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Examination of Readiness of Teachers in the Use of Information-Communication Technologies in the Classroom

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Abstract**—**This paper compares the readiness of chemistry teachers to use information and communication technologies in chemistry in 2018 and 2021. A survey conducted in 2018 on a sample of teachers showed that most teachers occasionally use visualization and digitization tools in chemistry teaching (65%), but feel that they are not educated enough to use them (56%). Also, most teachers do not have adequate equipment in their schools and are not able to use ICT in teaching or digital tools for visualization and digitization of content (44%). None of the teachers find the use of digitization and visualization tools useless. Furthermore, a survey conducted in 2021 shows that most teachers occasionally use visualization and digitization tools in chemistry teaching (83%). Also, the research shows that some teachers still do not have adequate equipment in their schools and are not able to use ICT in chemistry teaching or digital tools for visualization and digitization of content (14%). Advances in the use of ICT in chemistry teaching are linked to pandemic conditions and the obligation to conduct online teaching. The share of 14% of teachers who still do not have adequate equipment to use digital tools in teaching is worrying.

Keywords**—**Chemistry, digital content, e-learning, ICT, visualization.

I. Introduction

THIS paper examines the equipment of schools with information and communication technology (ICT) and the readiness of teachers to use information and communication devices and technologies for teaching purposes. Also, it is examined to what extent and which tools for visualization and digitization teachers/professors use for the purposes of teaching chemistry.

It is a common opinion that technology will certainly find its place in the teaching process by itself. However, the rapid development of ICT in the last two decades has left almost no reflection in teaching, if we exclude the teaching of informatics. There is a real danger of repeating the story with audiovisual and other multimedia tools that heralded a revolution in teaching, that in classrooms these tools would become obsolete even before they were used. Despite such a negative experience, we are convinced that the computer can improve school teaching and learning. In order to find your place in classes, one needs to:

1. respect the peculiarities of the subject;
2. enable the student individual access;
3. involve teachers in the entire process, and especially enable them to adapt educational digital content to their teaching style. [1]

Although digital technologies and the Internet have caused major changes in the past ten years in the context of upbringing and education, the application of e-learning despite efforts and promotion is limited in scope. One of the obstacles in most Croatian schools is certainly the poor information infrastructure and the uneven equipping of students with digital technologies.

In recent years, research on the use of ICT in education has often been conducted [2]-[4]. In the mentioned researches, the impact of the application of ICT on education is described. The authors state that ICT has a positive effect on educational achievements in primary school and that there is a positive relationship between the length of the period of ICT use and students' success on the PISA mathematics tests. Research also shows that schools with better ICT equipment achieve better results than schools with poorer ICT equipment [5]. On the other hand, students are members of the so-called "Net generation" and they cannot imagine their life without ICT.

In the literature, members of the Net generation are most often described through seven common characteristics: specific, protected, self-confident, team-oriented, conventional, under pressure and successful [6]. In addition to great racial and ethnic differences, they are very interested in new technologies, are more inclined to group activities, but also identify with the values of their parents more than any generation before them [7]. They have very large impact on higher education [8].

Each succeeding generation has been observed to acquire greater digital literacy compared to its predecessors, who are only a few years older, and each succeeding cohort demonstrates a greater capacity for non-textual, digital expression [9].

Aim of the Research

Two studies were conducted on a random sample of chemistry teachers in primary and secondary schools. The same survey questionnaire was used in 2018 and 2021, and the aim was to investigate whether there are differences in school equipment, in the use of specialized chemistry classrooms, IT classrooms, and in the use of digital tools and applications for the purposes of conducting chemistry classes in primary and secondary schools.

The following hypotheses were put forward:

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H1. In 2021, schools are better equipped with IT equipment and the Internet than in 2018.
H2. In 2021, teachers use digital teaching content and applications more than in 2018.
H3. There is no difference in the selection of applications that teachers use in chemistry classes in 2018 and 2021.

II. Research Methodology

A. Sample of Participants

The sample consisted of 86 chemistry teachers from Croatia. 43 chemistry teachers participated in the research conducted in 2018, and 43 teachers participated in the research conducted in 2021. The samples were random.

B. Research Instrument

The research was conducted using an online questionnaire created in the Google Forms tool. The questionnaire consisted of 14 questions. Four questions were related to gender, age, years of service and place of work. Other questions are related to the use of tools for visualization and digitization in teaching chemistry. 3 questions were in the form of multiple-choice (you can choose several answers), and 7 questions were in the form of choosing one one of the offered answers. The time required to fill out the questionnaire was up to 5 minutes.

C. Procedures of Data Processing

After the research had been carried out, the data collected by the described instrument were entered in the computer program for statistical processing in SPSS 16 [19], and the results were presented graphically in a commercial data processing program, Microsoft Excel [20].

III. Results and Discussion

In the research conducted in 2018, 43 chemistry teachers (6 male and 37 female teachers) between the ages of 25 and 61 participated (*M* = 42.32; *SD* = 9.24). The majority of teachers work in secondary school (53.5%), while the working experience of the interviewed teachers varies from 4 months to 38 years (*M* = 15.98; *SD* = 9.50) (Table I).

TABLE I
Descriptive Data for the Description of the Sample in the Research Conducted in 2018 (N = 43)

		M	*SD*	*Min*	*Max*
Age		42,32	9.24	25	61
Length of service		15.98	9.50	0.33	38
		f	%		
Sex	Male	6	14.0		
	Female	37	86.0		
Current employment	Elementary School	16	37.2		
	High school	23	53.5		
	Elementary and high school	2	4,6		
	Other [1]	2	4,6		

Note: 1-, National Center for External Evaluation of Education (NCVVO), Agency for Education (AZOO).

In the research conducted in 2021, 43 chemistry teachers (3 male and 40 female teachers) between the ages of 24 and 59 participated (*M* = 39.57; *SD* = 10.59). The majority of teachers work in primary school (76.74%), while the length of service of the surveyed teachers varies from 2 months to 32 years (*M* = 12.83; *SD* = 9.56) (Table II).

TABLE II
Descriptive Data for the Description of the Sample in the Research Conducted in 2021 (N = 43)

		M	*SD*	*Min*	*Max*
Age		39.57	10.59	24	59
Length of service		12.83	9.56	0.17	32
		f	%		
Sex	Male	3	7.0		
	Female	40	93.0		
Current employment	Elementary School	33	76,74		
	High school	10	23,26		
	Elementary and high school	0	0		
	Other [1]	0	0		

Note: 1-NCVOO, AZOO.

Table III shows that the largest number of chemistry teachers in 2018 sometimes (36.4%) teach chemistry in a specialized chemistry classroom. According to the slightly above-average height of the arithmetic mean (*M* = 3.32) and the distribution of frequencies by category, it can be seen that the teachers do teach chemistry a little more often (often and always) in a specialized chemistry classroom than they do not (never and rarely).

TABLE III
Frequency of Conducting Chemistry Lessons in a Specialized Chemistry Classroom (N = 44, Research Conducted in 2018)

		f	%	*M*	*SD*
1	Never	6	13.6		
2	Rarely	3	6,8		
3	Sometimes	16	36.4	3.32	1.29
4	Often	9	20.5		
5	Always	10	22.7		

Table IV shows that the largest number of chemistry teachers in 2021 sometimes (29.3%) teach chemistry in a specialized chemistry classroom. According to the slightly above-average height of the arithmetic mean (*M* = 3.22) and the distribution of frequencies by category, it can be seen that the teachers do teach chemistry a little more often (often and always) in a specialized chemistry classroom than they do not (never and rarely).

TABLE IV
Frequency of Conducting Chemistry Lessons in a Specialized Chemistry Classroom (N = 41, Research Conducted in 2021)

		f	%	*M*	*SD*
1	Never	7	17,1		
2	Rarely	5	12.2		
3	Sometimes	12	29.3	3.22	1.41
4	Often	6	14.6		
5	Always	11	26.8		

In the comparison of the results of the research conducted in 2018 and 2021, a decrease in the percentage was observed.

By analyzing the samples and performing the χ^2-test, it was observed that with a reliability of 95%, we can conclude that there is a statistically significant difference between the respondents in the frequency of using the specialized chemistry classroom in 2018 and 2021 ($\chi^2 = 0.4243$, df = 4).

In the research conducted during 2021, a decrease in the share of chemistry classroom usage compared to 2018 was noted. The objective reason for this phenomenon is the implementation of online classes in schools during the COVID-19 pandemic.

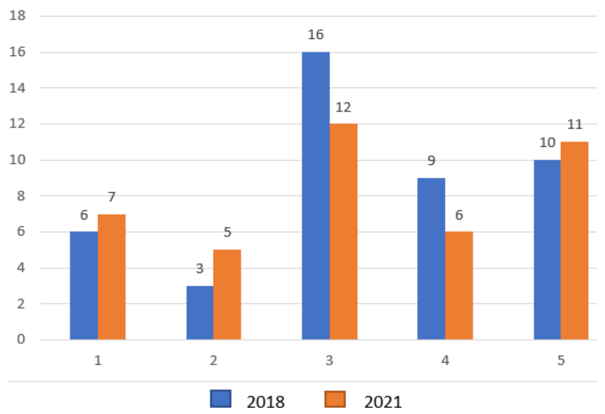

Fig. 1 Distribution of the frequency of conducting chemistry lessons in a specialized chemistry classroom (set 1 = survey results conducted in 2018, set 2 = survey results conducted in 2021)

Table V shows that in 2018, as many as 69.8% of chemistry teachers never use computer classrooms for the purposes of teaching chemistry. This is indicated by the below-average height of the arithmetic mean (*M* = 1.56) and the frequency distribution, which indicate that the majority of chemistry teachers rarely use or do not use computer classrooms for the purposes of teaching chemistry, and a very small number of teachers (9.3%) often uses them (Table V).

TABLE V
FREQUENCY OF USING THE IT CLASSROOM FOR THE PURPOSES OF TEACHING CHEMISTRY (N = 43, RESEARCH CONDUCTED IN 2018)

		f	%	*M*	*SD*
1	Never	30	69.8		
2	Rarely	6	14.0		
3	Sometimes	3	7.0	1.56	0.98
4	Often	4	9.3		
5	Always	0	0		

Table VI shows that in 2021, as many as 66.7% of chemistry teachers never use computer classrooms for the purposes of teaching chemistry. This is indicated by the below-average height of the arithmetic mean (*M* = 1.55) and the distribution of frequencies, which indicate that the majority of chemistry teachers rarely use or do not use computer classrooms for the purposes of teaching chemistry, and a very small number of teachers (7.3%) often uses them (Table VI).

Through the analysis of samples and the implementation of the χ^2-test, it was observed that with a reliability of 95% we can conclude that there is a statistically significant difference between the respondents in 2018 and 2021 in the frequency of using the IT classroom ($\chi^2 = 0.6671$, df = 2).

TABLE VI
FREQUENCY OF USING THE IT CLASSROOM FOR THE PURPOSES OF TEACHING CHEMISTRY (N = 42, RESEARCH CONDUCTED IN 2021)

		f	%	*M*	*SD*
1	Never	28	66.7		
2	Rarely	8	19,1		
3	Sometimes	3	7.3	1.55	0.91
4	Often	3	7.3		
5	Always	0	0		

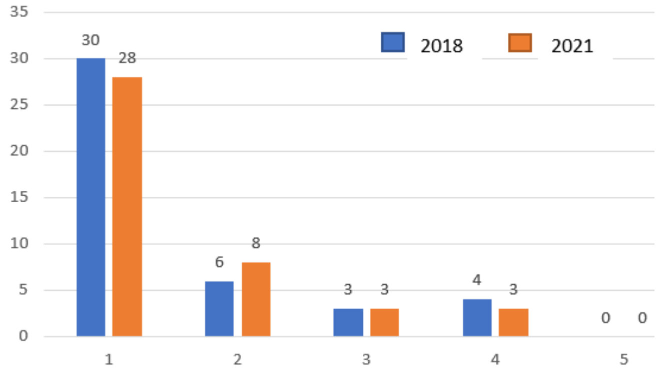

Fig. 2 Distribution of the frequency of use of the computer classroom for the purposes of teaching chemistry (set 1 = results of the survey conducted in 2018, set 2 = results of the survey conducted in 2021)

From Table VII, it can be seen that the majority of the examined chemistry teachers use digital tools for visualization in chemistry classes (in 2018, 68.2%, and in 2021, 86%), while a smaller number do not (in 2018, 31.8 %, and in 2021 14 %).

TABLE VII
USE OF DIGITAL TOOLS FOR VISUALIZATION IN CHEMISTRY CLASSES (N_{2018} = 44, N_{2021} = 43)

	f_{2018}	%	f_{2021}	%
No	14	31.8	6	84
Yes	30	68.2	37	14

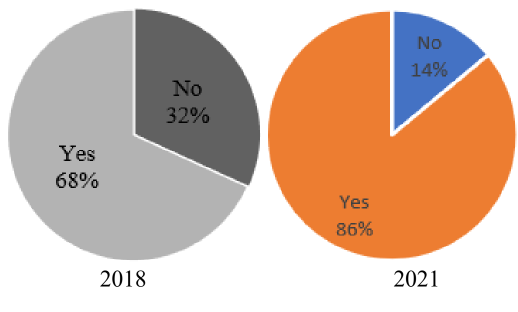

Fig. 3 Distribution of usage of digital tools for visualization in chemistry classes (in%)

By analyzing the samples and performing the χ^2-test, it was observed that with a reliability of 95%, we can conclude that there is a statistically significant difference between respondents in 2018 and 2021 in the interest in using digital tools ($\chi^2 = 0.0005$, df = 1). There is a marked increase in the interest of teachers in using digital tools.

It is interesting that there is no statistically significant difference in the reasons for not using digital tools, as well as in the preferences of individual applications.

Chemistry teachers who do not use digital visualization tools in chemistry classes as the most common reasons for not using them mention insufficient education for the use of such tools (47.4% in 2018, and 7% in 2021) and insufficient information about the existence of such tools (in 2018, 21.1%, and in 2021, 9%). A smaller number of teachers cite reasons of a technical nature, such as the absence of a computer in the classroom (in 2018, 15.8%, and in 2021, 4.7%) and lack of Internet access at school (in 2018, 10.5%, and in 2021, 11.6%). At the same time, in 2018, 5.3% of chemistry teachers cited lack of time as the reason for not using digital visualization tools. It is interesting that in 2021, 4.7% of teachers believe that the use of visualization tools will not contribute to increasing the quality of chemistry teaching, and 2.3% of teachers cite reluctance to change established methods and forms of work as the reason for not using digital visualization tools.

TABLE VIII
REASONS WHY CHEMISTRY TEACHERS DO NOT USE VISUALIZATION TOOLS FOR CHEMISTRY TEACHING PURPOSES

		f_{2018}	$\%_{2018}$	f_{2021}	$\%_{2021}$
1	Insufficient education to use such tools	18	47.4	3	7
2	Insufficient information about the existence of such tools	8	21.1	4	9
3	Absence of computers in the classroom	6	15,8	2	4,7
4	Lack of internet access at school	4	10.5	5	11.6
5	Lack of time	2	5.3	0	0
6	The use of visualization tools will not contribute to increasing the quality of chemistry teaching	0	0.0	2	4,7
7	They do not want to change established methods and forms of work	0	0.0	1	2,3

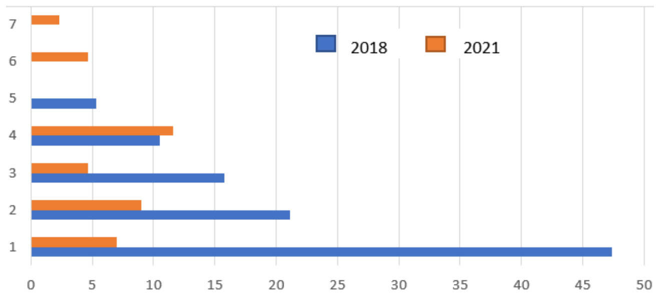

Fig. 4 Distribution of reasons why chemistry teachers do not use visualization tools for the purposes of chemistry teaching (in %) (set 1 = results of the survey conducted in 2018, set 2 = results of the survey conducted in 2021)

Teachers who use digital tools for visualization most often in chemistry classes use ChemSketch [10] (in 2018, 34%, and in 2021, 44%), Chemix [11] (in 2018, 25.5%, and in 2021, 42%) and PhET [12] (in 2018, 19.1%, and in 2021, 42%). At the same time, to a very small extent (2-7%) they use the tools Marvin [13], GoLabz [14], chem4word [15], ChemLab [16], PCCL [17], jmol [18] and pages with simulations.

Teachers most often found out about the existence of digital tools they use for visualization in chemistry classes by independently searching for available content on the Internet (33.8% in 2018, and 53.5% in 2021). In addition to independent searches, they most often found out about digital tools either through professional meetings organized by AZOO or education organized by CARNet, and the research conducted in 2021 shows that teachers learned about the existence of digital tools mainly through recommendations from colleagues (41.9%).

TABLE IX
TOOLS USED BY CHEMISTRY TEACHERS FOR VISUALIZATION IN CHEMISTRY CLASSES UNTIL THE WORKSHOP

	f_{2018}	%	f_{2021}	%
ChemSketch	16	34.0	19	44.2
Chemix	12	25.5	18	41.9
PhET	9	19,1	18	41.9
Marvin	3	6.4	0	0
GoLabz	2	4.3	3	7
chem4word	2	4.3	1	2,3
ChemLab	1	2.1	1	2,3
jmol	1	2.1	0	0
Pages with simulations	1	2.1	4	9.3
PCCL	0	0.0	1	2,3

TABLE X
SOURCES FROM WHICH CHEMISTRY TEACHERS LEARNED ABOUT THE EXISTENCE OF TOOLS THEY USE FOR VISUALIZATION IN CHEMISTRY CLASSES

	f_{2018}	%	f_{2021}	%
Independent search of available content on the Internet	23	33.8	23	53.5
Professional meetings organized by AZOO	14	20.6	15	34.9
Education organized by CARNet	14	20.6	15	34.9
County expert councils	9	13.2	16	37.2
Recommendation of a friend or colleague	7	10.3	18	41.9
College	1	1.5	0	0

A statistically significant difference in the equipment of schools in 2021 compared to 2018 was confirmed, but in its degradation. In 2018, teachers were more satisfied with school equipment than in 2021.

- H1 is rejected. As the main reason for the worse situation in 2021 compared to 2018, respondents cited the equipment of schools with internet infrastructure.
- H2 is confirmed. In 2021, teachers use digital materials more often in chemistry classes than they did in 2018.
- H3 is confirmed. There is no difference in the selection of applications that teachers use in chemistry classes in 2018 and 2021.

IV. LIMITATIONS AND SHORTCOMINGS OF THE CONDUCTED RESEARCH

The research was conducted on a random sample of chemistry teachers in the Republic of Croatia. The limitation of the research is the number of participants. In the future, the research should be conducted on a larger sample. Due to the rapid change and development of digitization, the questionnaire needs to be updated with new applications.

V. CONCLUSION

In the researches conducted in 2018 and 2021 participated 86 chemistry teachers. Chemistry teachers sometimes teach chemistry in a specialized chemistry classroom. In the research conducted during 2021, a decrease in the share of chemistry classroom usage compared to 2018 was noted. The objective reason for this phenomenon is the implementation of online classes in schools during the COVID-19 pandemic. The majority of the examined chemistry teachers use digital tools for visualization in chemistry classes. Chemistry teachers who do not use digital visualization tools in chemistry classes as the most common reasons for not using them mention insufficient education for the use of such tools and insufficient information about the existence of such tools. A statistically significant difference in the equipment of schools in 2021 compared to 2018 was confirmed, but in its degradation. In 2018, teachers were more satisfied with school equipment than in 2021. There is no difference in the selection of applications that teachers use in chemistry classes in 2018 and 2021.

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