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RESEARCHING THE USER EXPERIENCE OF STUDENTS WITH SPECIAL EDUCATIONAL NEEDS USING VIRTUAL CHEMISTRY LABORATORIES

Abstract. Students with special educational needs face significant barriers in chemistry lessons, especially in traditional chemical laboratory settings. Currently, this work is relevant because it is aimed at identifying key barriers preventing their participation in chemistry lessons, as well as studying the perception of a virtual laboratory by students with special educational needs. The aim of the work was to investigate what obstacles students with disabilities face in traditional chemistry lessons and how their experience changes when using a virtual laboratory. Open interviews with seven students with disabilities were processed using the method of thematic analysis. The analysis revealed four main barriers in the traditional learning format: 1) accelerated pace of material delivery, 2) lack of practical interaction, 3) physical limitations, 4) emotional limitations. The virtual laboratory has overcome these obstacles by providing security, individual pace of work, multimodal visualization, and an enhanced sense of meaningful participation. The participants noted an increase in self-confidence, a decrease in anxiety in the classroom and increased motivation for the subject. The results confirm the potential of virtual environments as an inclusive tool that promotes equal participation of all students in a unified educational process.

Key words: special educational needs, virtual laboratory, inclusive education, education barriers, accessibility, adaptive technologies, academic performance.

Introduction

Chemistry, being the main discipline, requires accessibility of practical classes using laboratory work and experiments for all students. But starting in 2023, such activities have faced the inability to provide for many people with limited opportunities. Many students with special educational needs (SEN) face such problems when working with traditional laboratory practice as: unavailability of laboratory equipment, lack of safety, experiment planning, etc. Students with SEN may have difficulty understanding complex concepts or performing multi-step procedures, which are the most important part of learning chemistry. In addition, students with SEN often report the impossibility of doing laboratory work on their own and at the same time feeling isolated from the group. This unintentional separation of students with disabilities from their peers prevents them from learning together, thereby impairing the quality of education. To solve this problem, some schools provide adaptive laboratory equipment, assistive technologies, or offer alternative assignments (Abdurazova et al., 2025). The relevance of the work is due to the growing need to ensure equal access to quality education for all students, including those with special educational needs. Virtual chemical laboratories offer a new learning method. The purpose of virtual laboratories is to provide real–world simulation of chemical experiments so that students can actively and engagingly participate in the learning process (Herga et al., 2016).

On this topic, Abdurazova et al. (2025) examined the existing barriers and opportunities associated with virtual chemistry laboratories for students with SEN. They studied the physical, cognitive, and sensory obstacles that arise when studying chemistry, and considered learning using virtual labs to overcome these barriers. The article also highlights technological aspects that can enhance the impact of virtual reality (VR), augmented reality (AR), and artificial intelligence (AI). The article contains an overview methodology such as case studies, analysis of recent research, systematization of opportunities and barriers, as well as comparative analysis. As a result, the authors came to the following conclusions: virtual laboratories promote more independent learning for inclusive students, increase student engagement and motivation, and improve their academic performance in the classroom. However, the disadvantages of such tools are the limited availability of virtual instruments, insufficient teacher training in such technologies, and social problems. The authors added that the use of VR, AR, AI, and data analysis allows for the creation of more personalized and manageable virtual labs. If all stakeholders (schools, teachers, developers) cooperate in the future, it will be possible to transform chemistry education, making it more inclusive, effective and accessible.

A similar point of view is shared by Takkouch et al. (2023), having explored the perceptions of accessibility, equality, diversity, and inclusivity of undergraduate and graduate students in online science laboratory courses. The main objectives of this work were to find out what barriers exist in online laboratory courses for different groups of students, and to identify which functions can make laboratory classes more inclusive. The data were obtained using an online questionnaire with questions about perceptions of accessibility, barriers, and satisfaction with laboratory work formats. As well as through semi-structured interviews to gain a deeper understanding of students' opinions, preferences, and identify topics. Thanks to these data, the authors have revealed that online labs provide flexibility, convenience, and the ability to perform work at a comfortable pace for students with disabilities. Despite the difference in research approaches, the results of Abdurazova et al. (2025) and Takkouch et al. (2023) coincide; they demonstrate the same trends in the data obtained.

Based on these barriers, Gavronskaya et al. (2021) have developed a theoretical model of a virtual laboratory to make online chemistry courses more inclusive for students with SEN. The work was aimed at students with hearing, visual, and musculoskeletal impairments. The main goal of this article was to describe the features of learning in a virtual laboratory and to offer different integration options for this group of students. Eventually, a virtual laboratory model was developed for different categories of students with SEN. For example, for students with hearing impairments, subtitles should be added; for visually impaired students, audio descriptions; for students with motor limitations, a light interface so that they can move less. The authors conclude that the proposed model will be a significant step towards ensuring inclusivity in online laboratory classes in the future.

Gallardo-Williams and Dunnagan (2021) focused on the possibility of creating virtual laboratories in such a way that they facilitate the involvement of underrepresented groups in the study of organic chemistry. They analyzed the existing virtual laboratories used in organic chemistry and examined which design elements had already been implemented to ensure inclusivity. In this article, the authors do not conduct a quantitative analysis, but only describe, analyze and prove how virtual laboratories can be designed to ensure inclusivity. The analysis was conducted based on existing experiments in virtual laboratories, student feedback, design features, and how students perceive such laboratories. Accordingly, the authors concluded that a good design of a virtual laboratory can help students from different groups feel more involved in the learning process.

Similarly, Supalo *et al.* (2016) tried to find out whether the involvement of students with complete or partial blindness in laboratory classes in chemistry and physics in secondary schools is increasing. The study was conducted in regular classrooms, where students with varying degrees of visual impairment and sighted students were present. The study used video recordings of laboratory work, which were analyzed depending on the degree of physical participation of students. In addition, qualitative monitoring of student interaction was conducted, as well as interviews with students and teachers. The joint work of students with visual impairments and their sighted partners allowed us to obtain comparative data. As a result, the study showed that adaptive technologies really increase the degree of participation of visually impaired students in laboratory activities. These educational platforms helped students to actively participate in the experimental part, independently perform measurements and analyze the results. However, students with complete visual impairment needed more time to complete laboratory tasks compared to students with partial blindness, which is a limitation of this article.

The article by Robles et al. (2025) examines the introduction of digital platforms as a tool to support inclusive education in chemistry teaching. The work is dedicated to removing barriers to accessibility, inclusivity and diversity in science education. The main purpose of the work is to identify, design and use a digital platform to support students with different educational needs. To achieve these goals, researchers have integrated various digital tools, multimedia resources, visual models, etc. into the platform. These adaptations allowed students to study chemistry, choosing the most appropriate way to learn the material. The results obtained by Robles et al. (2025) are consistent with those of Gallardo-Williams and Dunnagan (2021) and Supalo et al. (2016). They showed that using a digital platform that takes into account the individual abilities of students creates an enriched educational environment. The authors also noted that lessons using digital platforms increase students' motivation and interest in the subject, especially when the tasks offered correspond to their prevailing types of intelligence.

The main purpose of this article is to identify the barriers that students with SEN often face when studying chemistry, as well as to analyze how the adaptive functions of virtual laboratories contribute to the creation of an inclusive educational environment.

Based on the collected literature and the purpose of the study, two interrelated hypotheses were formulated. First, it is assumed that students with SEN in traditional chemical laboratories face various barriers, which leads to passive participation in classes. Secondly, it is assumed that adaptive functions make it possible to overcome these barriers, in which students with disabilities can not only participate, but also actively engage.

To uncover this topic, additional research is needed to explore the perception and personal experiences of students with SEN in a virtual and inclusive environment. Therefore, we conducted a study to answer the following research questions:

1. What barriers do students with special educational needs face when studying the subject?
2. How do the adaptive functions of virtual laboratories affect the formation of an inclusive educational environment?

Methodology

Research design

Several qualitative methods were used in this work. We used individual open interviews (one-on-one open-ended interviews) to get subjective perceptions, feelings, and detailed aspects that cannot be quantified. This type of method helps to identify non-obvious problems related to emotional and psychological barriers. The second chosen method is called semi-structured observation. This method helps to obtain data on the interaction of participants with the virtual laboratory. It shows the specific aspects of working with a virtual laboratory that create these barriers. The combination of the two methods gave us data with which we can study the participant's practical experience with the virtual laboratory.

Sample

The participants were students with different types of special educational needs in different educational institutions (gymnasium and “comfort” schools) in the city of Kaskelen. The sample of participants was conducted among students who had already completed chemistry, so that in the future they could perform the practical part in virtual laboratories.

Data collection

An analysis of the literature review showed that most studies are limited to analyzing the content of the finished data. However, the work of authors such as Supalo et al. (2016) and Takkouch et al. (2023) included conducting interviews and a pedagogical experiment. Based on the successful experience of these authors, qualitative analysis methods, including individual interviews, were chosen to collect primary data.

To conduct an individual open interview, a set of questions was developed that can provide answers to research questions. These interview questions have passed the validation and peer review stage. The expert group consisted of five specialists: a scientific supervisor, a doctor of sciences, a moderator chemist, a moderator psychologist, and a moderator defectologist. The selection of experts from diverse fields of expertise was driven by the need for a comprehensive assessment from various professional perspectives. According to the influence of expert assessments, these questions changed several times before the final result. The tool for conducting the practical part is a virtual laboratory, namely platforms such as: PheET, PraxiLabs, Nobook Virtual Laboratory.

Data collection was carried out individually for each student due to their differences in their age categories, as well as the need for an inclusive approach. The majority of the sample consisted of middle school students, since the presence of inclusive students in high school is less common, and the younger grades have not yet started studying chemistry.

As a result, seven participants with different types of inclusivity from 11 to 13 years old (M = 12) were selected for an individual open interview.Grade 6 was also included in the study because were taking natural science, which includes basic chemistry topics.All demographic data on the participants were shown in table 1.

Table 1. Demographic characteristics of the participants

Participant	Age	Education level	Type of disability	Type of educational institution
Student 1	12	6^{th} grade	DCD	“Comfort”-school
Student 2	13	8^{th} grade	DCD	Gymnasium
Student 3	12	7^{th} grade	DCD	Gymnasium
Student 4	11	6^{th} grade	SPD	Gymnasium
Student 5	12	7^{th} grade	SLD	Gymnasium
Student 6	12	6^{th} grade	DCD	Gymnasium
Student 7	12	6^{th} grade	DCD	“Comfort”-school

*DCD – Development Coordination Disorder; SPD – Students with Physical Disabilities; SLD – Speech and Language Disorder

First, the participants were given introductory information about the virtual laboratory platform and its purpose. After a brief briefing, an individual lesson on a selected chemical topic was held. In the process of working with virtual laboratories, when students studied chemistry, their psychological and emotional perceptions and behavior were monitored. Before the interview, a semi-structured observation was conducted, during which we prepared a protocol in advance, which included: demonstration of difficulties, emotional behavior, and seeking help. The observation was framed in the form of descriptive notes, followed by a classification by topic. The duration of the virtual laboratory lesson was approximately 30 minutes, followed by a 15-minute interview. Through interviews, it was possible to provide subjective assessments of the comfort, level of engagement and motivation associated with this platform.

Data analysis

The experts evaluated the interview questions according to the following criteria: clarity, relevance, content coverage, comprehensibility, ethics, usefulness. The assessment of compliance with each criterion was carried out on a four-point scale (corresponds, partially corresponds, etc.).

The summary score assigned by one expert to a specific issue was determined using the average score of the assessments lined up according to all six criteria. All the experts' scores are shown in Table 2.

Table 2. Expert agreement

Experts	Quest 1	Quest 2	Quest 3	Quest 4	Quest 5	Quest 6
Expert 1	4.00	4.00	3.80	3.70	3.70	4.00
Expert 2	4.00	4.00	4.00	4.00	4.00	4.00
Expert 3	3.70	3.70	3.30	3.70	3.30	3.70
Expert 4	3.80	3.70	3.80	3.70	3.20	3.80
Expert 5	4.00	4.00	4.00	4.00	3.70	4.00

These estimates were analyzed in the IBM SPSS statistics program and calculations were made using the Kendal's W test, which can reflect the level of expert agreement. All these results are shown in tables 3 and 4.

Table 3. Kendall's W-Test Statistics

N	6
Kendall's W[a]	0.840
Chi-Square	20.162
Df	4
Asymp.Sig.	< 0.001

a. Kendall's Coefficient of Concordance

In Table 2, the Kendel coefficient showed W = 0.840, which shows a high level of consistency of expert assessments. This suggests that despite various expert assessments, all experts have built similar answers. The static significance of the obtained coefficient is p-value < 0.001, which allows us to confidently assert that the observed agreement of experts reflects a real general trend in their judgments. In addition to the general measure of consistency, an analysis of the average ranks in table 4 was carried out.

Table 4. Kendall's W-Test Ranks

Experts	Mean Rank
Expert 1	3.33
Expert 2	4.33
Expert 3	1.42
Expert 4	1.83
Expert 5	4.08

As a result, Expert 5 and Expert 2 were considered the most liberal experts, while Expert 3 showed great rigor in its assessment. Nevertheless, the high overall concordance coefficient (W=0.840, <0.001) indicates that these differences in the average ranks do not violate the general consensus of experts.

Thematic analysis was chosen to analyze the interview and semi-structured observation data because of its flexibility and suitability for in-depth study of the participants' experiences. To fully immerse yourself in the content, all the answers in the notes were carefully listened to. Then we highlighted the key phrases, for example, "I enjoyed working in a virtual environment," "I was interested," "I felt comfortable at work." These phrases turned into codes that could unite into large theme groups. For example, all the phrases about "repeatability", "security", were included in the general topic “Virtual laboratory security". We checked each topic to ensure that the participants' opinions were correctly reflected. As a result, we formulated the main topics that better describe the personal experience of the participants, and in order to preserve the “voice” of the participant, we added their direct quotes to the topics.

Ethical considerations

We obtained permits for the pedagogical experiment with the help of a contract, which states that all ethical standards are observed when working with participants. The students were invited to participate voluntarily, with the guarantee that their participation in the interview would be anonymous and the results of the lesson would not affect the reputation of the school. To participate in the interview, the participants provided verbal consent. All audio recordings were transcribed and then deleted.

Results

A thematic analysis of interviews with seven participants revealed five main obstacles to effective participation in chemistry lessons:concentration difficulties, lack of practical interaction, physical limitations, emotional barriers. They are described in detail in table 5.

Table 5. Barriers encountered by students with SEN during laboratory classes

Main Theme	Subtheme	Definition
Cognitive barriers	Fast pace of learning	The students with SEN report, that the teacher's fast pace makes the lesson difficult to understand.
	Absence of visual accompaniment	Lessons without visual accompaniment are uninteresting.
Physical limitations	The cognitive load of multitasking	Students with motor impairments have difficulty coping with laboratory tools.
Emotional barriers	Fear of failure and condemnation	Students with SEN avoid participating in the lab class for fear of making a mistake.

Cognitive barriers

Students with special educational needs have identified several cognitive barriers that make it difficult to learn new material. One of the most frequently mentioned responses was the accelerated learning rate. The participants noted that they did not have enough time to process the information quickly. This topic is especially relevant in different classrooms, where students process information in different ways. The response of one of the participants clearly demonstrates this problem:

“I don't have time to figure it out when the teacher starts explaining the topic quickly. And then they give you a new topic... and everything gets messed up in my head.” (S2)

Analyzing this answer, it can be assumed that the teacher speaks quickly not because they are so used to teaching, but because there are many children with different needs in the class. In such classes, it is very difficult to explain the material in different ways for each student, which is why students with SEN have learning difficulties. Or the second reason may be that the teacher has no experience working with children with special educational needs.

Another problem that students with special educational needs have noted is that traditional lessons based on oral explanation and problem solving often cause difficulties in understanding a new topic. In their opinion, such formats do not allow them to fully visualize abstract concepts. At the same time, the participants emphasized that the use of multimedia and interactive tools such as presentations, videos, illustrations, and game platforms greatly facilitates the assimilation of content and increases motivation to learn.

“When we teach classes in a playful way, I start to get interested in a new topic." (S3)

This response indicates that visual and interactive support helps to increase the involvement and activity of students with SEN in the educational process.

Physical limitations

The participants emphasized that the lack of practical experience makes it difficult to master the theoretical material on chemistry. Many of them noted that due to their special educational needs, they simply observe the work of their peers during laboratory work. Such passive participation reduces not only the depth of understanding, but also the involvement in the learning process.

"It's difficult for me to move around without help, so I usually just watch the process." (S4);

"I stand aside and watch others conduct experiments." (S2)

This experience shows that any knowledge is acquired most effectively through action. Physical limitations not only affect the student's active participation in the learning process, but also reduce his self-confidence.

Emotional barriers

Although some participants had no motor impairments, they noted that due to self-doubt and fear of making a mistake, they often avoid the practical part. For them, lab work is associated with the risk of public unpleasant experiences. One of the participants put it this way:

"I can do it, but I'm afraid I'll spill or break something. Let others do it better..." (S1)

The participant's statement reflects the anxiety associated with peer evaluation and the fear of making a mistake in a real laboratory environment. This situation highlights the importance of creating a safe learning environment in which error is perceived as a natural part of the learning process. As can be seen from the data below, the virtual laboratory provides just such an environment.

Table 6 shows the positive aspects of using a virtual chemistry laboratory for students with SEN. This table provides an overview of 4 topics and the corresponding 6 subtopics based on the interview data.

Table 6. The main advantages of using a virtual chemistry laboratory for students with SEN

Main Theme	Subtheme	Definition
Increased security and accessibility	A comfortable and risk-free environment	The students came to the conclusion that the virtual laboratory provides a comfortable and safe environment for students with SEN.
	Reducing physical barriers	Students with musculoskeletal disorders discover that they can operate the platform without assistance.
Improved understanding	Improving lesson clarity	Students report that the use of guided procedures and interactive elements makes abstract chemical concepts more understandable.
Individual learning experience	Independent work	Students can repeat experiments, pause, rewind, or explore information at their own pace.

	Improving self-esteem	Many participants reported that they felt more confident after using the virtual labs.
Increased motivation	Feeling connected to the lesson	The participants noted that the lessons conducted in the virtual laboratory increased their interest in the subject.

Increased security and accessibility

During classes in virtual labs, participants noted increased safety and accessibility associated with a comfortable and risk-free environment, as well as reduced physical barriers.

A comfortable and risk-free environment

The participants emphasized that classes in virtual laboratories create a safe and comfortable environment, free from the physical risks typical of traditional laboratories. Unlike working with real chemicals, a virtual environment allows you to conduct experiments without fear of harming yourself.

“Nothing will explode or spill there. You can do your job without worrying.” (S5)

“In my current life, I'm always afraid to throw it away, but then I clicked “delete” and everything is fine.” (S7)

Practical experience is always important for students with SEN, for whom safety is considered a prerequisite for cognitive activity.

Reducing physical barriers

Students with motor or sensory impairments note that when working with virtual reality, all physical barriers disappear. The digital environment allows them to complete tasks independently, without outside help.

“In class, I usually watch my classmates. But here I am the same as everyone else.” (S4)

“It's like a game, just about chemistry. I want to go all the way to the end!" (S2)

“The sound appears when you complete the tasks correctly. Cool!” (S5)

This experience highlights the transformative potential of virtual labs: they not only replace real-world hands-on experience, but also expand the opportunities for students with various physical disabilities to participate in the lesson.

Improved understanding

The participants noted that the use of visual elements makes abstract chemical concepts more understandable. Controlled devices help students experiment, make mistakes, and draw conclusions on their own.

“I mixed different substances and immediately saw what was exploding and what wasn't. It makes me remember reactions better.” (S4)

This answer convincingly proves that interactive and guided learning environments contribute to the concretization of abstract thinking and the formation of a deep understanding of chemical concepts.

Individual learning experience

Independent work

The participants emphasized that the opportunity to repeat experiments, pause them, and study the topic at an individual pace contributes to deeper learning and reduces cognitive overload. This feature is appreciated in the context of a variety of learning needs, including differences in information processing speed. As one of the participants noted:

"If I didn't have time to understand what happened in the reaction, I just paused and read the explanation."(S5)

"I don't have to wait for everyone to finish to move on. I worked the way I felt comfortable."(S3)

These statements indicate that the individualized pace of interaction with educational content in a virtual environment makes it possible to better understand the material, because everyone can decide for themselves how many times they need to repeat the experiment. This is especially important for students who find it more difficult to perceive information quickly.

Improving self-esteem

The analysis revealed a similar theme related to the growth of students' academic confidence after interacting with virtual laboratories. Many participants reported that using an interactive environment allowed them to feel more confident when working with chemical concepts.

"Before that, I was always silent in class because I thought I didn't understand anything. And in the virtual laboratory, I repeated the experiments and understood the essence of the topic." (S5)

This suggests that when children work in virtual labs, they not only memorize and understand the material better, but also begin to believe in themselves as a person.

Increased motivation

Participants repeatedly noted that classes using interactive simulators seemed to them "more interesting", "less boring" and "like a game", which increased their desire to participate in lessons and learn something new. According to the students, this motivation arose not only because of the visual appeal of the interface, but also because of the feeling of active participation in the learning process: the opportunity to "do it yourself", rather than just listening to explanations, gave personal meaning to the study of the subject. One of the participants put it this way:

"It's like a game, but it's smart. And I want to go through everything to the end, figure out every task." (S6)

These statements demonstrate the transition from external motivation ("I need to study because there will be a test") to internal motivation ("I'm interested in figuring this out myself"). This effect is especially noticeable among students who previously had no particular interest in science subjects or had difficulties in the traditional learning format.

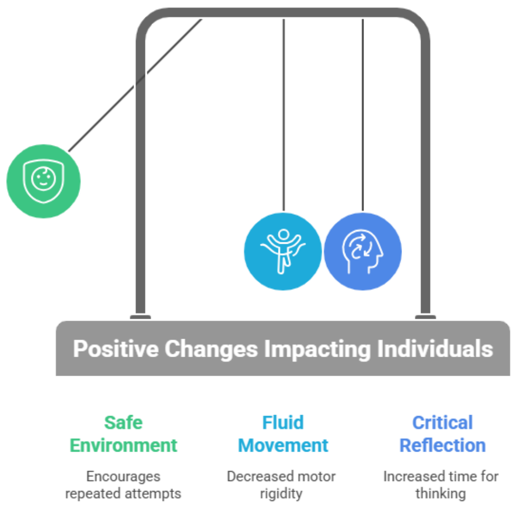

Figure 1- Semi-structured observation data

Figure 1 shows the semi-structured observation data. When working with virtual lab, all participants completed the experiment independently, without external assistance. Observations have shown: decreased motor functions, increased time for reflection and repeated attempts without fear of making mistakes.

Discussion

The responses received from seven students to the interview were processed using a thematic analysis, and five key barriers were identified that prevent students with SEN from participating in traditional chemistry lessons: difficulties with concentration, lack of practical experience, physical limitations and emotional fears. At the same time, a lesson using virtual labs has helped overcome many of these obstacles, creating a safe and accessible environment for students. Participants described cognitive barriers most vividly – namely, the fast pace of teaching and the difficulty of understanding abstract visualizations. As one participant noted earlier, "... And then they give us a new topic... and my head is all messed up." (S2). This suggests that in heterogeneous classrooms, it is very difficult for teachers to adapt to all students, and especially to students with delayed cognitive processing. In order to reduce the cognitive load, the virtual laboratory, on the contrary, allowed us to work at an individual pace. It helped to repeat the experiments several times, pause them and give them time to reflect.

Another major issue was the passive observation of laboratory experiments due to physical limitations or emotional barriers. Participants said: "... I'm just watching the process..." and "...I'm afraid I'll spill or break something." These answers show that the traditional laboratory for students with SEN often becomes a place of social exclusion and emotional discomfort. Again, if we compare with the answers that were received using a virtual environment, we can understand that VR eliminates all these barriers. As the students noted: "Nothing will explode there...", "It's like a game, just about chemistry." This highlights an important conclusion: accessibility is not only a technical adaptation, but also a restoration of the right to active participation.

Moreover, the growth of academic confidence of students, who were mostly silent in class and began to feel "whole" after the lesson with VR, turned out to be especially significant. This moment vividly reflects the statements of one schoolgirl: "Before that, I was always silent... And in virtual reality, I understood the topic." This suggests that a successful experience in a safe environment can restart motivation and change self-perception, which is especially important for children who have long experienced failure in school.

Conclusion

There are two research questions in this article, the answers to which were obtained through thematic analysis. The results of the thematic analysis show that traditional chemistry lessons create significant barriers for students with special educational needs. In traditional chemistry lessons, students with SEN are often forced to remain passive observers, which in turn reduces not only academic growth, but also their sense of belonging to the learning process.

A virtual laboratory, on the other hand, simultaneously removes physical, cognitive, and emotional obstacles. The interview participants noted that in a digital environment they can work independently, at their own pace, without the risk of error and the possibility of repeated experiments, without additional assistance. This not only improves the understanding of abstract chemical concepts, but also restores academic confidence and intrinsic motivation.

The results demonstrate a high degree of similarity when compared to the findings of the authors cited at the beginning of the article. Each research identifies common key barriers that students with SEN face in traditional chemistry labs.

Nevertheless, it is important to acknowledge several limitations encountered in this study. One limitation is that the study was conducted on a small sample and did not include students with severe communication impairments who could not participate in an oral interview. In addition, due to the difference in participants (type of inclusivity, age, level of education, etc.), it was difficult to compare them with each other and conduct a large quantitative analysis. Therefore, a qualitative analytical approach was selected as the most appropriate method.

Despite these limitations, the findings offer an important practical method: a virtual laboratory is not just a substitute for real chemical experiments, but also a tool for inclusive learning. This tool uuu in the process, and feel equal.

The results obtained allow us to formulate a number of recommendations for teachers and educational policy makers.

First, virtual laboratories should be considered as an integral element of inclusive chemistry education. They provide an opportunity for students with disabilities not only to participate in the lesson, but also to actively participate in scientific knowledge.

Secondly, teachers are encouraged to use virtual labs more often in the learning process. The ability to work at your own pace, repeat experiments many times, and visualize abstract concepts is especially important for students with cognitive impairments or physical limitations.

Third, it is advisable for educational institutions to include virtual laboratories in the standards of equipment for inclusive classrooms. At the same time, it is important to provide teachers with methodological support and training in the use of virtual environments.

In conclusion, the virtual laboratory demonstrates its potential not as an imitation of a real experience, but as an inclusive educational environment in which students with SEN receive various opportunities for active and safe participation in scientific knowledge for the first time.

References

1 Abdurazova, P. A., Usenbay, A. U. & Aldanazarova, M. Sh. (2025). Advancing inclusive education: the impact and potential of virtual laboratory simulations for students with disabilities in chemistry. *Vestnik NAN RK, 413*(1), 5–22.

2 Gallardo-Williams, M. T., & Dunnagan, C. L. (2021). Designing diverse virtual reality laboratories as a vehicle for inclusion of underrepresented minorities in organic chemistry. *Journal of Chemical Education*, *99*(1), 500–503.

3 Gavronskaya, Y., Larchenkova, L., Kurilova, A., & Gorozhanina, E. (2021). Virtual lab model for making online courses more inclusive for students with special educational needs. *International Journal of Emerging Technologies in Learning*, *16*(2), 79–94.

4 Herga, N. R., Čagran, B., & Dinevski, D. (2016). Virtual laboratory in the role of dynamic visualisation for better understanding of chemistry in primary school. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(3), 593-608.

5 Robles, L. E. R., Hernández-Aguirre, A., & Bautista, I. B. D. (2025, April). Using a digital learning platform to support inclusive learning of chemistry at the university level. In *2025 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1–7). IEEE. https://doi.org/10.1109/EDUCON62633.2025.11016323

6 Supalo, C. A., Humphrey, J. R., Mallouk, T. E., Wohlers, H. D., & Carlsen, W. S. (2016). Examining the use of adaptive technologies to increase the hands-on participation of students with blindness or low vision in secondary-school chemistry and physics. *Chemistry Education Research and Practice*, *17*(4), 1174–1189.

7 Takkouch, M., Zukowski, S., & Campbell, N. (2023). Students' perspectives and experiences with equity, diversity, inclusion, and accessibility in online and in-person undergraduate science laboratory courses. *Journal of Perspectives in Applied Academic Practice*, *11*(3). https://doi.org/10.56433/jpaap.v11i3.581

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ВИРТУАЛДЫ ХИМИЯ ЗЕРТХАНАЛАРЫН ПАЙДАЛАНУ КЕЗІНДЕ ЕРЕКШЕ БІЛІМ БЕРУ ҚАЖЕТТІЛІКТЕРІ БАР ОҚУШЫЛАРДЫҢ ПАЙДАЛАНУШЫ ТӘЖІРИБЕСІН ЗЕРТТЕУ

Аңдатпа. Ерекше білім беру қажеттіліктері бар студенттер химия сабақтарында, әсіресе дәстүрлі химия зертханаларында айтарлықтай кедергілерге тап болады. Қазіргі уақытта бұл жұмыс өзекті, өйткені ол олардың химия сабақтарына қатысуына кедергі келтіретін негізгі тосқауылдарды анықтауға, сондай-ақ ерекше білім беру қажеттіліктері бар студенттердің виртуалды зертхананы қабылдауын зерттеуге бағытталған. Жұмыстың мақсаты мүмкіндігі шектеулі студенттердің дәстүрлі химия сабақтарында қандай кедергілерге тап болатынын және виртуалды зертхананы пайдалану кезінде олардың тәжірибесі қалай өзгеретінін зерттеу болды. Мүмкіндігі шектеулі жеті студентпен ашық сұхбат тақырыптық талдау әдісін қолдану арқылы өңделді. Талдау дәстүрлі оқыту форматындағы төрт негізгі кедергілерді анықтады: 1) материалды жеткізудің жеделдетілген қарқыны, 2) практикалық өзара әрекеттесудің болмауы, 3) физикалық шектеулер, 4) эмоционалды шектеулер. Виртуалды зертхана қауіпсіздікті, жеке жұмыс қарқынын, мультимодальды визуализацияны қамтамасыз ету және мағыналы қатысу сезімін арттыру арқылы осы кедергілерді жеңді. Қатысушылар өзіне деген сенімділіктің артуын, сабақтардағы алаңдаушылықтың төмендеуін және пәнді оқуға деген ынтаның артуын атап өтті. Нәтижелер барлық оқушылардың бірыңғай білім беру процесіне тең қатысуына ықпал ететін инклюзивті құрал ретінде виртуалды орталардың әлеуетін растайды.

Түйін сөздер: арнайы білім беру қажеттіліктері, виртуалды зертхана, инклюзивті білім беру, білім берудегі кедергілер, қолжетімділік, бейімделу технологиялары, оқу үлгерімі.

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ИЗУЧЕНИЕ ПОЛЬЗОВАТЕЛЬСКОГО ОПЫТА УЧАЩИХСЯ С ОСОБЫМИ ОБРАЗОВАТЕЛЬНЫМИ ПОТРЕБНОСТЯМИ ПРИ ИСПОЛЬЗОВАНИИ ВИРТУАЛЬНЫХ ХИМИЧЕСКИХ ЛАБОРАТОРИЙ

Аннотация. Учащиеся с особыми образовательными потребностями часто сталкиваются со значительными барьерами на уроках химии, особенно в традиционных химических лабораториях. В настоящее время данная работа актуальна, поскольку направлена на выявление ключевых барьеров, препятствующих их участию в уроках химии, а также на изучение восприятия виртуальной лаборатории учащимися с особыми образовательными потребностями. Цель работы состояла в том, чтобы исследовать, с какими препятствиями сталкиваются учащиеся с ограниченными возможностями на традиционных уроках химии и как меняется их опыт при использовании виртуальной лаборатории. Открытые интервью с семью студентами с ограниченными возможностями были обработаны с использованием метода тематического анализа. Анализ выявил четыре основных барьера в традиционном формате обучения: 1) ускоренный темп подачи материала, 2) отсутствие практического взаимодействия, 3) физические ограничения, 4) эмоциональные ограничения. Виртуальная лаборатория преодолела эти препятствия, обеспечив безопасность, индивидуальный темп работы, мультимодальную визуализацию и усилив чувство значимого участия. Участники отметили рост уверенности в себе, снижение тревожности на уроках и повышение мотивации к изучению предмета. Результаты подтверждают потенциал виртуальных сред как инклюзивного инструмента, способствующего равноправному участию всех учащихся в едином образовательном процессе.

Ключевые слова: особые образовательные потребности, виртуальная лаборатория, инклюзивное образование, образовательные барьеры, доступность, адаптивные технологии, успеваемость.

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Appendices

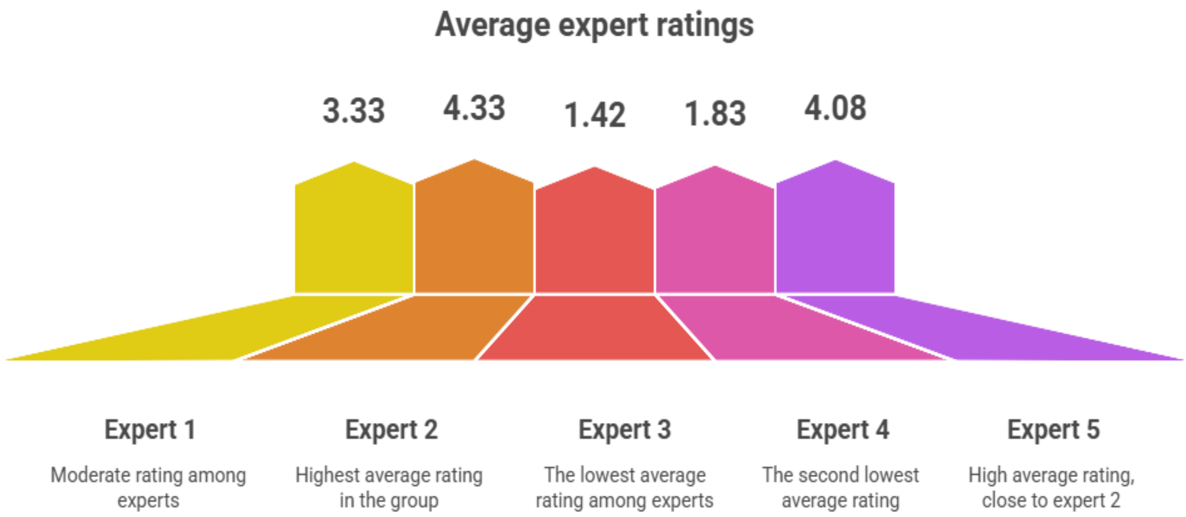

Figure 2- Comparative analysis of expert ratings