Interactive lessons with ICT in chemistry education

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Abstract
The purpose of this study was to develop and adapt interactive chemistry lessons for lower secondary schools based on the characteristics of interactive ICT-supported education. The verification was carried out from December 2018 to January 2019 with specialized school-board information technologies in Karaganda (Kazakhstan). There was a total of 55 respondents (20 female adolescents and 35 male adolescents), which entailed a total of 24 hours of experimental action per student. The results showed that more than 75 % of the students enjoyed working in an interactive environment and this positively affected their opinions towards the subject.

Keywords: Interactive lessons; information and communications technology (ICT); secondary school; chemistry teaching.

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Introduction

The development of interactive technologies and other free web-based applications allow teachers, nowadays, to present various types of lessons. With the development of information technologies, computers have shown themselves as the most powerful tools to develop students' ability to query and to support the teaching of science (Fetaji et al., 2007). In science education, computerized modelling and animations are used for describing, explaining, and predicting scientific processes. These transitions may promote higher order thinking skills, reasoning and explanation abilities which are fundamental for the learning of science (Barak & Dori, 2009).

ICT has the potential to solve real life issues in classrooms in a way that was not possible before in a traditional classroom setting. The flexible nature of ICT and the internet especially provide students with the opportunities for research, interaction, cooperation and collaboration (Cole, 2000). ICT enhances the instructional process through the arrangement of interactive instructive materials that increase learner inspiration and encourage easy attainment of fundamental aptitudes. Utilization of different multimedia tools such as TV, recordings, videos and computers applications provides more challenging and attractive learning atmosphere for learners of any age (Haddad & Jurich, 2017).

Some of the psychologists found that there is an increase in accuracy of perceiving the context of interactive educational communication in students, while their memory performance increases as well, and also the intellectual and emotional traits of a person like attention span, ability to distribute attention, ability to analyse the partner's activity (Blasco-Arcas et al. 2013; Koch & Vogt, 2015). Ziden et al. (2011) concluded that ICT has a positive effect on the academic accomplishment of students in science subjects. They also found that male students showed better performance as compared to female students.

According to the Gil-Flores, Rodríguez-Santero and Torres-Gordillo (2017), the common adoption of ICT in the education system has not influenced Europe's policymakers to implement different strategies. Hungary, the Czech Republic, Portugal, Germany, Slovakia and Italy finance schools that meet certain conditions. Other countries, such as Spain and United Kingdom, try to equip all schools. In France, Italy, Malta, Poland, Portugal, the Ministry of Education cooperates with private companies, providing incentives for students or families to acquire a laptop or a desktop computer.

Theoretical background

Why using interactive lessons?

The use of interactive lessons can be a great chance to reduce students' anxiety. Application of these types of lessons with ICT could give students not only the opportunity to work with each other, but also to feel comfortable and more confident (Chirimbou & Tafazoli, 2013). In classroom teaching and learning process, the use of ICT is imperative as it gives chance to both the teacher and the learners to operate, store, control and retrieve data other than to promote self-regulated and active learning (Ali, Haolader & Muhammad, 2013). All participants of the interactive lesson interact with each other, share information, jointly solve problems, simulate situations, and evaluate the actions of others (Panina & Vavilova 2008).

Advantages of using interactive lessons with ICT:

- The educational resources will be available for students who can find them at websites or digital books.
- Students will get the same chance to get education as students from urban areas. Moreover, they can get video tutorials, educational materials from teachers by that encourage active participation of everyone in the educational process;
- It saves time for students because they can learn by themselves at home, as they don't have to go to schools or private tutors.

- The system will be a motivation for the young generation to become self-sufficient with the help of ICT (Mahi, 2019).

During interactive lessons students are allowed to use their own mobile devices such a mobile phones and tablets, and the teachers are able to see the students' results on their own device (Sadykov & Čtrnáctová, 2019a). Couse and Chen (2010) found that the motivation of primary and secondary school children increased with the use of tablet computers during the instruction, compared to traditional teaching.

The study of Biloš et al. (2017) stated that there is a high level of mobile device usage among secondary school students on a daily basis; smartphones and laptops in Austria, Czech Republic, Germany. The majority of respondents (90.8%) were categorized as extensive internet users, while 68% perceived themselves to be advanced mobile device users. At the same time, the research Nikolopoulou and Gialamas (2017) indicated positive perceptions toward mobile devices among students in different countries, such as Greece, China, Italy, Northern Cyprus, Canada, Malaysia. Students' attitudes were positive, and most of the students (over 87%) expressed high self-efficacy in using mobile devices.

Yang and Chang (2017), in Taiwan, conducted an experiment with junior high school students to assess the smartphone to study Geography. The results showed that the students who learned with the proposed system, in the experimental group, achieved better results by learning with ubiquitous Geography learning system assistance. Joyce-Gibbons et al. (2018) in their studies conclude that while most students have access to mobile phones, they are not permitted to go to school with them.

Learning Management System – LMS:

Matsuuchi et al. (2008) created a *computer-supported interactive learning system* to provide an *interactive lesson* to all students. They distributed tablets to all students for their individual use. The system is composed of tablet PCs, a server machine, and a software for realizing the collaboration between the tablet PCs over our WLAN, as illustrated in fig. 1. In this system, the tablet PCs for teachers and students are interactively connected through a server by the WLAN, which covers our campus.

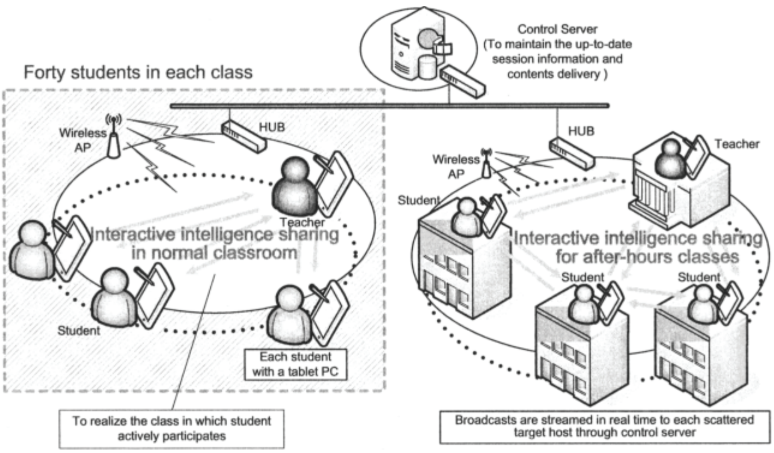


Figure 1 The conceptual structure of collaborative learning system

Wessels et al. (2007) developed *interactive lectures using wireless networks*. In interactive lectures, all students must be equipped with handheld computers or notebooks, using several wireless learning devices to interact. The basic software system with which to run the interactive lecture is designed as a typical client/server application. The clients for the students use WLAN to get connected to the server. The figure 2 shows the server architecture of interactive lectures.

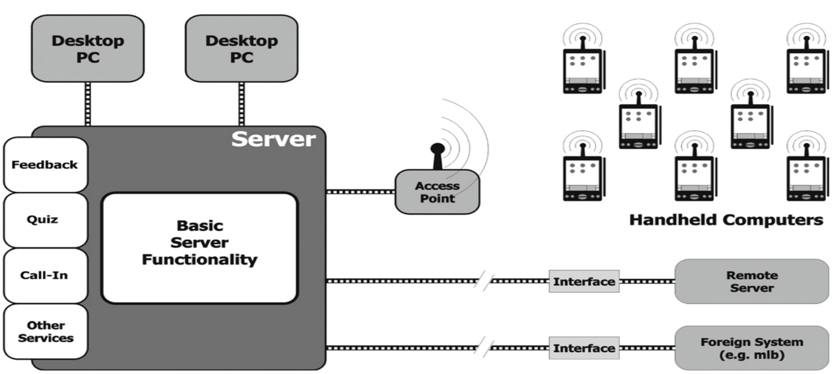


Figure 2 The server architecture of the interactive lecture

Yuusuke Nishiuchi et al. (2010) developed *new Terakoya system*, which provides an interactive lesson using Tablet PCs on a WLAN, linking the students in the dormitory and the teacher in school. In this new system, students and the teacher cooperate and interact in real time. This system can be used to submit and store lesson notes or coursework using one tablet PC.

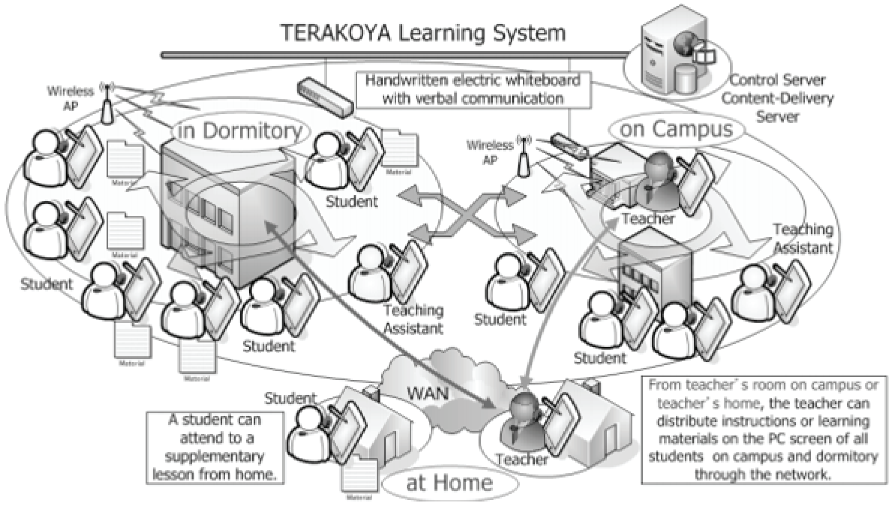


Figure 3 The Terakoya learning system

Interactive lessons in chemistry

In chemistry, ICT can be an effective tool in teaching and learning (Marešova & Klement, 2011):

- as a part of scientific equipment in order to make measurements and record data;
- to simulate / illustrate experiments that are too difficult, dangerous or time consuming;
- to simulate natural processes, including such as the formation of atoms / molecules;
- for imaging a very small-range or microscopic processes using a video microscope;
- to organize and display holistic data using databases, spreadsheets, and software;
- to create high-quality student presentations.

Avinash and Shailja (2013) found that the ICT program is more compelling and effective than the conventional teaching approach in terms of students' achievement scores in chemistry. Bellou et al. (2018) investigated a review of empirical research on digital learning technologies in secondary chemistry education. Their results showed that most researchers investigated chemistry topics related to the particulate nature of matter and used digital learning technologies (including mobile technologies).

Thera are some examples of interactive lessons using for chemistry teaching at ISCED 2-3 level:

The PhET Interactive Simulations project (2002) at the University of Colorado Boulder creates free interactive math and science simulations through an intuitive, game-like environment where students learn through exploration and discovery (https://phet.colorado.edu/en/simulations/category/chemistry).

Virginia site (2016) allowed students to use their mobile devices in class to look up and share information during class discussions, which facilitated engaged learning (www.doe.virginia.gov).

Waterloo launched the Open-Science website (2017) to provide free online lessons in general chemistry, covering topics from the Canadian 11th and 12th grade curricula. Each lesson is designed to work as a stand-alone topic and contains several interactive elements to help students learn (link: https://open.science.uwaterloo.ca/7) .

Virtual Kids Lab (2017) – this new platform in Japan offers a variety of interactive experiments online, to allow children aged 10 to 15 years to discover the world of chemistry through simple and safe experiments (link: www.basf.com).

The Open Educational Resource (OER) textbook (2018) has been written specifically for students as a reputable source for them to obtain information aligned to the Utah Chemistry Standards. Every year, the book will be revised using teacher feedback and with new objectives to improve the book (link: https://www.uen.org/core/core.do?courseNum=3620).

Among the freely available interactive programs and internet portals in chemistry in the Czech Republic, we can note, for example, Faculty of Science, Charles University in Prague or Faculty of Pedagogy Masaryk, University in Brno, secondary schools (Nový Jičín, Přerov, Slušovice, Kaplice), Integrated technical school Benešov. As well as chemistry educational materials and websites:

- educational portal E-ChemBook: http://www.e-chembook.eu;
- portal chemistry 2.0-3.0: http://www.chemiejinak.eu;
- portal Faculty of Science, Charles University to support the teaching of chemistry: http://www.studiumchemie.cz;
- chemistry textbooks: https://eluc.kr-olomoucky.cz;
- chemistry textbook for 8 grades: http://www.zschemie.euweb.cz;
- chemistry textbook for 8-9 grades: http://www.komenskeho66.cz/;
- e-learning chemistry: http://data.zsslusovice.cz/24844-chemie
- chemistry for beginners: https://xantina.hyperlink.cz/
- chemistry for 8-9 grades: http://jane111.chytrak.cz/

These portals aim to be an electronic assistant in chemistry, suitable when studying at the lower or upper secondary schools and other schools, preparing for graduation and exams in university. We would also like to note that there is no universal interactive chemistry course, which could be used in all stages of the chemistry lesson: warm-up, introduction, presentation, practice, evaluation.

The main characteristics of the interactive chemistry lessons

The starting point for creation of the interactive lessons for the ISCED 2 (lower secondary education) level was a thorough analysis of contents and methods of the current chemistry subject curriculum at this level in the Czech Republic and Kazakhstan, and research into the possibility of innovation of the subject matter and interactive teaching. The reasons for comparing the curriculum of these two countries are the similar structure and the fundamental educational reform. Our interactive lessons are created according to the interests, opportunities and professional orientation for lower secondary school students and will be used on the educational portal http://interactive-chemistry.ru.

The learning goals of this lesson are:

- to understand the causal relationships between composition, structure, properties and behaviour of substances;
- to correct the usage of chemical terminology, symbols of chemical elements, formulae of compounds and registration of chemical reactions;
- to understand the connection between chemistry and everyday life, technology and society (Sadykov, Čtrnáctová, 2019a).

The lesson contains all themes of the current chemistry curriculum for lower secondary schools, and each theme makes the utmost use of connecting the subject matter with its practical application; the subject matter is acquired on the interactive basis (Sadykov, Čtrnáctová, 2017).

Based on the research of Yuusuke Nishiuchi et al. (2010), Matsuuchi et al. (2008) and Wessels et al. (2007), we developed two models of interactive lessons (fig. 4) using the educational portal interactive-chemistry.ru. First model of interactive lesson uses the frontal approach, the second model uses the group approach. The teacher spends most of the class time giving a lecture but asks different type of questions in-between. These questions are derived from research findings to help students recognize their conflicted beliefs and misconceptions while discussing and exchanging ideas with their neighbours or groups.

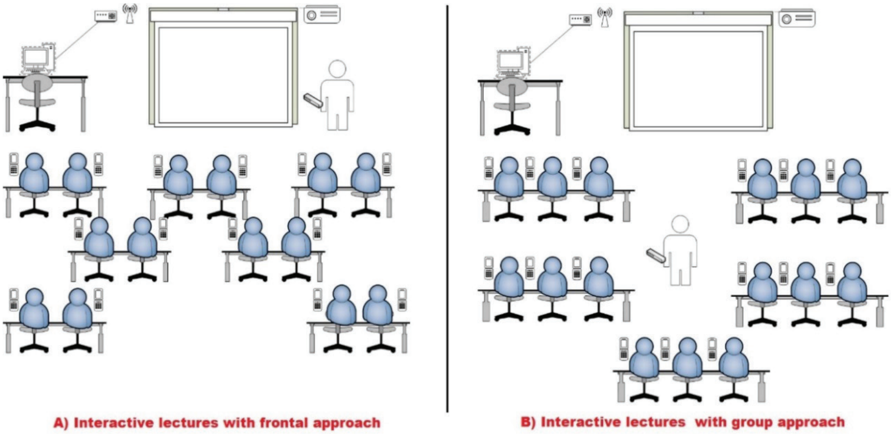


Figure 4 Two models of interactive lessons: a) with frontal approach; b) with group approach

In both forms of teaching, all students must be equipped with mobile phones, tablets or notebooks, using Wi-Fi hotspots to interact. All processed information can be stored on the educational portal's server. Tools provide specific services which are visible to and executable by the users.

An example of an interactive lesson on the topic „Types of chemical reactions" (http://interactive-chemistry.ru/mod/page/view.php?id=16) can be seen on figures 5-6. The main purpose of this interactive lesson is to develop understanding of the different types of chemical reactions. First, the lesson begins with interactive task №1-2 "According to the video-experiments (1-4), fill in the gaps in a sentence and find the matched pairs". Knowledge of four kinds of chemical changes (solid formation, color change, gas release and heat exchange) from previous lessons helps students to solve interactive tasks 1-2 (fig.5-6).

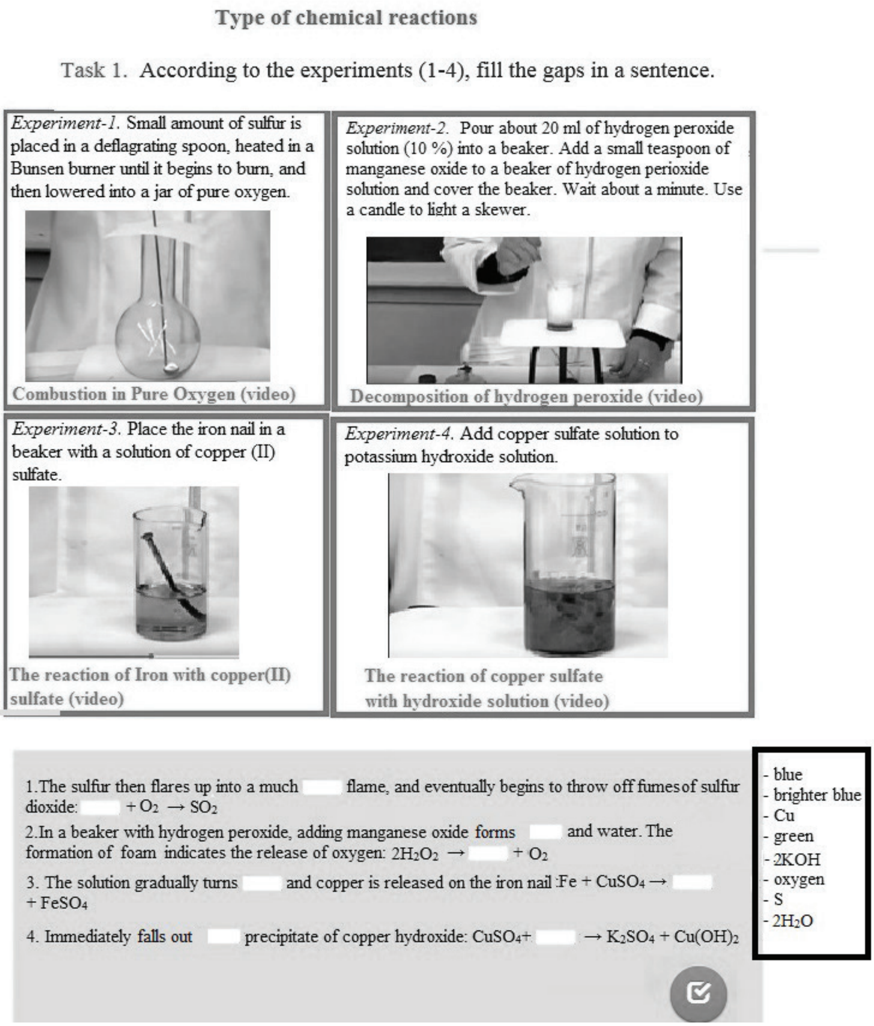
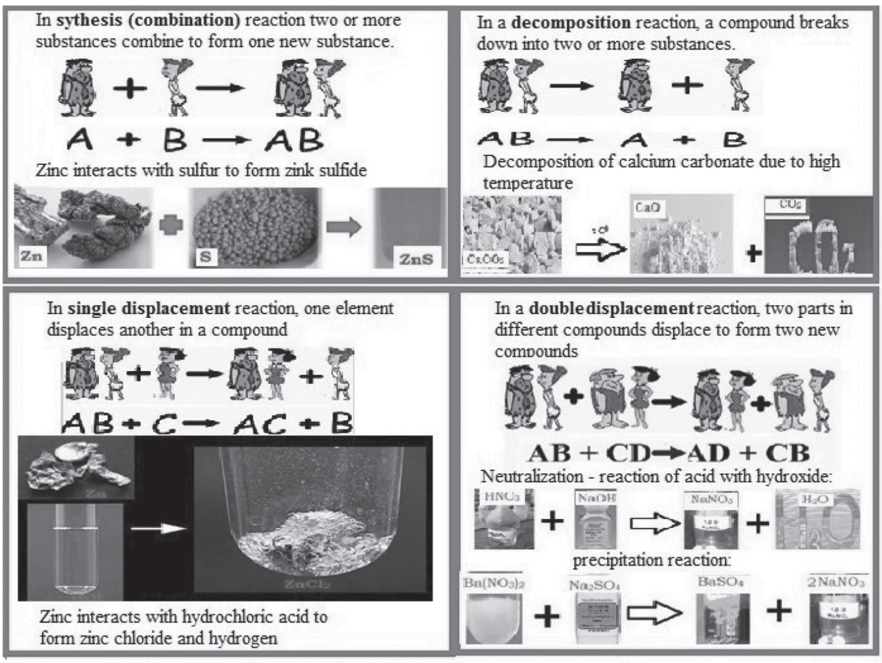
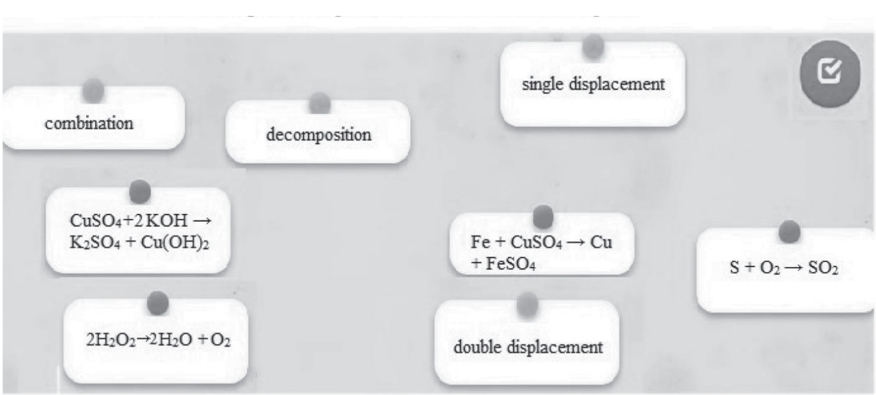


Figure 5 Interactive lesson on the topic "Types of chemical reactions"

Most chemical reactions can be classified as follows: combination, decomposition, single displacement and double displacement. The various definitions, animations, examples and knowledge about chemical properties of an element helped students to identify the types of chemical reactions correctly. Finally, interactive task №3 "what types of chemical reactions are hidden in the table" to develop a deeper understanding in students (Fig. 6).



Task 2 According to the experiment (1-4) find matched pairs



Task 3 It is nessesary to correctly determine the type of each chemical reaction and form a word from the correct letters

	Types of chemical reactions			
	Combination	Decomposition	Single displacement	Double displacement
$Mg + 2HCl \rightarrow MgCl_2 + H_2$	N	O	R	A
$2Fe(OH)_3 \rightarrow Fe_2O_3 + 3H_2O$	P	E	Y	Á
$Br_2 + 2KI \rightarrow 2KBr + I_2$	W	Z	A	K
$2Ag_2O \rightarrow 4Ag + O_2$	S	C	O	T
$K_3PO_4 + 3AgNO_3 \rightarrow Ag_3PO_4\downarrow + 3KNO_3$	S	X	A	T
$2Ca + O_2 \rightarrow 2CaO$	E	I	G	R
$CuSO_4 + 2KOH \rightarrow K_2SO_4 + Cu(OH)_2$	T	Y	B	O
$S + O_2 \rightarrow SO_2$	N	C	A	G

Figure 6 Interactive lesson on the topic "Types of chemical reactions"

3 Research characteristics

General Background

The research was carried out from November 2018 to January 2019 on specialized school-board information technologies in Karaganda (Kazakhstan). The main objective of the educational program of the school is development of individual, creative and research abilities of students in the active study of the use of information and communication technologies. This school services 292 students in grades 7–9 (2 classes in Russian language and 2 classes in Kazakh language are taught in each year).

Sample

The sample included four classes: 8 C, 8 D, 9 C, 9 D. There was a total of 55 respondents (20 female adolescents and 35 male adolescents), which entailed a total of 24 hours of experimental action per student. Their age ranged from 13 to 15 years old. For the instruction phase, students were informed about the purpose of the research, as well as their expected role in it.

Data Analysis

It was aimed at investigating the students' opinions on the basis of interactive lessons. The questionnaire used in this research consisted of ten closed-ended questions:

1. Do you like interactive lessons with the use of computer presentation?
2. Do you think that interactive lessons are more interesting than traditional lessons?
3. Was the explanation in the interactive lesson clear enough to understand the topic well?
4. Do you think that the interactive lessons had too much information, diagrams and images, so you found it difficult?
5. Was knowledge gained in an interactive chemistry lesson applied in real life?
6. Would you like it if interactive lessons like these could be carried out more often?
7. Were you interested in solving the tasks using a mobile phone or a tablet?

8. Do you like the game Kahoot? Is it quick and interesting and does it help you to check your knowledge?
9. Do you think that solving the tasks in this way is more interesting than with the traditional method?
10. Would you like if chemistry tasks like these could be solved more often?

The questionnaire used a three-point Likert scale from agree (1), neutral (2), and disagree (3), and it was selected as being the most appropriate to measure participants' opinions.

4 Results

During the pedagogical experiment, we carried out 24 interactive lessons of chemistry for lower secondary students, which were posted on the educational site: http://interactive-chemistry.ru. Figure 7 illustrates overall eight grades students' opinions toward interactive lessons. It shows separate answers for all questions. Students' answers to the questions were as follows:

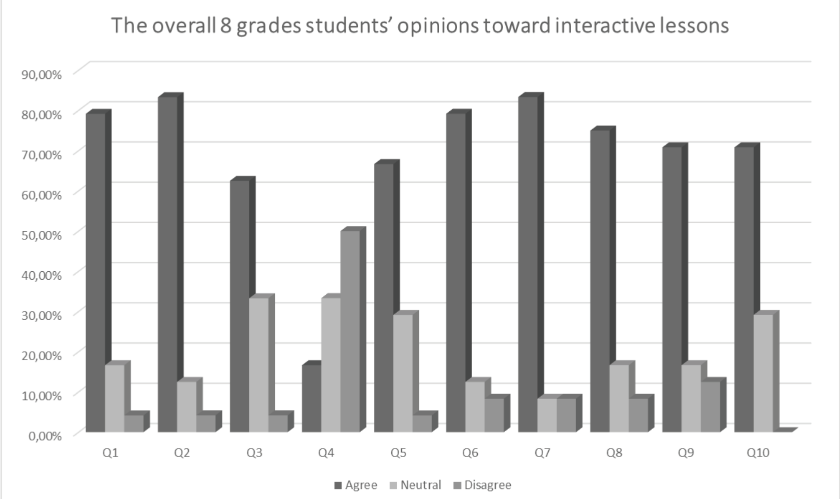


Figure 7 The overall 8 grades students' opinions toward interactive lessons

More than the four-fifths of the students (83 %) think that interactive lessons are more interesting than the traditional lesson and interest in solving the tasks using a mobile phone or a tablet, compared to just 4 % and 8 % respectively say they "disagree" in this area. Similarly, 79 % of the students like interactive lessons with the use of computer presentation and the game Kahoot as well as would like the interactive lessons to be carried out more often, while less than (17 %) answered with "no opinion" in this area. Only 8 % of students rate themselves as "disagree". In contrast to this, the percentage who prefer interactive tasks instead of the tradi-

tional solving methods and would like to solve interactive tasks more often is 70,83 %. It is interesting to note that half of the students (50 %) does not think that the interactive lessons had too much information, diagrams, and images. As a final point, it is not surprising that approximately 66 % of the students believe that the knowledge gained in an interactive chemistry lesson can be applied in real life.
Figure 8 illustrates overall of nine grade students' opinions toward interactive lessons. It shows separate answers for all questions. The students' answers to the questions were as follows:

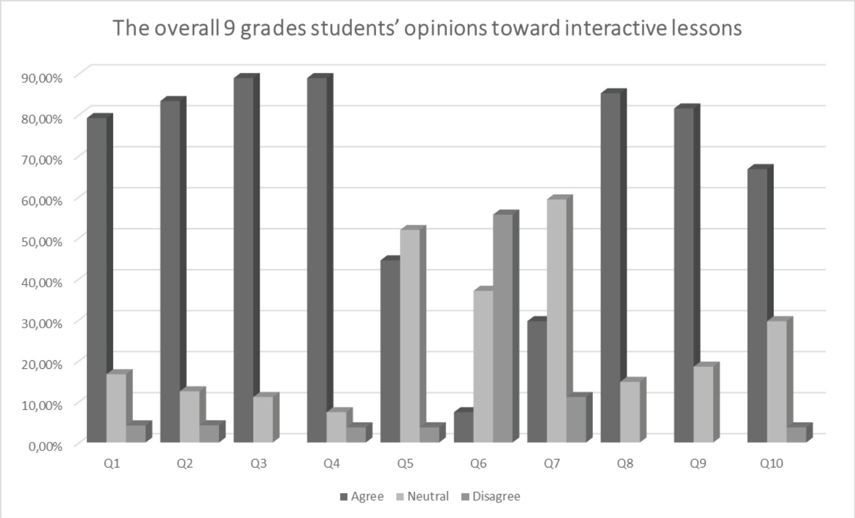


Figure 8 The overall 9 grades students' opinions toward interactive lessons

According to figure 8, it is noticeable that the highest percentage (89 %) of nine grade students like interactive lessons with computer presentation and believe that they are more interesting than the traditional lessons.
We can also see that the greatest proportion of students would like if interactive lessons could be carried out more often. They are also interested in solving the tasks using a mobile phone or a tablet (85 % and 81 % respectively), while less than (18%) picked "no opinion" in this area. Similarly, two-thirds of the students (66 %) like the game Kahoot and think interactive tasks are more interesting than the traditional solving methods. Only 4 % of students said they "disagree".
There is a smaller percentage of students (7.5 %) who believe that the interactive lecture had too much information, diagrams and images. Only 29.6 % of the nine grades students believe that knowledge gained in an interactive chemistry lesson can be applied in real life compared to the 66 % of students of eight grades.

5 Discussions

There are two main problems with using interactive lessons in teaching chemistry.
The first problem is the creation of an interactive lesson, which could be used in different stages of the chemistry lesson and actively involves students in the educational process. Nowadays, there are only a few teachers that have the necessary skills and knowledge to prepare quality interactive materials and applications. The significant shortage limits the effectiveness of the program for lower-secondary schools. Aslam and Kingdon (2007), Schwerdt and Wuppermann (2011), Traykov and Galcheva (2017) attempted to indicate students' opinions towards interactive lecturing. For this reason, many interactive learning materials created by commercial publishers do not always match the conception and idea of teachers, and their main problem is the often high price. The problems that came out more frequently in the field seem to be related to understanding the lesson's logic. Chiero and Beare (2010) concluded in their longitudinal study that ratings for online preparation lessons were consistently higher than for the more traditional ones, suggesting that online lessons can be as or more effective at preparing the next generation.
Tondeur et al., (2015) emphasized that access to proper and well-organized infrastructure is the main component for teachers to use technology in their educational practices. Our study, however, showed that more than 75 % of students enjoy working in an interactive environment and this positively affects their opinions towards the subject. We suggest that interactive lessons are sizeable teaching materials, and their verification in practice will require quite demanding and extensive research.

The second problem is "Which ICT tools can we use in teaching chemistry in the next 5-6 years?" ICT can be very helpful in education but there is a danger to it: students might try to learn and solve problems by manipulation without understanding the principles. The tools should challenge the students and encourage them to make observations and relate them to theory in order to develop a broader and deeper understanding (Guzman et al., 2013). Rather, access to laptops and other technologies can be the very first step toward the effective use of technology in the form of instructional and learning tools (Shapley et al., 2010).

The study (Nikolopoulou, 2018) revealed secondary students' positive perceptions toward mobile learning acceptance and the mobile phone was the predominant device which is used daily by almost all students. The study (Zheng et al., 2014) stated that laptops can be valuable tools for science instruction, but it also reconfirmed that effective implementation of technology requires sufficient and ongoing professional development, robust infrastructure and technical support. Blackwell (2013) concluded that the use of tablet computers could enable learning anywhere and at any time. The connection between home and school also allowed teachers to place the students anywhere in the classroom instead of having them tied to a computer or an IW. We believe that the combination of mobile phones and tablets allows several students to perform the activities at the same time, and this encourages them to interact with each other. For instance, they discussed the correct answers of the activities, and they willingly helped their partners if they did not know the correct answer (Sadykov & Čtrnáctová, 2019b).

6 Conclusions

In the first stage of our work, we created and adapted interactive chemistry lessons for lower secondary schools. We also presented some of the developed methodological options, which illustrate the ability to use interactive lessons to increase the activity of students and the effectiveness of the learning process using ICT. The lessons «Chemistry» which were created are available at the educational portal http://interactive-chemistry.ru. The great advantage is that since the material is posted on the learning site, students can work with it in the school as well as at home.

In the second stage of our work, the students' opinions toward interactive lessons were tested using a simple questionnaire survey. First verification at schools showed that more than 75 % of the students enjoy working with interactive lectures and this positively affects their opinions towards the subject. In this paper, we wanted to point out the importance of these lessons, so that the current and future teachers realize that the use of modern teaching lessons and interactivity in learning materials for teaching is becoming essential in pedagogical practice.

In the next part, we will therefore focus on verification of the use of interactive lectures in other schools both in Kazakhstan and the Czech Republic.

References

Ali, G. Haolader, F. A., & Muhammad, K. (2013). *The role of ICT to make teaching-learning effective in higher institutions of learning in Uganda*. International Journal of Innovative Research in Science, 2(8), pp. 61-73.

Aslam, M., Kingdon, G. *What can teachers do to raise pupil achievement?* The Centre for the Study of African Economies: University of Oxford, 2007.

Avinash, A., Shailja, S. (2013). *The impact of ICT on achievement of students in chemistry at secondary level of CBSE and up board in India*. International Journal of Science and Research, 2(8), pp.126- 129.

Barak, M., Dori, Y.J. (2009). *Enhancing higher order thinking skills among in-service science education teachers via embedded assessment*. Journal of Science Teacher Education, 20 (5), pp. 459-474.

Bellou, I., Papachristos, N. M., & Mikropoulos, T. A. (2018). Digital Learning Technologies in Chemistry Education: A Review. In D. Sampson, D. Ifenthaler, J. Spector, & P. Isaías (Eds.), *Digital Technologies: Sustainable Innovations for Improving Teaching and Learning* (pp. 57-80). Cham: Springer International Publishing.

Biloš, A., Turkalj, D., & Kelić, I. (2017). *Mobile learning usage and preferences of vocational secondary school students: The cases of Austria, the Czech Republic, and Germany.* Naše gospodarstvo, 63(1), pp.59–69.

Blackwell, C. (2013). *Teacher practices with mobile technology: Integrating tablet computers into the early childhood classroom*. Journal of Educational Research, 7(4), pp. 1–25.

Blasco-Arcas, L., Buil, I., Hernández-Ortega, B., & Javier Sese, F. (2013). *Using clickers* in class. The role of interactivity, active collaborative learning and engagement in learning performance. Journal of Computers & Education, 62, pp. 102–110.

Chiero, R., & Beare, P. (2010). A*n evaluation of online versus campus-based teacher preparation programs*. Journal of Online Learning and Teaching, 6(4), pp.780-781.

Chirimbou, S. & Tafazoli, D. (2013): *Technology & Media: Applications in Language Classrooms (tefl, tesl & tesol)*. Professional Communication and Translation Studies, 6(1-2), pp.187–194.

Cole, R. *Issues in web-based pedagogy*. London: Greenwood Press. 2000.

Couse, L. J., & Chen, D. W. (2010). *A tablet computer for young children? Exploring its viability for early childhood education*. Journal of Research on Technology in Education, 43 (1), pp.75–96.

Fetaji, M., Loskovska, S., Fetaji, B., & Ebibi, M. (2007). *Combining virtual learning environment and ıntegrated development environment to enhance e-learning*. In 29th International Conference on Information Technology Interfaces 25-28 June 2007, pp. 319-324 IEEE: Cavtat, pp. 319-324.

Gil-Flores, J., Rodríguez-Santero, J., & Torres-Gordillo, J. J. (2017). *Factors that explain the use of ICT in secondary-education classrooms: The role of teacher characteristics and school infrastructure*. Computers in Human Behavior, 68, pp.441-449.

Guzman, J.L., Dormidi, S., Berenguel, M. (2013). *Interactivity in Education: An Experience in the Automatic Control Field Inc*. Comput Appl Eng Educ, 21, pp. 360–371.

Haddad, W., & Jurich S. (2017). *ICT for education: Potential and potency in technologies for education*. Effects of Information and Communication Technology (ICT) prospects, 4 (1), pp 28-40.

Joyce-Gibbons, A., Galloway, D., Mollel, A., Mgoma, S., Pima, M. & Deogratias, E. (2018). *Mobile phone use in two secondary schools in Tanzania*. Education and Information Technologies, 23(1), pp. 73-92.

Koch, F., & Vogt, J. (2015). *Psychology in an interdisciplinary setting: A large-scale project to improve university teaching*. Psychology Learning and Teaching, 14(2), pp. 158–168.

Mahi, M.H, Tarannoom, T., Islam, M.A., & Khan, M.M (2019). A Web Based Interactive System to Promote ICT Education in Bangladesh. In *14th International Conference on Computer Science & Education* (ICCSE), Toronto, Canada, 2019, pp. 77-80.

Mařešová, H., Klement, M. (2011). *Technologie ve vzdělávání*. Olomouc: Univerzita Palackého v Olomouci. ISBN 978-80-244-2941-0

Matsuuchi, N., Yamaguchi, T., Shiba, H., Fujiwara, K., & Shimamura, K. (2008). Collaborative learning system providing interactive lesson through tablet PCs on WLAN, In *7th Asia-Pacific Symposium on Information and Telecommunication Technologies*, Bandos Island 2008, pp.47-51.

Nikolopoulou, K., & Gialamas, V. (2017). *High school pupils' attitudes and self-efficacy of using mobile devices*. Themes in Science and Technology Education, 10(2), pp. 53–67.

Nikolopoulou, K. (2018). *Mobile Learning Usage and Acceptance: Perceptions of Secondary School Students*. Journal of Computers in Education, 5, pp. 499-519.

Nishiuchi, Y., Matsuuchi, N., Yamaguchi, T., Shiba, H., Fujiwara, K., Mendori, T., Shimamura, K. (2010). Enhanced TERAKOYA learning system providing multi-point remote interactive lessons. In *8th Asia-Pacific Symposium on Information and Telecommunication Technologies*, Kuching, 2010, pp. 1-4.

Panina, T.S., Vavilova, L.N. (2008). Modern ways to activate learning. M.: Publishing centre "Academia".

Sadykov, T., Čtrnáctová, H. (2017). S*oučasné interaktivní metody výuky chemie na úrovni ISED 2. Aktuálne problémy dizertačných prác v teórii prirodoveného vzdelávania*. Trnava: Trnavská univerzita v Trnave, Pedagogická fakulta, 2017, pp. 53–60. ISBN 978-80-568-0107-9.

Sadykov, T. & Čtrnáctová, H. (2019a). *Application interactive methods and technologies of teaching chemistry*, Retrieved 20/09/2019, from https://www.degruyter.com/view/j/cti.ahead-of-print/cti-2018-0031/cti-2018-0031.xml?format=INT

Sadykov, T., Čtrnáctová, H. (2019b): ICT-supported Interactive Tasks in Chemistry teaching at the ISCED 2 Level as a Method of Active Teaching. In *Martin Rusek, Karel Hojer. Project-based education and other activating strategies in science education XVI* (PBE 2018).Praha: Charles University, Faculty of Education, 2019, pp.8-17. ISBN 978-80-7603-066-4.

Schwerdt, G., Wuppermann, A. C. (2011). *Is traditional teaching all that bad? A within-student between subject approaches*. Economics of Education Review, 30(2), pp.365–379.

Shapley, K., Sheehan, D., Maloney, C., & Caranikas-Walker, F. (2010). *Effects of technology immersion on teachers' growth in technology competency, ideology, and practices*. J Educ Comput Res, 42(1), pp. 1–33.

Tondeur, J., Krug, D., Bill, M., Smulders, M., & Zhu, C. (2015). *Integrating ICT in Kenyan secondary schools: an exploratory case study of a professional development program*. Technology, Pedagogy and Education. 24(5), pp.565-584.

Traykov, I., Galcheva, P. (2017). *Implementing Interactive Teaching Methods for 9th Grade Organic*. Chemistry Classes. Acta Scientifica Naturalis, 4 (1), pp.118–123.

Wessels, A., Fries, S., & Horz, H., Scheele, N (2007). *Interactive lectures: Effective teaching and learning in lectures using wireless networks*. Computers in Human, 23(5), pp. 2524-2537.

Yang, H.C., & Chang, W.C. (2017). *Ubiquitous Smartphone Platform for K-7 Students Learning Geography in Taiwan*. Multimedia Tools and Applications, 76, pp.11651-11668.

Zheng, B., Warschauer, M., Hwang J.K, Collins, P. (2014). *Laptop Use*, Interactive Science Software, and Science Learning Among At-Risk Students. J Sci Educ Technol, 23, pp. 591–603.

Ziden, A.A., Ismail, I. Spian, R., & Kumutha, K. (2011). *The effects of ICT use in teaching and learning on students' achievement in science subject in a primary school in Malaysia*. Malaysia Journal of Distance Education, 13(2), pp.19-32.