Experiences and Preferences: Face-to-Face and Distance Chemistry Education

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Abstract

The content, quality, and efficiency of education affect not only the level of scientific and technical knowledge and the development of production technologies but, above all, the demands of social and production practice. Understandably, new requirements for content and educational forms are also being developed in this changing environment. Chemistry is one of the disciplines that provides education in the fields of science and technology. The prerequisite and factor for the sustainable development of education at present is undoubtedly the development of innovative teaching methods and approaches, accompanied by professional qualifications in chemistry. In this paper, we address the issue of comparing in-person and distance learning in chemistry. The survey aimed to find out how primary and secondary school teachers perceive face-to-face and distance education in the science discipline. We focused on their experiences, opinions, advantages, disadvantages, and classroom problems encountered in both forms of education.

Keywords: Education, Chemistry, Pre-Service Teacher, Digital Competence, Teaching Form

1 Introduction

The contemporary educational environment is undergoing dynamic changes driven by technological progress, societal demands, and growing practical needs for the quality of vocational and professional education (OECD, 2020; Stebila et al., 2023; Žáčok et al., 2023). The content, quality, and effectiveness of education influence not only the level of scientific

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and technical knowledge but also the overall development of production technologies and the competencies required in modern society (Yemini et al., 2025).

Chemistry, as a natural science discipline, plays a significant role in shaping scientific thinking and developing practical skills; therefore, it is essential to address the effectiveness of different forms of chemistry instruction (Hofstein & Lunetta, 2004; Hofstein & Kind, 2012; Bretz, 2019). Its importance as a core natural science subject also underpins other technical disciplines. Chemistry provides students with fundamental scientific reasoning, an understanding of natural processes, and practical skills applicable across many different science subjects.

During 2019 and the subsequent years, a substantial shift in instructional formats occurred. The predominantly face-to-face forms of education used until then were significantly altered. The pandemic period accelerated the transition to distance (online) education. It raised new questions regarding the suitability and comparison of distance and face-to-face learning, as well as their limitations and potential, particularly in experiment-based subjects (Hofstein & Lunetta, 2004; Means et al., 2010; Seery, 2015; Bretz, 2019; Hodges et al., 2020).

Education during the pandemic, and especially in the post-pandemic period, has brought forward unresolved questions concerning the effectiveness of different instructional formats, differences in teachers' perceptions, and the lack of empirical studies specifically focused on chemistry education (Tsaparlis & Sevian, 2013; Taber, 2014; Seery, 2015; König et al., 2020; Trust & Whalen, 2020). Concerning the interconnection and sustainability of education, issues related to the effectiveness of individual instructional forms, teachers' perceptions, and the scarcity of chemistry-specific empirical research have become increasingly prominent. In a changing educational environment, it is understandable that requirements for instructional content and teaching methods are evolving as well. From the perspective of sustainability and practical relevance, chemistry education should support the development of competencies applicable in real-world contexts, including environmental awareness, responsible use of materials, and the application of chemical knowledge in everyday and professional practice.

This study aims to analyse how primary and secondary school teachers perceive face-to-face and distance instruction in chemistry and to identify the advantages, disadvantages, and challenges associated with both methods. Furthermore, the study seeks to assess which instructional formats and methods teachers consider more effective and under which conditions.

2 Material and Methods

This study focused on teachers' perceptions of hybrid (face-to-face and asynchronous online) instruction in chemistry at primary and secondary schools. The aim was to identify how this combined approach can enhance the advantages of both instructional modalities. Particular attention was paid to selected chemistry topics, as chemistry education includes laboratory

activities that require experimental work and the development of practical skills, not only in handling chemical substances but also in using laboratory equipment.

Data were collected through a questionnaire survey designed to capture teachers' subjective experiences and evaluations of different instructional approaches. The questionnaire consisted of 15 closed-ended and 3 open-ended questions (18 items in total). The survey was conducted between 2022 and 2024 among chemistry teachers at primary and secondary schools. Participation was voluntary, and the sample was intended to represent a wide range of teaching experience. The questionnaire covered demographic information (teaching experience, type of school, subjects taught), experience with face-to-face and distance teaching, perceived effectiveness of different instructional forms, identified problems and barriers, and teachers' views on sustainability and innovation in chemistry education.

The research sample included 50 teachers, of whom 30 taught chemistry (28 women and 2 men). Most respondents were from primary schools; among grammar school teachers, 4 women and 2 men participated. All participants had at least 5 years of teaching experience and had been teaching since at least 2019.

The collected data were processed using descriptive statistical methods. Responses to closed-ended questions were analysed quantitatively using frequencies and percentage distributions to summarise teachers' experiences and evaluations of different forms of instruction. Selected items were compared according to school type and length of teaching experience. Responses to open-ended questions were analysed qualitatively using thematic analysis. Participants' statements were coded and grouped into main thematic categories reflecting the benefits, limitations, and barriers of hybrid instruction in chemistry education. All data were processed anonymously.

3 Results and Discussion

Among the advantages of online and face-to-face instruction were flexibility (online) and practical learning and peer interaction (face-to-face). As reported by Carter et al. (2025), self-discipline and pacing pose key challenges in online education, whereas those associated with face-to-face instruction were minimal.

About the forms of instruction and the items included in the questionnaire, the study focused on the following areas:

- identifying teachers' experiences with both forms of education,
- identifying the advantages and disadvantages of both forms of education from teachers' perspectives,
- comparing the effectiveness of individual forms of education in terms of achieving educational objectives,
- examining the problems encountered in chemistry teaching in both forms of education,

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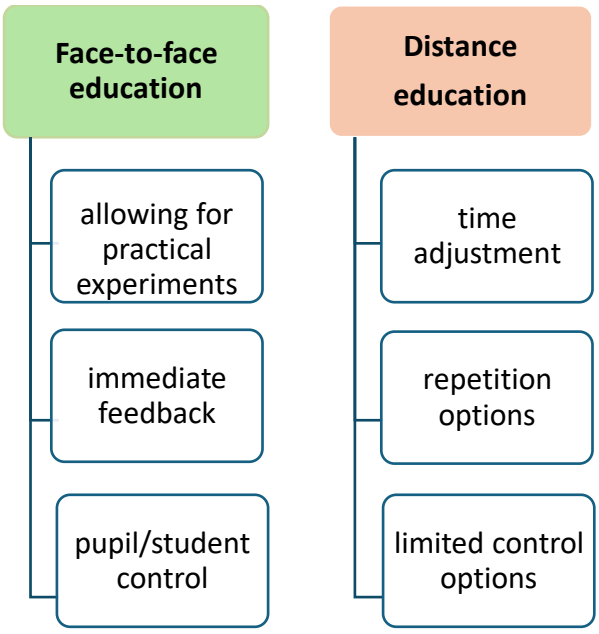
– proposing recommendations for practice and for the further development of innovative teaching methods, including identifying which form of instruction is perceived as more effective for different types of learning content.

3.1 Teachers' Experiences with both Forms of Education

In the introductory section of the questionnaire, teachers' experiences with face-to-face and distance education were compared. When the questionnaire items were grouped according to perceptions of face-to-face education in comparison with online education, teachers evaluated the forms of education as follows (Scheme 1):



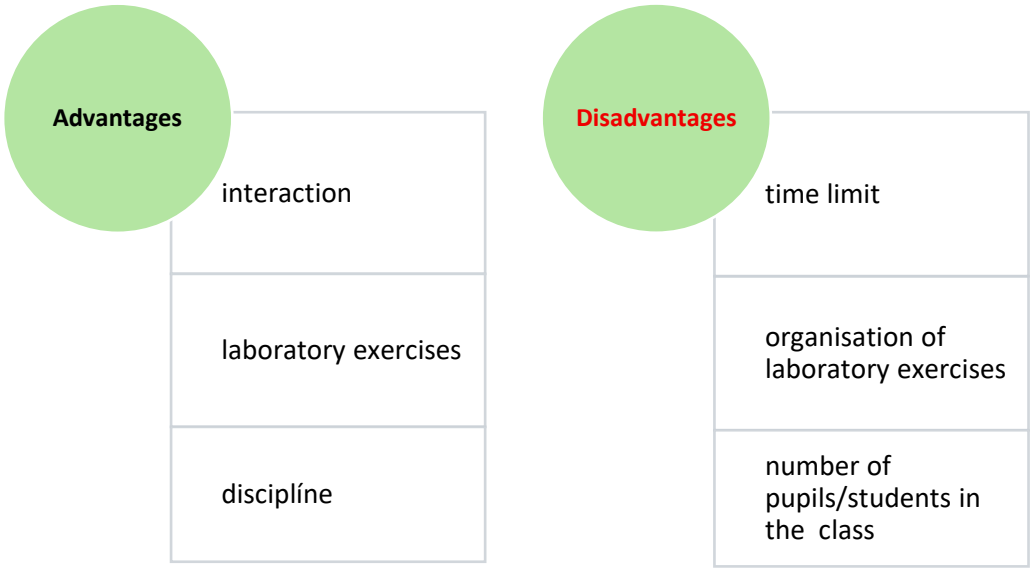
Scheme 1: Comparison of Face-to-Face and Distance Education in Chemistry at Primary and Secondary Schools.

When comparing the results, the majority of respondents reported that face-to-face education feels more natural and also allows them to verify knowledge through practical experiments. As noted by Velempini and Maruatona (2025), for full self-realisation, individuals need to acquire basic knowledge, skills, and habits that can be applied in everyday life. 18 teachers highlighted immediate feedback as a result, and the same outcome was observed during face-to-face lessons when monitoring pupils/students. In terms of evaluation, teachers considered the main advantage of face-to-face instruction to be the focus on teaching and the subsequent assessment of pupils´/students' acquired knowledge. The most important phase in the educational process is the motivational phase—stimulating interest, desire, effort, and the drive to achieve, accomplish, and create something new (Song & Bonk, 2016). In this phase, the role of a highly qualified teacher is irreplaceable (Ruiz-Mallén et al., 2022).

In online education, 27 respondents highlighted time flexibility as a positive aspect, and 60% noted the possibility of repetition. However, many also reported that online education can lead pupils/students to be less focused on learning.

3.2 The Advantages and Disadvantages of both Forms of Education from Teachers' Perspectives

In the following section, we identified the advantages and disadvantages of both forms of instruction from the teachers' perspective. After completing the questionnaire, the factors influencing face-to-face education were classified as its advantages and disadvantages (Scheme 2):



Scheme 2: Advantages and Disadvantages of Face-to-Face Education in Chemistry at Primary and Secondary Schools.

Online education was appreciated for its time flexibility (27 respondents) and the possibility of repeating content (60% of respondents). However, teachers noted that online learning can sometimes lead to reduced pupils/student focus. Teachers reported the following advantages of online education (Table 1):

	Advantages	Disadvantages
Online education	flexibility	limited possibilities for experimentation
	resource availability	weaker pupil/student attention
	use of digital tools	technical problems
	even activities	uneven motivation

Table 1: Advantages and disadvantages of online education.

One of the key areas often underestimated yet with a significant impact on the long-term sustainability of the workforce and quality of life is the development of qualifications and practical skills. In line with these goals, education at primary and secondary schools is a crucial phase, during which fundamental connections are formed among knowledge, attitudes, and habits essential for students' future qualifications through creative activity (Ramadani et al., 2023).

3.3 The Effectiveness of Individual Forms of Education

In the third section, we compared the effectiveness of different instructional approaches in achieving educational objectives, based on teachers' responses. When comparing the two forms of instruction, it can be concluded that both face-to-face and online teaching have their advantages and disadvantages. Based on the results, respondents considered face-to-face instruction as the more effective form (70%). In line with the State Educational Programme (iŠVP) and considering the nature and objectives of the chemistry subject, the organisation of lessons was adapted to the number of students in each class. This ensured appropriate conditions for the proper implementation of teaching and fulfilment of performance and content standards (iŠVP).
Teachers noted that online instruction was less effective for achieving subject-specific aims when pupils/students:

- planned and conducted observations, measurements, or experiments (practical activities);
- developed manual, intellectual, and social skills through practical work while applying safety principles for handling chemicals;
- mastered and applied proper chemical safety procedures.

Most teachers considered face-to-face instruction more natural and suitable for chemistry, particularly for laboratory work, demonstrations, and practical experiments. Benefits included immediate interaction, better oversight of students' activities, and more effective feedback.
Online education was viewed differently. Its flexibility and access to diverse resources were appreciated, but the hands-on nature of chemistry posed practical limitations.
Overall, teachers regarded face-to-face instruction as more effective for most content areas, especially laboratory work, demonstrations, and handling chemicals and lab materials. Online learning was considered better suited for theoretical topics, review, and multimedia-supported learning.

3.4 The problems in Chemistry Teaching in both Forms of Education

In the penultimate part, we examined the problems encountered in teaching chemistry in both forms of education. Most teachers considered the face-to-face form (Table 2) more natural and suitable for teaching chemistry, especially given the need for laboratory work,

demonstrations, and practical experiments. Educators emphasised the possibility of immediate interaction, greater control over pupils' and students' activity, and more effective feedback provision.

Teachers evaluated distance learning (Table 2) ambivalently. Many of them appreciated, in particular, its ability to use modern digital tools. On the other hand, it was significant that perceptions of limitations were related to chemistry's practical nature.

When comparing the two forms, teachers found that face-to-face instruction is more effective for most subjects, especially for laboratory activities, demonstrations, and work with chemicals and laboratory materials. According to them, distance education is more suitable for theoretical topics, curriculum revision, and the use of multimedia aids.

Education	Advantages	Disadvantages
Face-to-face for	• direct guidance of laboratory exercises and experimental demonstrations, • personal guidance of students when working with chemicals and equipment, compliance with health and safety regulations, • immediate feedback, • better discipline and concentration of students, • pupil/student involvement, • easier solution of problem situations.	• time and space requirements of laboratory exercises, • limited material resources in some schools, • higher organisational requirements.
Distance form	• flexibility in teaching, • easy sharing of digital resources, • the possibility of using interactive applications, simulators and videos, • availability of materials for students outside of school.	• inability to conduct experiments, • weaker student motivation and reduced attention, • technical problems (internet, devices), • limited feedback and control, • worse knowledge assessment.

Table 2: Perception of face-to-face and distance learning from the perspective of educators.

3.5 Proposing Recommendations for Practice and Further Development of Innovative Teaching Methods

When recommending practice in chemistry education as a proposal for practice and the further development of innovative teaching methods, respondents offered several suggestions based on their own experience. Respondents mentioned possible combinations

of face-to-face and distance learning (*blended learning*) as long as pupils/ students use correct procedures and techniques in practical activities, process and evaluate data obtained from coherent and disjointed texts, analyse problems, apply knowledge, formulate and verify hypotheses, and appropriately present professional knowledge and information. The optimal solution that teachers mentioned was a combination of both forms (*blended learning),* which uses the advantages of digital tools while maintaining face-to-face practical teaching.
If we consider the interpretation of what these results mean for the future of chemistry teaching, we can come to the following conclusions:
According to teachers, face-to-face education is more effective, especially for

- laboratory and practical topics,
- skills training,
- explaining complex concepts.

Distance education is suitable for

- theoretical topics,
- revision of the curriculum,
- use of multimedia aids.

Teachers perceive the most effective approach as a combined form (*blended learning*), which combines the advantages of both methods. This is also associated with considerations of the need for methodological innovations, the roles of digital tools, and improvements in teacher qualifications (Velempini et al., 2017).
Most respondents reported that face-to-face teaching felt more natural and enabled validation of knowledge through practical experiments. Immediate feedback was highlighted as a key benefit by 18 teachers, and similar results were observed in pupil and student evaluations of face-to-face classes. Teachers emphasised that the motivational phase – stimulating interest, engagement, and creativity – is crucial for learning and the role of a highly qualified teacher is irreplaceable (Song & Bonk, 2016; Ruiz-Mallén et al., 2022).

4 Conclusion

Currently, one of the main challenges for the sustainable development of education is the development of innovative forms and methods, accompanied by adequate professional qualifications of teachers. The results are in line with the findings of many current studies, which indicate that science subjects require direct manipulation of chemical substances and laboratory equipment and tools, which distance learning cannot fully replace. On the other hand, the online environment offers opportunities for innovation, such as virtual experiments, video demonstrations, and interactive quizzes, which can enrich traditional teaching. Both forms have their specificities, but in science subjects, the face-to-face format remains key. The results also point to the need to develop teachers' digital competencies and to systematically

support schools in introducing modern technologies to develop innovative methods in chemistry teaching.

The survey showed that chemistry teachers prefer face-to-face education, mainly because of the subject's practical nature, the need for direct interaction with pupils and students, and the provision of better-quality feedback. However, distance education offers several additional advantages that can be effectively applied to selected topics, especially those of an abstract nature. However, distance education can complement face-to-face teaching by addressing theoretical issues and by using digital tools. Teachers identified several problems associated with distance education, in particular, low pupil/student motivation and technical difficulties. Nevertheless, they consider digital technologies an essential part of modern education. In the future, it is important to support the development of teachers' digital competences, to innovate teaching methods, and to create conditions for the effective combination of both forms of education. A promising approach seems to be combining both forms of education, which optimises the learning process and leverages the strengths of face-to-face and distance education.

Blended learning appears to be a promising approach to sustainable, modern teaching of science subjects, including chemistry. For future development, it is necessary to support innovations, methodological guidelines and further education of teachers in the field of modern teaching technologies.

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