Science Education Quarterly, 2024, Vol. **1**, Iss. 2, pp. 103–108 https://doi.org/10.55056/seq.824

The rebirth of home chemistry experiments: An international perspective and the Ukrainian context

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Abstract

The use of home chemistry experiments has experienced a resurgence in recent years, particularly in light of the COVID-19 pandemic and the need for remote learning solutions. This perspective article examines the rebirth of home chemistry experiments from an international viewpoint, with a specific focus on the Ukrainian context. We differentiate between household and home chemistry experiments, discussing their advantages and challenges based on the work of Ukrainian educator Andrii Kyrylovych Hrabovyi and recent studies. The impact of home chemistry experiments on chemistry education is explored through international case studies from the United States, Finland, South Africa, and Brazil. We argue that even with the return to normal learning conditions in Ukrainian schools, home chemistry experiments should occupy a leading position among the means of teaching chemistry due to their ability to develop design and research skills, foster a caring attitude towards nature, and promote interest in studying chemistry. The experience of Luis Eduardo Doná in developing a home chemistry laboratory kit using affordable and accessible materials is highlighted as an example of how such initiatives can bridge the gap between theoretical learning and practical applications. We conclude that while home chemistry experiments remain a necessity in Ukraine, a review of their role in chemical education worldwide can be a significant step towards improving the quality of chemistry education.

Keywords

home chemistry experiments, household chemistry experiments, chemistry education, COVID-19, Ukraine, international perspective, STEM education, kitchen chemistry

1. Introduction

In chemistry education, one of the most important teaching methods is the educational chemistry experiment, which aims to ensure, in particular, the formation of skills to apply theoretical knowledge of chemistry in practical activities. However, in recent decades, chemistry education in Ukraine has suffered from circumstances that have significantly complicated the use of chemistry experiments as an effective means of teaching chemistry. Ineffective functioning of Ukraine's economy since the restoration of its independence caused a significant reduction in funding for educational institutions, which led to a shortage of chemical glassware and reagents in educational chemistry laboratories. This trend towards the depletion of material resources in educational chemistry laboratories sparked interest among teachers who cared

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about the quality of chemistry teaching in the use of household and home chemistry experiments.

Household and home (DIY, hands-on) chemistry experiments have been known for quite some time and have been used in chemistry teaching methods at least since the middle of the 20th century. Their application was mainly related to the demonstration of the practical importance of chemical knowledge and the interest of students in chemistry [10]. However, home chemistry experiments have experienced a resurgence globally, particularly with the onset of the COVID-19 pandemic in 2020 [2, 4, 17]. This has required educators to rapidly develop new solutions to deliver chemistry laboratory education remotely [2].

The global trend towards virtual and remote learning techniques, including kitchen chemistry and at-home laboratories, can provide a wide-ranging venue to teach chemistry laboratories effectively and encourage diversity and inclusivity [11]. Despite their relevance to real-world applications and potential to expand upon fundamental chemical principles, such experiments are underrepresented in the virtual platform [11].

The translation of chemistry lab experiments into home settings improves the accessibility of chemistry education. In the Brazilian context, Pitre, Stokes and Mlsna [16] developed an at-home chemistry lab experience for survey of organic chemistry students, using household materials and reagents. The developed course was implemented successfully, with preliminary evaluation through student comments and staff reflections suggesting it was a valuable exercise.

2. Household vs home chemistry experiments

In the Ukrainian context, it is important to distinguish between household and home chemistry experiments. They represent two different entities, although they relate to each other as a whole and a part [12].

Household experiments (uzhytkovi khimichni eksperymenty in Ukrainian) involve the use of household substances as reagents or objects of study. But it can be conducted in a school chemistry laboratory using "professional" chemical glassware and some reagents. It can be teacher-led, and therefore demonstrational, but it can also be student-led. It can be conducted in chemistry lessons or in extracurricular activities.

Home experiments (domashni khimichni eksperymenty in Ukrainian) can only be performed at home in the absence of special chemical glassware and reagents directly by the student (with possible assistance or supervision from parents).

Home experiments are a priori household experiments, but not every household chemical experiment can be a home experiment [12]. Avdieieva [3] defines home chemistry experiments as a type of extracurricular work that students perform individually at home under the supervision of parents. We, in turn, propose to define a home chemistry experiment as an educational chemistry experiment of a household nature, carried out by students independently at home, at any time according to instructions, in some cases under adult supervision [12].

Andrii Kyrylovych Hrabovyi[1], in his seminal work on the theoretical and methodolog-

[1]Andrii Kyrylovych Hrabovyi (25.12.1946 – 22.02.2024) was a renowned Ukrainian chemist and educator. Born in Kamianka, Cherkasy oblast, he graduated from the Chemistry Faculty of Cherkasy Pedagogical Institute in 1970. He worked as a chemistry teacher in Kamianets-Podilskyi before joining the Bohdan Khmelnytsky National University of Cherkasy in 1974, where he progressed from lecturer to professor. In 1981, he defended his PhD thesis in pedagogy. Prof. Hrabovyi authored numerous scientific works, textbooks, and manuals for chemistry teachers and students. He was a distinguished educator of Ukraine with a total work experience of 50 years. His contributions to modern education and science were significant, and he was highly respected by students and educators throughout Ukraine.

ical foundations of educational chemical experiments in general education institutions [10], provides a comprehensive classification of educational chemistry experiments according to various criteria, as summarized in table 1.

Table 1
Classification of educational chemistry experiments according to Hrabovyi (10).

Criteria	Types of experiments
activity of teacher and students	teacher-led, student-led
form of organisation	demonstration, laboratory, practical work
organisational forms of learning	lesson, extracurricular
method of execution	real, imaginary, virtual
method of managing students' independent work	research, illustrative

3. Advantages and challenges of home chemistry experiments

The main advantages of home chemistry experiments include: the ability to work at home with substances that are available in everyday life and therefore relatively safe; the formation of environmentally literate behavior in everyday life and the environment; the strengthening of motivation to study chemistry through the application of subject knowledge to ordinary substances and materials; meeting the interest and curiosity of students; the ability to make chemical knowledge closer and simpler to perceive; the ability to provide a quality learning process in distance learning conditions and the unavailability of an educational chemistry laboratory [6, 8, 9, 14].

An important advantage of home chemistry experiments in recent times is their compliance with the criteria for organising STEM education, project activities of students, the use of upcycling and modelling in students' research activities in chemistry [13]. The home experiment creates conditions, even a necessity, to design, adapt, model and reveal creative abilities to implement all stages of a chemical experiment in such unusual conditions.

The main disadvantages of home chemistry experiments are: limited ability to use any necessary chemicals and chemical glassware; difficulty in ensuring simplicity, accessibility and reliability of the experiment at the same time; the teacher's inability to make adjustments to the course of the experiment, pointing out the student's erroneous actions and possible sources of errors; lack of opportunity to form students' skills in working with special chemical glassware and equipment; possible deviations in the results of the experiment, which are associated with the different quality of household chemicals and the inability to strictly adhere to all experimental conditions; use of unsuitable premises and substances and actions dangerous to health, which in many cases requires the presence of adults during the experiment [9].

However, practice shows that it is possible to organise even quite complex chemical experiments (and not only from the school curriculum) as home experiments [12]. All of the above makes it possible to assert that with proper methodological organisation, home chemistry experiments can be used to conduct a significant part of the laboratory experiments in chemistry defined by the program as compulsory.

4. Impact on chemistry education

The impact of home chemistry experiments on chemistry education has been noted in several studies. Albright, J. Stephenson and Schindler [1] reported on converting a

two-week chemistry course for high school students to a remote and virtual four-week course due to the COVID-19 pandemic. The virtual version of the course was able to maintain the same learning objectives and activities when compared to the in-person session and integrated additional expanded lessons, kitchen chemistry activities, and an emphasis on careers in science in order to increase student engagement. Student feedback indicated that interest in a career in STEM was increased overall.

Chen et al. [5] explored how kitchen chemistry experiences during the high school years were associated with students' STEM identity and their STEM career interests using a large U.S. national sample of freshman college students. For STEM identity, they found a gender interaction, with participation in kitchen chemistry activities having a stronger positive effect on STEM identity for girls than for boys, thus narrowing the gender gap. STEM-related career interests were generally boosted by kitchen chemistry experiences, with those effects applying equally to all students, regardless of their gender and race/ethnicity.

Nuora and Välisaari [15] introduced the Kitchen Chemistry (KC) course and its influences on chemistry education as a whole in the Finnish context. KC was found to give lower secondary school pupils the opportunity to understand the chemical phenomena in a familiar context. Teachers of visiting groups saw that integration is the challenge: pupils often see the subjects of chemistry and home economics as separate entities. The chemistry education students highlighted real-world connections to chemistry concepts and contexts and found KC to be an interesting form of teaching chemistry.

Sewry, Ngqinambi and Ngcoza [18] examined attitudes to science when doing kitchen chemistry at science clubs in under-resourced township schools in South Africa. The findings of the study revealed that the learners had a more positive attitude toward science after they had been engaged in the kitchen chemistry hands-on practical activities. Additionally, the integration of everyday knowledge promoted conceptual understanding and improved the performance of the learners.

5. Conclusion

Thus, we are convinced that even with the return to normal learning conditions in Ukrainian schools, home chemistry experiments should occupy one of the leading positions among the means of teaching chemistry. Thanks to features that contribute to the development of design and research skills, a caring attitude to nature, interest in studying chemistry and understanding its place in human life and everyday life, home chemistry experiments should be a mandatory component in the system of studying chemistry. And if for teaching chemistry in Ukraine, home chemistry experiments are still a necessity, then for the rest of the civilised world, a review of its role in chemical education can be a significant step towards improving its quality.

As demonstrated in the work of Luis Eduardo Doná, the development of a home chemistry laboratory kit using affordable and accessible materials can be an effective tool for chemistry education, especially in the context of the COVID-19 pandemic and the need for remote learning [7]. Such initiatives can help bridge the gap between theoretical learning and practical applications, and make chemistry education more engaging and relevant for students.

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