, M. H., & Mittal, H. K. (2023). Exploring the Performance of Container Runtimes within Kubernetes Clusters. *International Journal of Computing*, 22(4), 509-514. <https://doi.org/10.47839/ijc.22.4.3359>

OCA18. - Characteristics of the output's impact on socio-economic practice

The results of this study have a significant impact on socio-economic practice, particularly in the fields of information technology, industrial automation, and the operation of critical services. Identifying the optimal solution for high-availability container platforms enables organizations to manage their IT infrastructures more efficiently, reducing service downtime costs and increasing overall reliability.

For the business sector, these findings can be crucial when deciding on the implementation of container technologies based on specific needs, such as fast data transfer or minimizing service outages. In the public sector and critical infrastructures—such as healthcare, transportation, and energy—more efficient management of high-availability systems can contribute to the stable operation of essential services for society.

The study's conclusions can assist IT managers, system architects, and developers in selecting appropriate solutions for various deployment scenarios, ultimately enhancing the efficiency and security of digital services across a wide range of industries.

OCA19. - Characteristics of the output and related activities' impact on the educational process

The analysis of high-availability container solutions provides valuable insights that can be applied in the teaching of subjects focused on cloud computing, virtualization, cybersecurity, and IT infrastructure management.

Students in technical fields can utilize these findings in practical exercises and projects, where they will experiment with various container platforms and evaluate their performance and availability in real-world scenarios. Additionally, research activities related to this study may inspire the development of new educational materials, laboratory tasks, and case studies, enhancing the quality of education in modern IT technologies.

The research results can also be leveraged in professional training and development programs for IT professionals, improving their readiness to design and implement high-availability solutions in practice. This output thus contributes to increasing technological literacy and practical skills for both future and current IT specialists.

4th evaluated output**OCA5. - Area of assessment**

Aplikovaná informatika/ Applied informatics

OCA6. - Category of the research/ artistic/other output

scientific output

OCA7. - Year of publication of the research/artistic/other output

2019

OCA8. - ID of the record in the Central Registry of Publication Activity (CRPA) or the Central Registry of Artistic Activity (CRAA)

103169

OCA9. - Hyperlink to the record in CRPA or CRAA

<https://app.crepc.sk/?fn=detailBiblioForm&sid=1C4C6AA85D9A3B933198B2703D>

Title of the publication to which the hyperlink points

DDoS reflection attack based on IoT: A case study

OCA13. - Hyperlink to the webpage where the output is available (full text, other documentation, etc.)

https://link.springer.com/chapter/10.1007/978-3-319-91192-2_5?utm_source=getftr&utm_medium=getftr&utm_campaign=getftr_pilot&getft_integrator=scopus

Title of the publication to which the hyperlink points

DDoS Reflection Attack Based on IoT: A Case Study

OCA14. - Characteristics of the author's contribution

The evaluated individual, as the lead author (50%), contributed to all phases of the research output, from the initial conceptual design of the solution, through experimental testing and analysis of the obtained results, to the writing process of the article and the incorporation of reviewers' recommendations.

OCA15. - Annotation of the output with contextual information concerning the description of creative process and the content of the research/artistic/other activity, etc.

DDoS reflection attack based on IoT: A case study / Marek Šimon, Ladislav Huraj, Tibor Horák, 2019. - Príspevok indexovaný v Scopus id=2-s2.0-85048047285.

In: **Cybernetics and algorithms in intelligent systems. 3. volume : proceedings of 7th Computer Science on-line conference 2018** : proceedings of 7th Computer Science on-line conference 2018. 3 : volume / Radek Silhavy. - 1. vyd. - Cham : Springer International Publishing AG, 2019. - (ISSN 2194-5357, Advances in Intelligent Systems and Computing, ISSN 2194-5357 ; 765). - ISBN 978-3-319-91191-5, s. 44-52 [print, online].

With the growing number of Internet of Things (IoT) devices, the risk of their misuse for cyberattacks, particularly DDoS attacks, is also increasing. This article focuses on reflective DDoS attacks, where the attacker uses IoT devices to redirect attack traffic without the need to compromise them. Three types of IoT devices were selected for analysis – a smart light bulb, an IP camera, and a Raspberry Pi. The study demonstrates their potential involvement in such attacks and provides an initial insight into their communication traffic.

OCA16. - Annotation of the output in English

The article addresses the development and implementation of remote laboratories in education, which in recent years have become a common tool not only at technical universities but also at lower levels of the educational system. The authors highlight the complexity of this technology, which, although it brings numerous benefits, also carries certain challenges and risks. Special attention is given to issues related to the long-term operation and reliability of remote experiments, emphasizing the need to ensure the innovation of these devices. Furthermore, the article analyzes a problem often overlooked in the design and use of remote experiments, namely device safety, as students may consciously or unconsciously test the limit parameters of experiments. This research emphasizes the need to balance educational objectives with the technical and safety requirements in the operation of remote laboratories.

OCA17. - List of maximum 5 most significant citations corresponding to the output

1 (**Web of Science Core Collection:WOS:000474623600001; Current Content Connect:CCC:000474623600001; SCOPUS:2-s2.0-85068940728**) 132610: Secure Internet of Things (IoT)-Based Smart-World Critical Infrastructures: Survey, Case Study and Research Opportunities / Liu, Xing [Autor] ; Qian, Cheng [Autor] ; Hatcher, William Grant [Autor] ; Xu, Hansong [Autor] ; Liao, Weixian [Autor] ; Yu, Wei [Autor]. - DOI 10.1109/ACCESS.2019.2920763. - WOS CC ; SCO ; CCC **In: IEEE access** [elektronický dokument] : practical innovations, open solutions. - Piscataway (USA) : Institute of Electrical and Electronics Engineers. - ISSN (online) 2169-3536. - Roč. 7 (2019), 79523-79544 [online]

2 (**Web of Science Core Collection:WOS:000568850200084; SCOPUS:2-s2.0-85088979921**) 202913: A multi-class neural network model for rapid detection of IoT botnet attacks / Alzahrani, Haifaa [Autor] ; Abulkhair, Maysoon [Autor] ; Alkayal, Entisar [Autor]. - DOI 10.14569/IJACSA.2020.0110783. - WOS CC ; SCO **In: International Journal of Advanced Computer Science and Applications** [textový dokument (print)] [elektronický dokument] . - Bradford (Veľká Británie) : Science and Information (SAI) Organization. - ISSN 2158-107X. - ISSN (online) 2156-5570. - Roč. 11, č. 7 (2020), 688-696 [tlačaná forma] [online]

3 (**SCOPUS:2-s2.0-85090738578**) 206053: An enhanced view of incidence functions for applying graph theory to modeling network intrusions / Easttom, Chuck [Autor] ; Adda, Mo [Autor]. - DOI 10.37394/232011.2020.15.12. - SCO **In: WSEAS transactions on applied and theoretical mechanics** [textový dokument (print)] [elektronický dokument] . - London (Veľká Británie) : World Scientific and Engineering Academy and Society. - ISSN 1991-8747. - ISSN (online) 2224-3429. - Roč. 15 (2020), 98-105 [tlačaná forma] [online]

4 (**Current Content Connect:CCC:000909183000001; Web of Science Core Collection:WOS:000909183000001; SCOPUS:2-s2.0-85145882542**) 1009058: Current Technologies for Detection of COVID-19: Biosensors, Artificial Intelligence and Internet of Medical Things (IoMT): Review / Irkham, Irkham [Autor, 20%] ; Ibrahim, Abdullahi Umar [Autor, 20%] ; Nwekwo, Chidi Wilson [Autor, 20%] ; Al-Turjman, Fadi [Autor, 20%] ; Hartati, Yeni Wahyuni [Autor, 20%]. - DOI 10.3390/s23010426. - WOS CC ; SCO ; CCC **In: Sensors** [textový dokument (print)] [elektronický dokument] . - Bazilej (Švajčiarsko) : Multidisciplinary Digital Publishing Institute. - ISSN 1424-3210. - ISSN (online) 1424-8220. - Roč. 23, č. 1 (2023), [online] [tlačaná forma]

5 (**Web of Science Core Collection:WOS:000867267600001; Current Content Connect:CCC:000867267600001; SCOPUS:2-s2.0-85139959754; KIS:STU Bratislava_StuUsCat/0097503**) 514553: Internet of Things: Security and Solutions Survey / Sadhu, Pintu Kumar [Autor, 33.333%] ; Yanambaka, Venkata P. [Autor, 33.334%] ; Abdelgawad, Ahmed [Autor, 33.333%]. - WOS CC ; SCO ; CCC **In: Sensors** [textový dokument (print)] [elektronický dokument] . - Bazilej (Švajčiarsko) : Multidisciplinary Digital Publishing Institute. - ISSN 1424-3210. - ISSN (online) 1424-8220. - Roč. 22, č. 19 (2022), [online] [tlačaná forma]

OCA18. - Characteristics of the output's impact on socio-economic practice

The increase in the number of IoT devices requires investments in robust protection and risk management, which can have economic consequences for organizations. Additionally, individuals' privacy may be compromised through compromised devices that can be used to spread malware or collect data. This phenomenon drives the need for new regulatory frameworks to protect against cyber threats, while the demand for security technologies is rising. The compromise of IoT devices in critical infrastructure or smart systems can have far-reaching economic and social consequences, highlighting the need for adequate responses and effective security measures at all levels of society.

OCA19. - Characteristics of the output and related activities' impact on the educational process

The output of the article addressing cyber threats related to IoT devices has the potential to impact the educational process in the field of cybersecurity and technology. The growth of IoT devices and their vulnerabilities to DDoS attacks, including reflective attacks, highlights the need for increasing awareness of cyber threats and the protection of digital systems. Educational institutions should update their curricula to include topics such as IoT security, methods of defending against DDoS attacks, and network vulnerability analysis.

The issue discussed in the article directly affects courses such as Computer Networks I, II, and III, which are taught by the instructor. The results of the experiments are presented in relevant lectures as part of the teaching process. The topics covered align with the content of these courses, both methodologically and technically, and will positively influence the educational process. Moreover, the area of cybersecurity is the subject of many thesis projects that the instructor supervises in the academic program.

5th evaluated output

OCA5. - Area of assessment

Aplikovaná informatika/ Applied informatics

OCA6. - Category of the research/ artistic/other output

scientific output

OCA7. - Year of publication of the research/artistic/other output

2012

OCA8. - ID of the record in the Central Registry of Publication Activity (CRPA) or the Central Registry of Artistic Activity (CRAA)

829888

OCA9. - Hyperlink to the record in CRPA or CRAA

<https://app.crepc.sk/?fn=detailBiblioForm&sid=5C5A3A32D1C107703C159E88FA>

Title of the publication to which the hyperlink points

Preparing and managing the remote experiment in education

OCA13. - Hyperlink to the webpage where the output is available (full text, other documentation, etc.)

<https://ieeexplore.ieee.org/document/6402077>

OCA14. - Characteristics of the author's contribution

The evaluated person, as the lead author (50%), contributed to all phases of the output creation, from the initial design of the solution concept, through experimental testing, analysis of the achieved results, to the writing process of the article and the incorporation of review recommendations.

OCA15. - Annotation of the output with contextual information concerning the description of creative process and the content of the research/artistic/other activity, etc.

T. Kozík and M. Šimon, "Preparing and managing the remote experiment in education," *2012 15th International Conference on Interactive Collaborative Learning (ICL)*, Villach, Austria, 2012, pp. 1-4, doi: 10.1109/ICL.2012.6402077.

The article addresses the development and implementation of remote laboratories in education, which have become a common tool not only at technical universities but also at lower levels of the educational system in recent years. The authors highlight the complexity of this technology, which, although it brings numerous benefits, also carries certain challenges and risks. Special attention is given to the issues of long-term operation and reliability of remote experiments, emphasizing the need to ensure innovation of these devices. Furthermore, the article analyzes a problem often overlooked in the design and use of remote experiments—device safety, as students may consciously or unconsciously test the limit parameters of experiments. This research emphasizes the need for a balance between educational goals and the technical and safety requirements in the operation of remote laboratories.

OCA16. - Annotation of the output in English

The article addresses the development and implementation of remote laboratories in education, which have become a common tool not only at technical universities but also at lower levels of the educational system in recent years. The authors highlight the complexity of this technology, which, although it brings numerous benefits, also carries certain challenges and risks. Special attention is given to the issues of long-term operation and reliability of remote experiments, emphasizing the need to ensure innovation of these devices. Furthermore, the article analyzes a problem often overlooked in the design and use of remote experiments—device safety, as students may consciously or unconsciously test the limit parameters of experiments. This research emphasizes the need for a balance between educational goals and the technical and safety requirements in the operation of remote laboratories.

OCA17. - List of maximum 5 most significant citations corresponding to the output

1 T. Bohné, I. Heine, F. Mueller, P. -D. J. Zuercher and V. M. Eger, "Gamification Intensity in Web-Based Virtual Training Environments and Its Effect on Learning," in *IEEE Transactions on Learning Technologies*, vol. 16, no. 5, pp. 603-618, Oct. 2023, doi: 10.1109/TLT.2022.3208936.

2 Klaudia Krawiecka, Jack Sturgess, Alina Petrova, and Ivan Martinovic. 2021. Plug-and-Play: Framework for Remote Experimentation in Cyber Security. In *Proceedings of the 2021 European Symposium on Usable Security (EuroUSEC '21)*. Association for Computing Machinery, New York, NY, USA, 48-58. <https://doi.org/10.1145/3481357.3481518>

3 Uckelmann, D., Mezzogori, D., Esposito, G., Neroni, M., Reverberi, D., Ustenko, M., & Baalsrud-Hauge, J. (2021). Guideline to Safety and Security in Federated Remote Labs. *International Journal of Online and Biomedical Engineering (ijOE)*, 17(04), pp. 39-62. <https://doi.org/10.3991/ijoe.v17i04.18937>

4 Uckelmann, D., Mezzogori, D., Esposito, G., Neroni, M., Reverberi, D., Ustenko, M. (2021). Safety and Security in Federated Remote Labs – A Requirement Analysis. In: Auer, M., May, D. (eds) *Cross Reality and Data Science in Engineering*. REV 2020. *Advances in Intelligent Systems and Computing*, vol 1231. Springer, Cham. https://doi.org/10.1007/978-3-030-52575-0_2

5 Cvjetković, V.M., Stanković, U. (2017). Arduino Based Physics and Engineering Remote Laboratory. In: Auer, M., Guralnick, D., Uhomobhi, J. (eds) *Interactive Collaborative Learning. ICL 2016*. *Advances in Intelligent Systems and Computing*, vol 545. Springer, Cham. https://doi.org/10.1007/978-3-319-50340-0_51

OCA18. - Characteristics of the output's impact on socio-economic practice

The output of this article highlights the importance of remote laboratories in modern education, which are increasingly used at technical universities and lower levels of the educational system. These laboratories enable broader access to experimental activities, but also present challenges in terms of their long-term operation and reliability. This creates a need for investments in both technical and human resources for their management and innovation. The risks associated with device safety and the potential for unintentional damage to equipment by students require the consideration of safety measures, which may increase maintenance and oversight costs. At the same time, the need for a balance between educational objectives and technological requirements emerges, which can impact the development and implementation of new educational methods. In the economic context, these technological innovations stimulate the growth of demand for specialized tools and platforms for remote laboratories, thus supporting the development of the educational technology and IT solutions market. The output can contribute to more efficient deployment of remote laboratories and improve their integration into the educational process.

OCA19. - Characteristics of the output and related activities' impact on the educational process

The output of this article has a significant impact on the educational process, particularly in the area of implementing remote laboratories, which are becoming a common tool in technical and lower-level education. These laboratories provide broader access to experimental activities, increasing the availability of educational opportunities. However, with the introduction of this technology, new challenges arise, especially concerning the long-term operation and reliability of remote experiments. The development and operation of these devices require investments in technical and human resources, which may affect the efficiency of the educational process.

This research also highlights the need to address safety issues and risks associated with the use of remote laboratories. Students may experiment with limit parameters, which could lead to unintentional damage to equipment. Therefore, it is essential to implement safety measures and monitoring systems that allow managing these risks.

These findings suggest that the effective deployment of remote laboratories requires a balance between educational objectives and technical requirements, which may influence the further development of educational methods and technologies in this area.