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METHODS OF TEACHING CHEMISTRY

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Students' opinions toward interactive apps used for teaching chemistry

The solution of the problem of effective use of apps is not only in the analysis of learning outcomes, but also in consideration of the students' opinions toward learning chemistry with the help of these applications. Good results can undoubtedly be achieved in teaching chemistry if traditional and interactive teaching methods are intelligently combined. Mobile interactive apps allow educators to teach regardless of place and time, they provide the opportunity to learn both in the classroom and outside, and this is their big advantage. It also gives the teacher opportunity to interact with students on a more personal level with the help of mobile digital devices that the learners use regularly. This article, presents the results of a study of students' opinions about the use of mobile interactive applications in chemistry lessons. The approbation was carried out at a specialized school of information technologies in Karaganda (Kazakhstan), at the school Chýně, and at the first private language gymnasium Hradec Králové (Czech Republic). The results showed that more than 60 % of the students enjoy interactive apps, which positively affects their opinions towards the subject.

Keywords: chemistry, interactive apps, interactive teaching, information and communication technologies, smart devices, bring your own device (BYOD), secondary school, students' opinions, students' engagements.

Introduction

In the past two decades, despite the boom in information and communication technologies (ICT) for education, the dominant paradigm of the educational system around the world has not changed. It is still largely based on the transfer of knowledge to passive learners, where teachers impose content and methods on students. According to Falcao et al. [1], technologies were simply aggregated into this outdated structure, despite the radical changes they brought in people's lives. Schools are at the core of education systems. At the same time, the ratio of computers to school size has been identified as a potential factor that influences student academic achievement [2].

According to OECD (Organisation for Economic Co-operation and Development) [3] statistics, the average percentage of households with internet access at home increased from 74 % in 2012 to 88 % in 2017 among its member countries. Moreover, 96 percent of 15-year-old students have a computer, smartphone, or tablet at home across the OECD countries [4]. The growing use of smartphones and tablets by the population, in general, increases opportunities to support learning and motivation in the educational domain. Students' access to ICT at schools and homes has also been improved by increased national investment in ICTs and lower prices for ICT tools [5]. Integration of mobile digital devices with learning has been validated as a promising way to improve the educational achievements, motivations, and interests of students [6], to engage learners [7], improve academic performance through sharing learning with social networks [8]. Ally and Prieto-Blázquez [9] emphasized that smart devices are crucial for both teachers and students, as learning can be available in different time zones and locations. However, Moos and Marroquin [10] research have shown that the effects of participation in technological activities on students' academic interests are often short-lived because the technology novelty wears out quickly.

Interactive apps can be used not only as software applications but also for communication and entertainment [11, 12]. From an educational community perspective, interactive apps can be viewed as communication channels used for information sharing, social and learning support, as well as for problem solving [13]. Students can quickly find information online, but finding out which sources are credible and useful is difficult for them [14]. Weimer [15] and McCombs [16] suggest that successful implementation of educational apps requires changes in content function instructor's role, learning responsibility, personalization of learning, processes and purposes of assessment. This often means establishing positive interpersonal relationships, facilitating the learning process adapting to the individual, social and class learning needs, and encouraging students to take responsibility and personal challenges. In another study, I-Chun et al. [17] have created some of the steps to introduce digital lesson applications. First, the teacher starts with a brief introduction and expresses motivation regarding the learning content at the beginning of the lessons. Then, the prompting activity: the student is asked a question, and the learner has some time for reflection before answering. After that, within the framework of activity students should complete a small exercise or a simple simulation related to a learning concept. During the period of performing, the embodied experience becomes learning clues to assist the students' mental processing for knowledge construction. Through this example, student gains knowledge regarding what and how the concept can be applied when the character provides further analysis and explanation. After the exemplifying process the student can better understand the learning concept by speaking out the summary of the example or ideal case in a concise sentence. Finally, the student can ask as many times as he/she wants to clearly understand the learning concept, which would be obscure to him/her.

The aim of the paper was to study the students' opinions based on interactive apps application in chemistry teaching. This article also covers 10 popular and mostly free apps in 5 areas of activity that can be used to learn chemistry.

1. Chemical molecular viewers. This type of apps can simulate models of molecular systems, and users can manipulate the model to visualize it under different conditions (Fig. 1). Moreover, students can visualize abstract concepts as well as explore and test scientific modelling to promote deep learning and conceptual understanding in science [11].

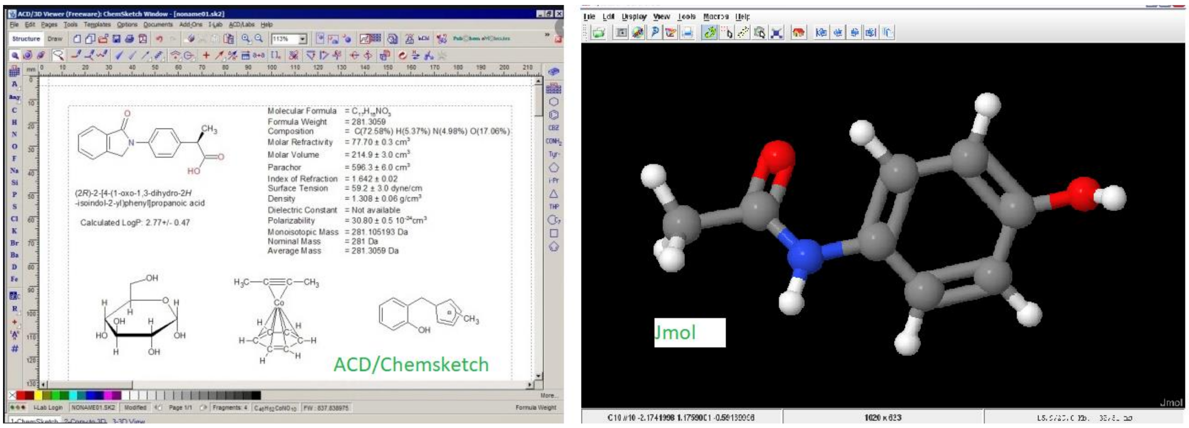

Figure 1. Chemical molecular viewer

Some students tend to prefer to learn from animations compared to other forms of representation. For these reasons, animation is an attractive option for educators. Examples of molecular viewer apps for lower-secondary schools:

• Chem Tutor provides visual representations of atoms: Lewis structures, energy diagrams, and orbital diagrams. Students receive an introduction to the representations and worked on two problem sets, in which they used representations to learn about atomic structure. Moreover, Chem Tutor provides error-specific feedback [18].

• ACD/Chemsketch is designed specifically to support the teaching of chemistry, so it contains many graphical options to facilitate the creation and editing of various chemical structures. Students can drag and rotate 3D models, zoom in and out, record frames, and manipulate the view in many ways [19].

• Jmol is a computer app for molecular modelling chemical structures in 3 dimensions. It can be integrated into web pages to display molecules in a variety of ways (ball-and-stick models, space-filling models, ribbon diagrams) [20].

2. Periodic Table and databases apps. Several apps address the need for portable devices as study guides or easy chemistry helpers [21]. Although the web browsers on mobile devices can access modern Periodic Table and online databases for browsing, there is also an increasing shift to lightweight apps dedicated to the platform (Fig. 2).

Figure 2. Periodic Table and databases apps

These apps can also be integrated to search chemical names or other identifiers of chemical structures in chemistry lesson [22]:

• Periodic Table is a digital application that is more geared towards learning general or inorganic chemistry and reinforcing various aspects of the periodicity of elements.

• iElements provides a good Periodic Table with a lot of information for each element such as its name, symbol, atomic number, phase, density, melting point, boiling point, heats of fusion and vaporization, specific heat, oxidation states, electronegativity.

• Mobile Reagents provides access to an 11 million reagent database and can be searched by exact or partial name and formula, or by using the camera to take a photograph of a chemical structure and automatically convert it to a structure search query.

3. Chemical calculation and reaction apps. In addition to chemical compounds and related chemical reactions, their balancing, common calculations, search and associated details are certainly of interest to chemists (Fig. 3).

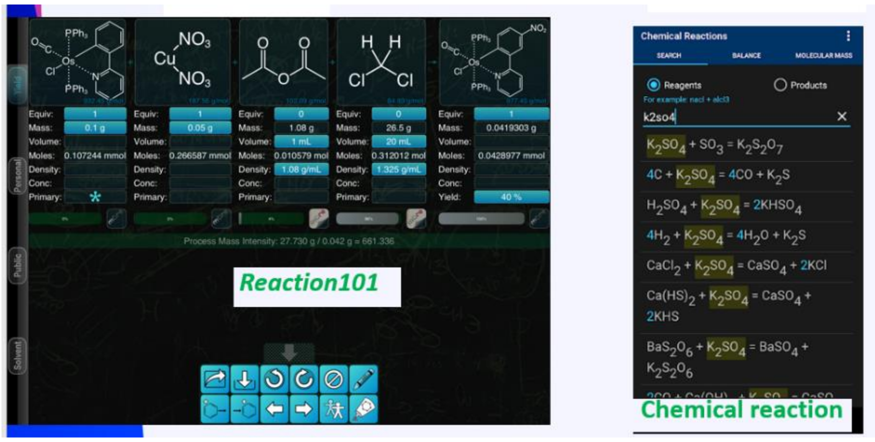

Figure 3. Chemical calculation and reaction apps

These applications are intended to aid routine calculations in the field of chemistry [21–22]:

• MolWeight is a tool that allows calculation of the molecular weight and other key properties of the compound. Moreover, a calculator is provided to determine the molecular weight of any substance by its chemical formula.

• Chemical reaction and Reaction101 are used as a chemical reaction editor with features for reaction balancing. The individual reaction components can be easily found by name, formula, structure or structure similarity methods. These apps use molecular weight (calculated from structures) and stoichiometry to derive any of the missing quantities, saving laborious calculations and manual checking.

4. Virtual chemical laboratory apps (Fig. 4). In traditional laboratory work students usually spend a lot of time in data collection while doing only simple manipulation and analysis of data. However, this tactile experience of learning might produce naive and mistaken explanation by students. Such experience would not be enough to prepare future scientist [23]. As a consequence, virtual application labs are still considered the most effective approach, as students can instantly run a high-quality lab [24], save time in data collection and processing, and change the system configuration that often cannot be changed in a real laboratory [25]. The main advantage of a virtual lab is the safety that it offers for handling dangerous equipment and reagents [26].

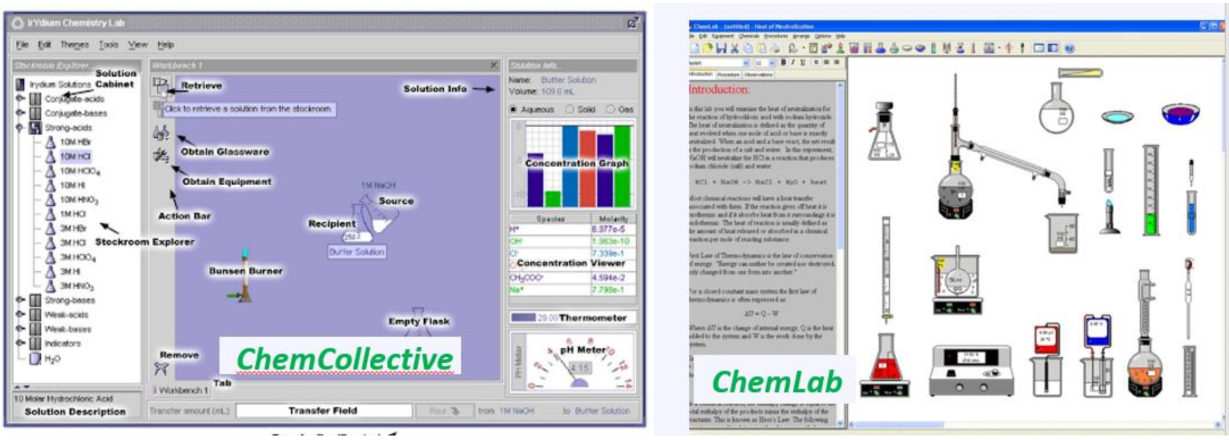

Figure 4. Virtual chemical laboratory apps

Here are examples of virtual chemical laboratory apps for lower-secondary schools:

• Chem Collective offers several virtual chemistry experiments and includes tools such as scenario-based-learning activities, tutorials and tests [27];

• ChemLab is the interactive chemistry lab simulation that is necessary to create your own virtual laboratory experiment. The database contains a large selection of chemicals and commonly used laboratory equipment [28].

5. Game-based learning apps. In game-based learning self-explanation can help students to generate more explicit representations of their knowledge, and, in turn, can positively affect accessibility, recall and transfer of knowledge [29]. Sadykov and Ctrnactova [30] stated in their research that students enjoy working with interactive tasks, and this has a positive effect on their attitude towards the subject. In addition, gamification involves the use of features such as scores, badges, rankings, and rewards, making immediate feedback possible. It encourages students to participate in the learning environment and allows them to complete tasks (Fig. 5). During gamification it is possible to monitor and assess successful learning and provide feedback on the assessment to students for formative purposes [31].

Here are some examples of game-based learning apps for lower-secondary schools:

• Learningapps.org is an interactive game-based app that allows the teacher to create personal interactive tasks and exercises. These programs also allow students to use their mobile devices for learning, and the teacher, respectively, can see the results of students on their own device. This model of organization of educational interaction is called Bring Your Own Device (BYOD) or Bring Your Own Technology (BYOT). The ability to provide immediate feedback to all participants increases the interactivity and adaptability of learning [30].

Figure 5. Game-based learning apps

• Kahoot is game-based learning and platform used in classrooms. It can be used with any subject, any age, and any device equipped with either cell signal or internet, and players do not even need to register to sign up for an account. This game also provides a tool for creating quizzes including adding pictures and videos to the questions. It also makes it possible to publish and share your own quizzes, as well as edit quizzes made by others [32].

Experimental

We have developed our questionnaire to study the students' opinions based on application interactive lessons with mobile apps during ten interactive lessons. The questionnaire used in this research consisted of ten closed-ended questions. A three-level rating scale from 1 to 3 (1 — Agree, 2 — Neutral, 3 — Disagree) was chosen as the most appropriate for measuring participants' opinions.

In the introductory part the students were briefed on the purpose of the questionnaire. The first part of the questionnaire collected factual data concerning, in addition to age and gender, the type of school and the level of students in chemistry for the last year. The second part of the questionnaire concerned the attitude of lower-secondary school students towards interactive forms of learning.

Questions 1, 2, 7, 9 were aimed at determining the interest and motivation of the students in the interactive lesson conducted using interactive apps compared to traditional lessons. Questions 3 and 4 determined how interactive lesson is understandable and does not pose any significant difficulties. In questions 5, 6, 8, 10 we were interested in whether students find this method interesting or useful and would they like to learn this way more often.

The survey participants were asked the following questions:

1. Do you like interactive lessons with the use of mobile apps?
2. Do you think that interactive lessons are more interesting than traditional?
3. Was the explanation in the interactive lesson with the use of mobile apps 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 with the use of mobile apps applied in real life?
6. Would you like if an interactive lesson with the use of mobile apps like these could be carried out more often?
7. Were you interested in using the mobile apps with a mobile phone or tablet?
8. Do you like the Kahoot and Learningapps.org apps? Is it quick and interesting and does it help you to check your knowledge?
9. Do you think that solving tasks with interactive apps more interesting than traditional ways?
10. Would you like if interactive apps like these could be used more often?

Results and Discussion

Part 1. The verification of interactive materials was carried out in two groups of students: 8-KZ (15 male and 11 female adolescents) from specialized school-board information technologies in Karaganda (Kazakhstan); 8-CZ (8 male and 10 female adolescents) from first private language gymnasium Hradec Králové (Czech Republic). Interactive materials were tested on the topics: "*Chemical reaction, Factors affecting the rate of chemical reaction, and Classification of chemical reactions"* (Fig. 6–7). Among the respondents there were

52 % male and 47 % female adolescents. The average age of students was 13.5 years. According to the types of schools, we used *Chemical reaction, Reaction101, Kahoot* apps in our interactive lessons.

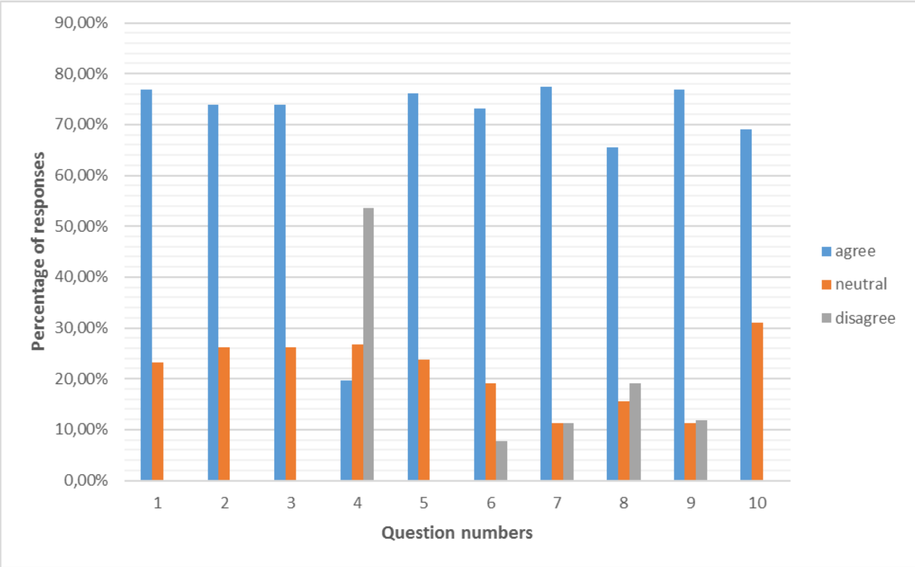

Figure 6. The results of the survey. Part 1 for 8-KZ group students

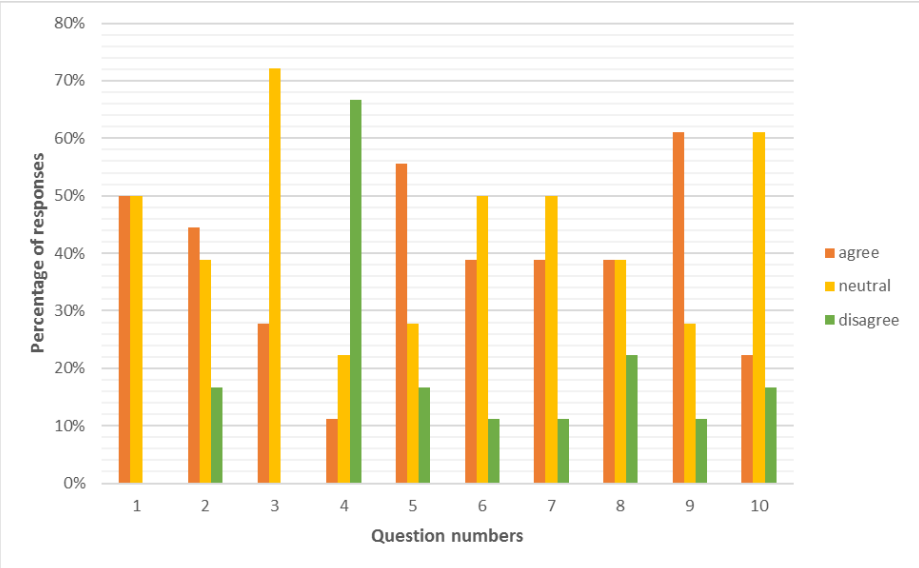

Figure 7. The results of the survey. Part 1 for 8-CZ group students

As can be seen in Figure 8, the majority of respondents (64 %) rated interactive lessons with using mobile apps positively, and more than 60 % of respondents think that interactive lessons are more interesting than the traditional (questions 1-2). 62 % of respondents would like to an interactive lesson more often, about 30 % of respondents rated their attitude to this form of learning with the answers “neutral”, and only 5–8 % of respondents expressed a completely negative attitude to this form of learning (question 6).

Most of the students (64 %) believe that interactive lessons with the mobile apps were illustrative and did not contain too much information, diagrams, and pictures, 30 % of the surveyed students answered “neutral”, 16 % of students find it too difficult (question 4). About 70 % of students believe that the knowledge that was obtained in an interactive chemistry lesson can be applied in real life, only 5 % of students consider this chemistry lesson to be of little use for real life (question 5).

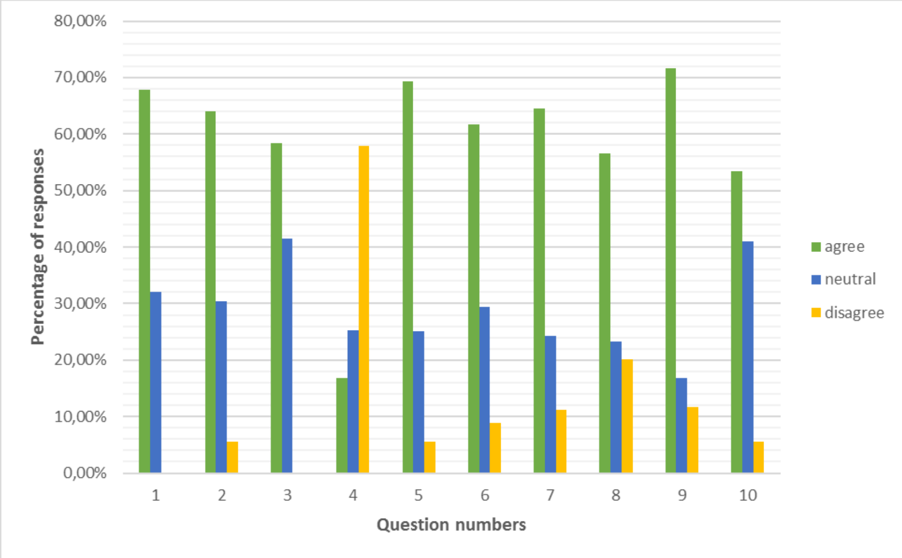

Figure 8. Total results of the survey. Part 1

More than two-thirds of respondents were interested in using interactive apps on a mobile phone or tablet, only 15 % of respondents were not interested in this form of learning (question 7). More than 70 % of respondents rated solving tasks using interactive apps more interesting than the traditional way, and 53 % of respondents would like to be engaged in this way of learning more often (question 9–10).

There was a significant difference between the two group's grades from Kazakhstan and the Czech Republic regarding answers. It can be seen from Figures 6-7 that group 8-KZ rated the interactive materials more positively than group 8-CZ, which had a significantly higher "neutral" response rate.

Part 2. The verification of interactive materials was carried out in two groups of students: 8-KZ (15 male and 10 female adolescents) from specialized school-board information technologies in Karaganda (Kazakhstan); 8-CZ (8 male and 10 female adolescents) from school in Chýně (Czech Republic). Interactive materials were tested on the topics: "Periodic table, Chemical bond" (Fig. 9–10). Among the respondents there were 48 % male and 52 % female adolescents. The average age of students was 13.5 years. In this part 2 we used various applications such as *Learningapps.org*, *Periodic table* and *Database apps*.

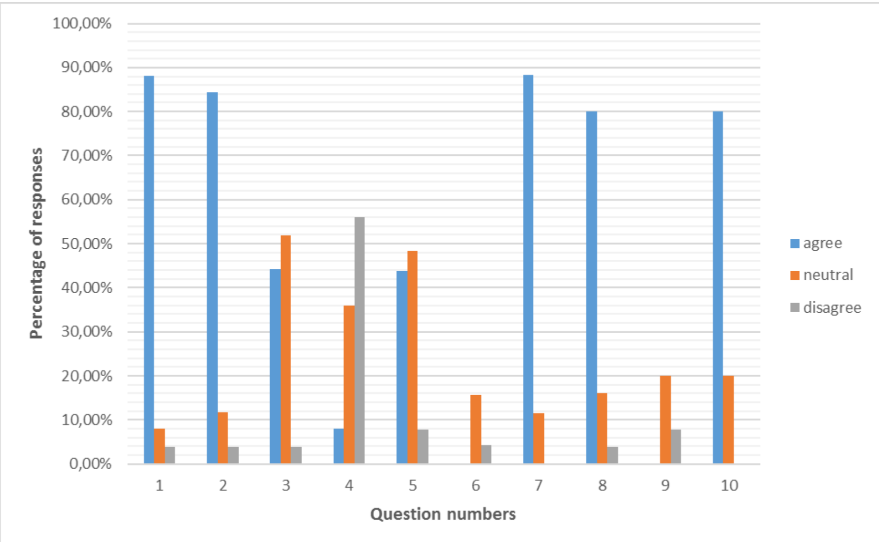

Figure 9. The results of the survey. Part 2 for 8-KZ group students

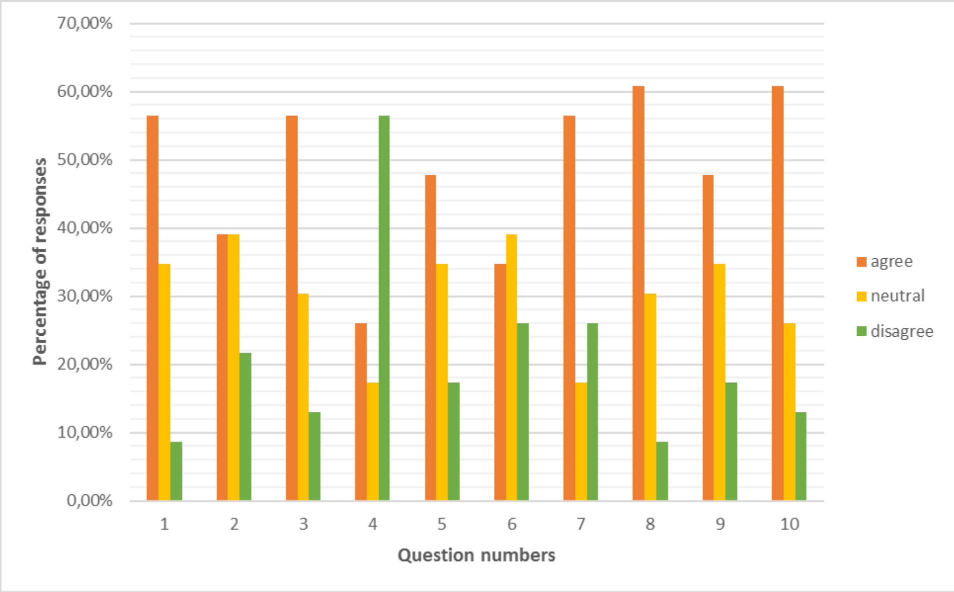

Figure 10. The results of the survey. Part 2 for 8-CZ group students

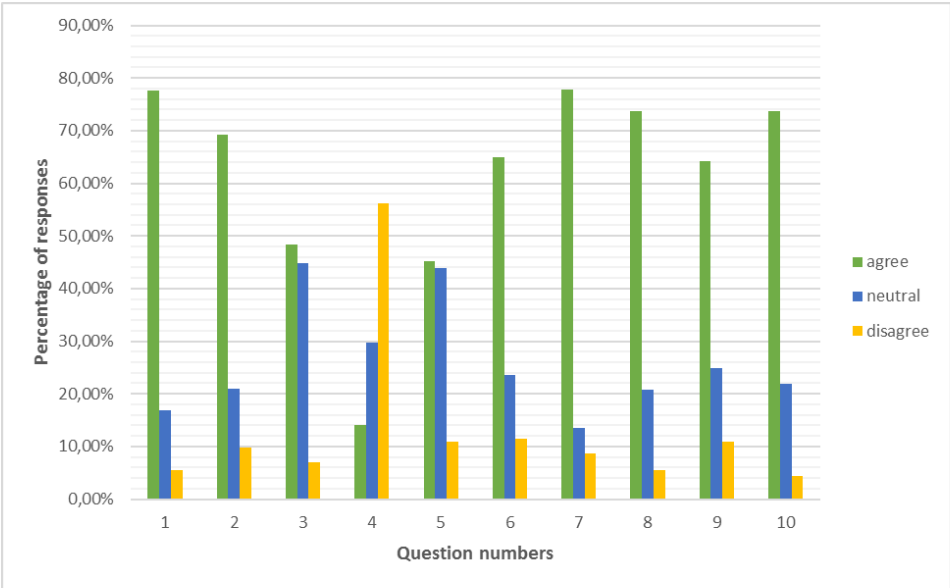

Figure 11. Total results of the survey. Part 2

As can be seen in Figure 11, the majority of respondents (70 %) rated interactive lessons with using mobile apps positively and think that interactive lessons are more interesting than the traditional, only 9 % prefer the traditional form of the lessons (questions 1–2). Further question 4 showed that 56 % of respondents believe that interactive lessons with the mobile apps were illustrative and did not contain too much information, diagrams and pictures, 16 % of students find it too difficult.

45 % of students answered “agree”, 43 % — “neutral” and 12 % — “disagree” at the question 5 “Do you think that the knowledge that was obtained in an interactive chemistry lesson can be applied in real life?”. Questions 7 and 8 were asked to find out whether students like to use mobile apps on a mobile phone and tablet. The respondents rated this method of learning mostly positively (70 %), only 8 % of respondents believe that it is not suitable for learning.

In questions 6 and 9 respondents were asked if they would like an interactive lesson and solving tasks with mobile apps carried out more often, 65 % of respondents answered positively.

There was a significant difference between two group’s grades from Kazakhstan and the Czech Republic regarding answers. It can be seen from Figures 9-10 that group 8-KZ rated the interactive materials more positively than group 8-CZ, which had a significantly higher “neutral” response rate.

Figures 12–13 showed a significant difference in some responses to the questionnaire in Kazakhstan and Czech Republic. The differences are particularly evident in questions 2, 6, 7, and 9. In our opinion, this difference is due to the fact that verification of interactive lessons with mobile apps carried out in one school and two groups in Kazakhstan, and two schools and two groups of students taught by two different teachers in the Czech Republic. Another factor may be the generally lower interest in learning using ICTs, due to the widespread and frequent use of this technique only for entertainment purposes in the Czech Republic.

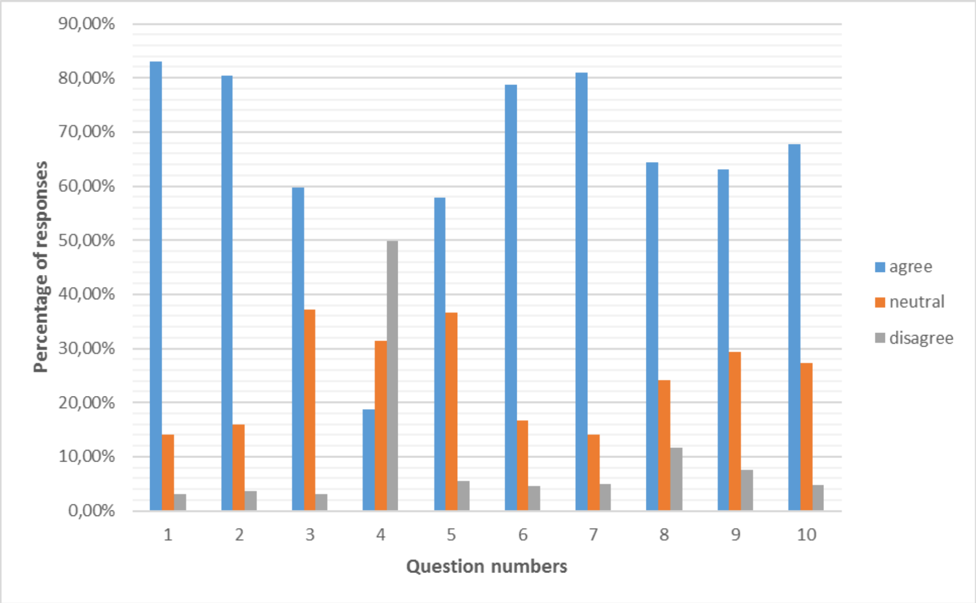

Figure 12. Total results in Kazakhstan

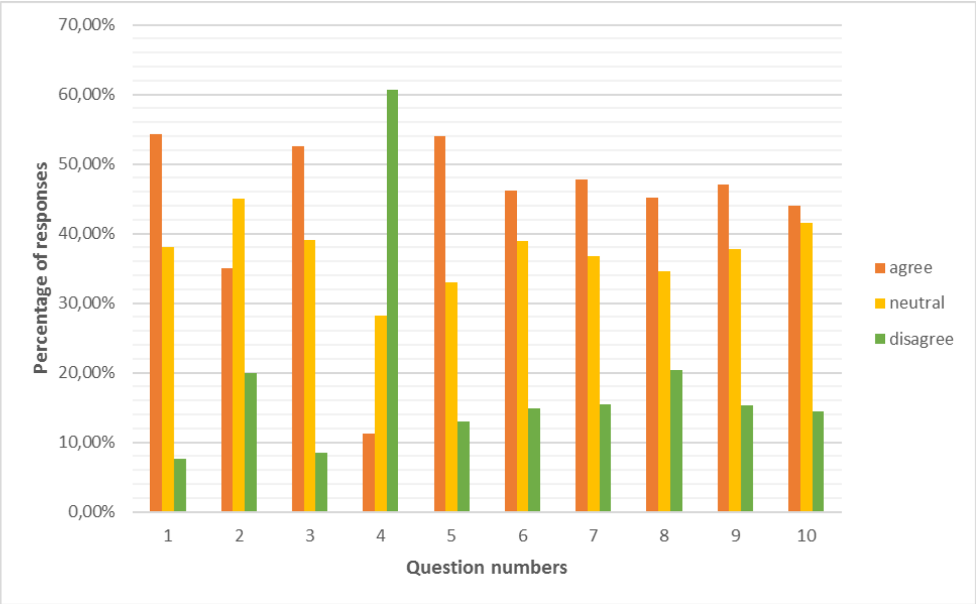

Figure 13. Total results in Czech Republic

Conclusions

A literature review of previous studies has shown that mobile apps used for lower-secondary school improve achievement and engagement. It is clear that students with mobile digital devices can access virtual information equivalent to a large research library.

During the verification of interactive materials we are faced with the willingness of teachers to use tablets and mobile phones, but also with the lack of scientific training and understanding of current science and technology issues on the application market. There was no statistically significant difference between the use of different types of mobile apps during ten interactive lessons. One of the possible alternative explanations for this result is the small amount of methodological literature for the use of interactive applications for tablets and mobile phones in teaching chemistry.

Special chemical software can help students to generate more explicit representations of their knowledge, positively affect accessibility, recall and transfer of the knowledge to chemists. In this study we have defined and described the interactive apps supporting an increase in the activity of students, and the effectiveness of the learning process for lower secondary schools. This study was limited by a relatively small sample size; however, the findings have important implications for teacher professional development and educational app design.

This result suggests that interactive apps support learning and increase student enjoyment, and this positively affects their attitude towards the subject. We think that one way to solve this problem is to involve teachers in the app's development process. Moreover, we believe that the combination of mobile phones and tablets allows multiple students to perform the activities at the same time, and this encouraged them to interact with each other. Therefore, in the next research we will focus on verification of the use of interactive apps as well as identifying the most effective apps for teaching chemistry in other schools in both Kazakhstan and the Czech Republic.

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Химияны оқытуда интерактивті қосымшалар пайдалану бойынша оқушылардың пікірлері

Интерактивті қосымшаларды тиімді пайдалану мәселесін шешу тек бағалау арқылы оқу нәтижелерін талдау ғана емес, сонымен қатар оқушылардың осы қосымшалар арқылы химияны оқытуға деген пікірлерін ескеру болып табылады. Сөзсіз, оқытудың дәстүрлі және интерактивті әдістерін ұтымды үйлестіре отырып, химияны оқытуда жоғары нәтижелерге қол жеткізуге болады. Мобильді интерактивті қосымшалардың үлкен артықшылығы олар оқытушыларға орны мен уақытына қарамастан сабақ беруге, сыныпта да, одан тыс жерлерде де оқуға мүмкіндік береді. Сондай-ақ, бұл мұғалімге оқушылар мен жүйелі түрде қолданатын мобильді сандық құрылғылардың көмегімен оқушылар мен жеке деңгейде қарым-қатынас жасауға мүмкіндік туғызады. Мақалада химия сабақтарында мобильді интерактивті қосымшаларды қолдану туралы оқушылардың пікірлерін зерттеу нәтижелері келтірілген. Апробация Қарағандыдағы (Қазақстан) мамандандырылған ақпараттық технологиялар мектебінде, Хыня мектебінде (Чехия) және Градец Краловтың (Чехия) бірінші жеке тілдік гимназиясында жүргізілді. Нәтижесінде оқушылардың 60 %-дан астамы интерактивті қосымшалар мен жұмыс істеуді ұнататынын көрсетті, бұл олардың химия пәніне деген көзқарасына оң әсер етеді.

Кілт сөздер: химия, интерактивті қосымшалар, интерактивті оқыту, ақпараттық-коммуникациялық технологиялар, интеллектуалды құрылғылар, жеке құрылғыңызды алып келіңіз (BYOD, негізгі мектеп, оқушылардың пікірлері, оқушылардың қызығушылығы.

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Мнения учащихся об интерактивных приложениях, применяемых для обучения химии

Решение проблемы эффективного использования интерактивных приложений заключается не только в анализе результатов обучения с помощью оценок, но и в учете мнений учащихся на обучение химии с помощью этих приложений. Бесспорно, разумно сочетая традиционные и интерактивные методы обучения, можно добиться высоких результатов в обучении химии. Большим плюсом мобильных интерактивных приложений является и то, что они позволяют преподавателям обучать вне зависимости от места и времени, дают возможность учиться как в классе, так и за его пределами. Это также возможность взаимодействовать с учащимися на более личностном уровне с помощью мобильных цифровых устройств, которые учащиеся используют на регулярной основе. В данной статье авторами приведены результаты исследования мнения учащихся об использовании мобильных интерактивных приложений на уроках химии. Апробация проводилась в Специализированной школе информационных технологий в Караганде (Казахстан), в школе Хыне (Чехия) и в первой Частной языковой гимназии Градец Кралове (Чехия). Результаты показали, что более 60 % учащихся получают удовольствие от работы с интерактивными приложениями, что положительно влияет на их отношение к предмету.

Ключевые слова: химия, интерактивные приложения, интерактивное обучение, информационно-коммуникационные технологии, интеллектуальные устройства, принеси свое собственное устройство (BYOD), основная школа, мнения учащихся, вовлеченность учащихся.

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