UPGRADING SCIENCE WITH ENGLISH AND ICT

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Abstract

The 21st century brought many changes to the Slovenian school system. The idea of teaching using more modern, active methods and forms of learning and teaching where the student follows the idea "What I hear, I forget. What I see, I remember. What I do, I understand!" was necessary. Information and communication technology development enabled all participants in learning and teaching to look outside the box and beyond the horizon. It enabled students to be more involved in the pedagogical process and encouraged their activity. The Covid-19 pandemic literally overnight changed the learning and teaching process. The students were confused and scared, and the teachers faced the professional challenge and the desire to motivate their students and reach their educational goals. Using online applications (Liveworksheets, Edpuzzle, WordItOut, Wordwall), developing reading comprehension, formative assessment, flipped learning, making videos, and multilingual teaching in combination with classic methods is a successful example of a months-long cross-curricular integration of science and English. The evaluation of the work and the students' reflection showed how vital good lesson planning is, as well as the fluidity and almost imperceptible intertwining of the two subject areas (Chemistry-English and Biology-English). Immediate feedback helped to reach the learning goals faster and better. Multilingualism is an essential step toward the school of the future. The quality of the acquired knowledge and skills was visible in the final report - the student's grades.

Keywords: *cross-curricular integration, ICT, online applications, science teaching*

Introduction

The Covid-19 pandemic has brought significant changes to Slovenian education. Overnight, we needed to adapt to conditions we had not been prepared for - remote work. We focused all our energy on preparing customized lessons, which undoubtedly presented a big challenge. The established methods and forms of learning and teaching suddenly became unsuitable for working remotely. On the other hand, the students felt confused and scared. The formation of online classrooms reconnected teachers and students, and video conferences became the new "live" classes. Due to the absence of direct contact with students and the difficulty of obtaining feedback, the biggest challenge was to make the lessons enjoyable, motivating, active, and thriving. Active learning and teaching methods, online apps, and multilingualism have proven successful when working remotely and in the classroom.

Chemistry and English

The primary school chemistry curriculum divides chemistry content into units. The chemistry curriculum is designed to realize fundamental competencies (abilities) for lifelong learning, defined as a combination of knowledge, skills, and attitudes. Priority in chemistry is given to developing mathematical competence, fundamental competencies in natural sciences, and digital literacy. At the same time, the chemistry curriculum enables the implementation of many components of other vital competences for lifelong learning:

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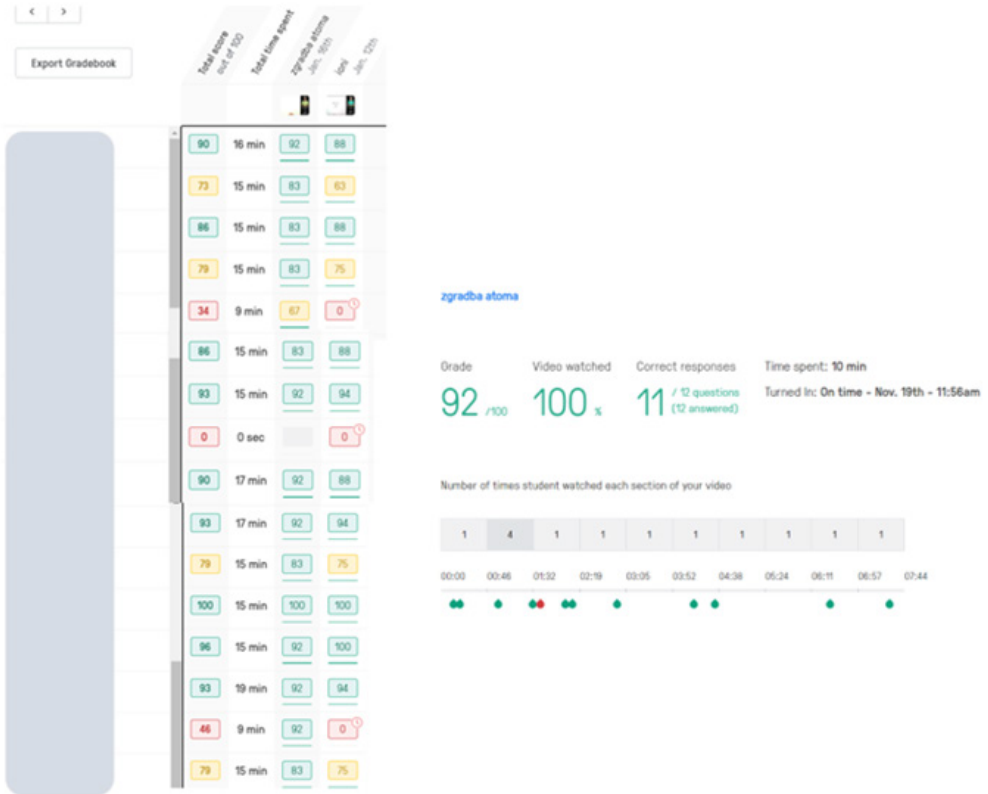
communication in the mother tongue (the ability to express and understand concepts, facts, thoughts, emotions and opinions in written and oral form; creating and expressing one's oral and written arguments in a persuasive manner appropriate to the circumstances), communication in foreign languages (understanding the most basic chemical terminology in a foreign language for using resources in book and electronic form), learning to learn (planning one's own activities, responsibility for one's own knowledge, independent learning, developing metacognitive skills, work habits), social and civic competences (constructive communication when participating in a group; responsible attitude towards arranged tasks and obligations), self-initiative and entrepreneurship (creativity, taking initiatives, planning, organizing, leading, risk assessment, decision-making) (Učni načrt. Program osnovna šola. Kemija, 2011).

The initial idea was that the students would reach some of the goals of the unit Atom and the structure of the atom with the help of a video explanation. I found a content-appropriate video on the Internet, but it was in English. I forwarded the video to an eight grade English teacher and asked for an expert opinion on the appropriateness of the video. It was a spontaneous beginning of the cross-curricular integration of science and English. Using different forms and methods, I taught the unit on atoms, and students completed various tasks to gain knowledge of the unit. The purpose of the video was to consolidate the acquired knowledge. In the English lesson, students watched the video and acquired the vocabulary. To consolidate their knowledge in chemistry, the students used the Edpuzzle application, where they solved the tasks based on the video.

The application serves as a tool to prepare an interactive video by adding comments and questions to the video, which the students can answer. Student responses are recorded and can help the teacher monitor progress and understanding. The teacher can monitor the results of individual students and obtain information on the difficulty of the tasks. It is essential feedback that allows the teacher, as well as the students, to consolidate and revise. The application is suitable for testing comprehension and theoretical content. It enables individual enrollment of students in classes and thus provides a closed group of users to protect their personal data ("Edpuzzle," 2014).

Figure 1
Students' Scores in the Edpuzzle App



The evaluation and students' self-evaluation showed that the students successfully reached the goals set in chemistry and English. The purpose of the next step was to apply the acquired knowledge on the atom. The students randomly chose their respective atoms using the online learning tool Wordwall (Random cards). The students' task was to make a model of the chosen atom.

The Wordwall app allows teachers to create interactive games and printed materials for students. There are 33 templates available, and it is possible to create activities in 41 languages. Teachers put in the content, and the rest is automated. In the past, teachers used didactic slips and post-it notes, which they stuck to the wall or blackboard and thus made lessons more active and engaging. The Wordwall app works in the same way ("Wordwall About," 2021).

When using the Wordwall app, the students are task solvers as well as task creators. They can choose different templates (Open box, Quiz, Matching, Random wheel, Missing word, Hit the mole) and create their own tasks.

As the shops were closed due to the pandemic, the students made a model of their atom from various materials they had at home. The teacher and the students determined the criteria for constructing the atom model. The most important rule was that the structure must be chemically correct (electrons, protons, neutrons, shells, electronic configuration); they could ignore the spatial relations (size).

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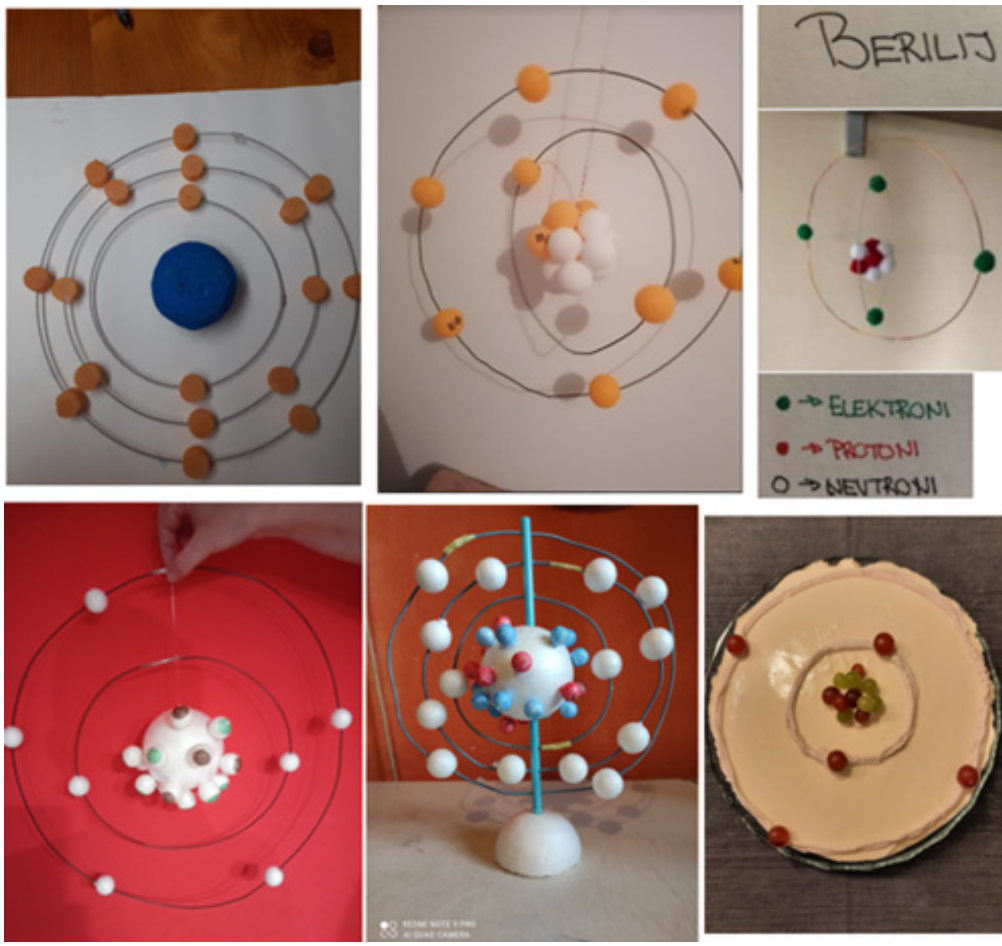
Figure 2
Students' Creations



I uploaded all the assignments and instructions to the online classroom, which gave the students constant access, and the teacher had an insight into the student's activity and engagement.

Since the result of cross-curricular integration and working with various online applications was successful, we carried out the unit on ions in a similar way. I explained the unit on ions via video conference; students worked independently using different methods. Students acquired English vocabulary with the video in English and did exercises in Liveworksheets to practice the use of the vocabulary. Students consolidated their knowledge of ions with the Edpuzzle online tool video.

The students' feedback was positive and encouraging. In their opinion, different approaches and their own activity made distance learning enjoyable, and the acquired knowledge sustainable. An essential step towards broadening their horizon is upgrading their knowledge of chemistry with professional terminology in English.

WordItOut is an application that I used to reinforce the labeling of cations, anions, and ion compounds. Students matched the formulas and labels in the word cloud and wrote down the pairs.

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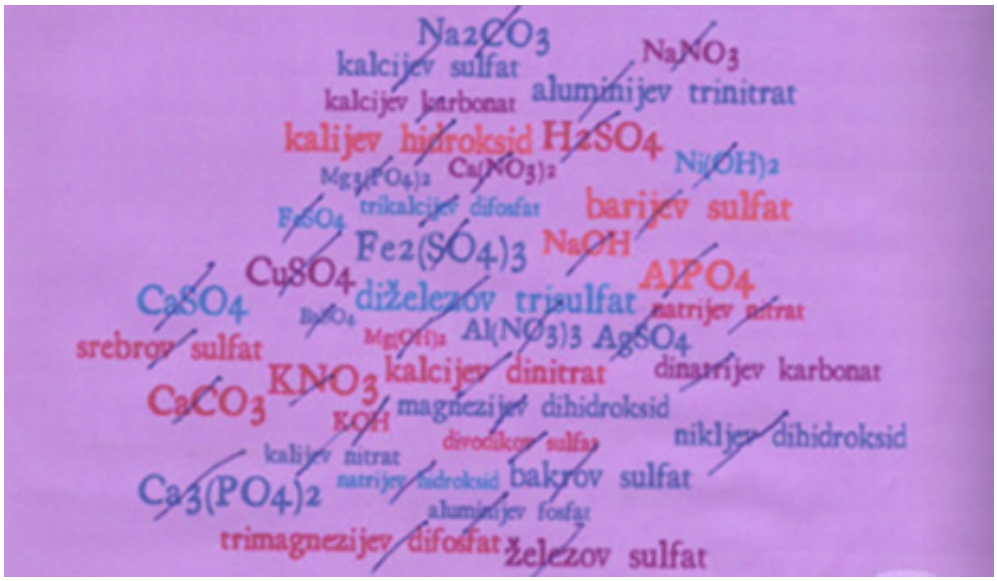
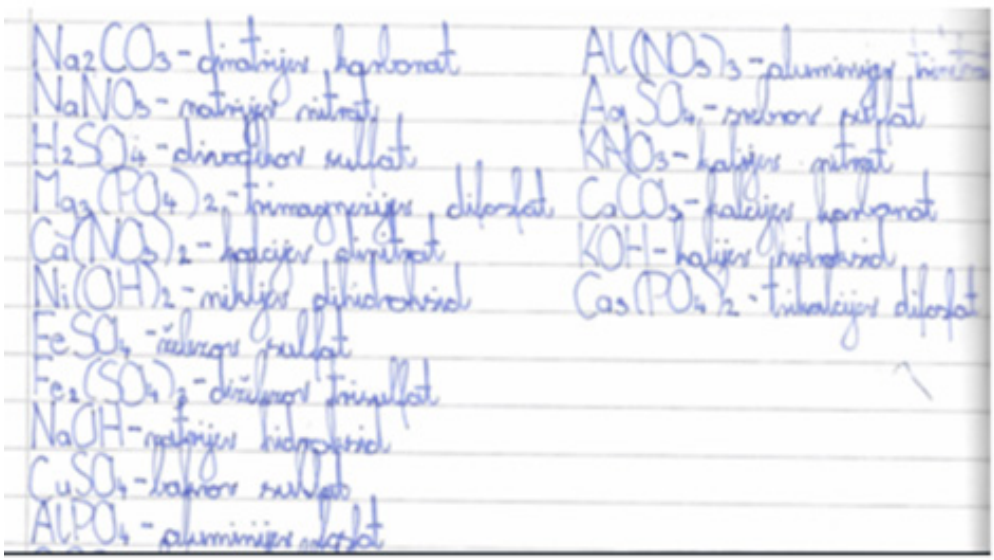
WordItOut is a word cloud generator that enables teachers to use many custom settings. They can create word clouds from sentences, entire documents, or tables. They can decide which words to show or remove from the word cloud and thus easily adjust their importance. They can design their own word cloud, find the perfect layout, choose the colors, fonts, and sizes, or let WordItOut choose a random look. It is possible to download a copy as an image file ("WordItOut - Enjoy Word Clouds, Create Word Art & Gifts," 2022).

Figure 3
Using the WordItOut Application





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Although the application is in English, it supports Slavic letters and enables the writing of chemical formulas. The students were already proficient in working with the online tools mentioned above. The immediate feedback that these online tools provide enables all participants of the learning process to track progress and provide additional explanations or revisions. The next level of the cross-curricular integration of chemistry and English, or the upgrade, was planned based on these findings.

Flipped learning and teaching is an innovation that was created based on evaluating one's own practice among teachers and looking for ideas to improve their teaching and increase the effectiveness of students' learning. Three elements are essential for this learning to be effective: content, curiosity, and the relationship with the teacher. Flipped learning is a teaching technique with two components: interactive group activities in the classroom and computer-based individual instruction outside the classroom. The key components of successful flipped learning are collaboration, student-oriented lessons (the teacher is a mentor, encourager, and guide), optimized learning space (suitable for group and collaborative learning formats), sufficient time for implementation, teacher support, and help in preparing online material (Plešec Gasparič, 2019).

The students were divided into five heterogeneous groups of four students each. The division was well planned, both in chemistry and in English. In the English lesson, students acquired professional terminology based on the video.

In the chemistry lesson, students analyzed and synthesized the acquired knowledge on the topic. As a group, the students recorded a video in their mother tongue explaining the subject (Formulas of ionic compounds and formulas of polyatomic molecules). The teacher and the students set the general criteria for the video. However, each group freely decided how to prepare the presentation and select the examples. Students' videos were reviewed by both teachers and corrected if necessary.

Each group prepared consolidation tasks in English for the students of the other groups in the Wordwall online tool. Both teachers reviewed the tasks and corrected the mistakes before students from the other four groups did the tasks. The application gives feedback on the tasks' results and thus enables teachers' assessment and students' self-assessment.

Evaluation always follows the stages of acquisition, consolidation, and revision of knowledge. It is necessary to assess and revise prior to evaluating the students' knowledge. Assessment in descriptive evaluation is, at the same time, an evaluation, while in numerical evaluation, assessment is the justification of the evaluation. In the evaluation, we focus on identifying and evaluating the student's achievements according to the set expected and mandatory goals (Golubič, 2013).

Making a video explanation of the task "My Atom" was a method of assessing the student's knowledge. Considering the different prior knowledge of chemistry and the student's computer literacy was necessary. The teacher and the students determined and set the criteria for making a video explanation. Using the WordItOut application, the students determined keywords and formed a word cloud. Students had to use these keywords and the atom model they had made during the lockdown in their presentations. However, the students could choose the method of presentation according to their preferences (use of presentation programs, blackboard, poster, and didactic leaflets). The students also proposed and, together with the teacher, formulated the evaluation criteria, which were the basis for evaluating their individual video explanations. Before the evaluation, students watched and assessed a few randomly selected video explanations according to the set criteria. In the formative assessment, the students compared and discussed their feedback.

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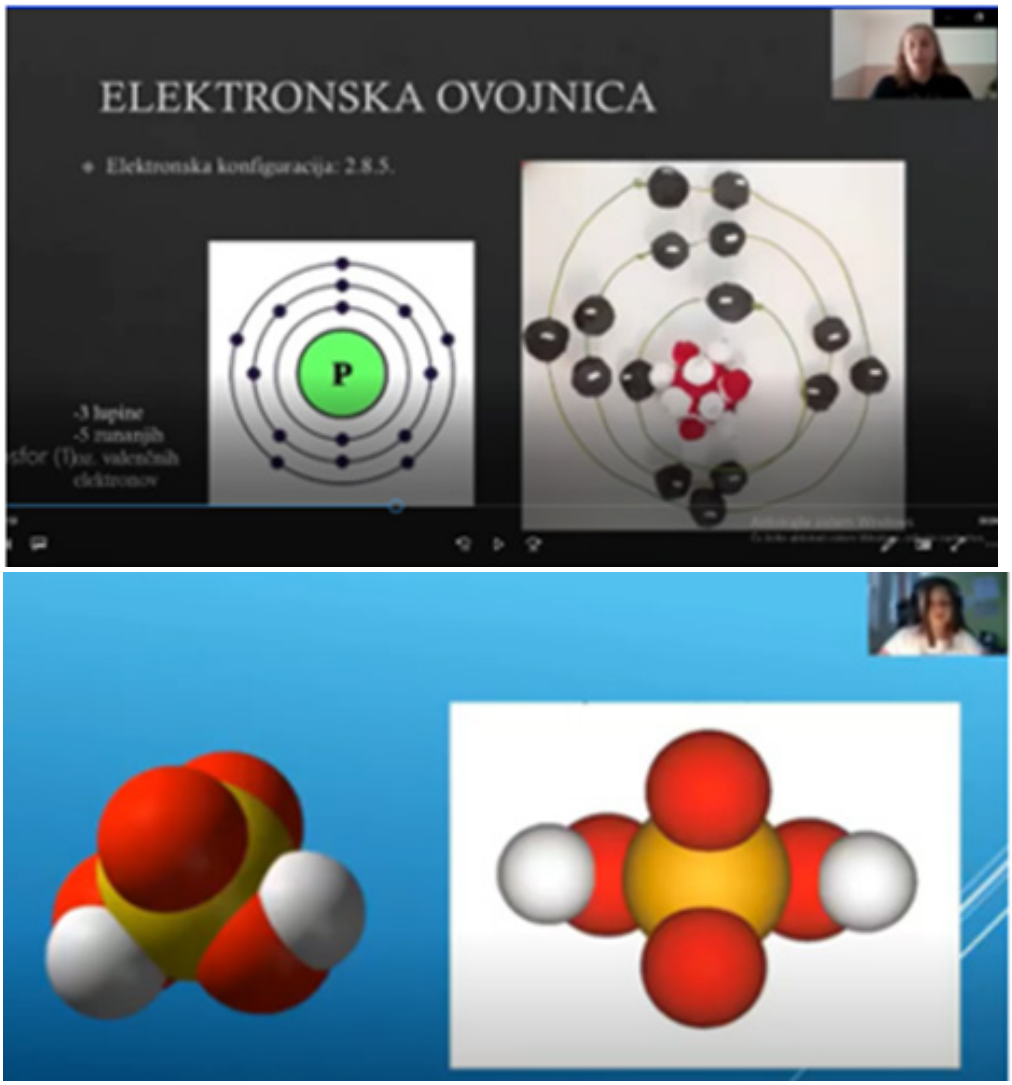
Figure 4
Students' Video Explanations on the Topic My Atom



Formative assessment emphasizes the importance of obtaining diverse evidence of learning and acquired knowledge (written, artistic, technical, practical, and other products, project work, and student performances). The diverse evidence enables students to show their knowledge in the way that suits them best. They prove what they know, how they understand the topic, and what they can do (use of knowledge, skills, problem solving, creativity). Formative assessment is how the teacher enables students to co-create the learning process (learning objectives, performance criteria, personal goals, setting questions, self-evaluation, peer assessment), which leads to a more active role of students and more sustainable knowledge.

Students assess their work and receive quality feedback from the teacher and classmates. The aim is to improve their learning and achievements (finding out to what

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extent they have achieved the goals). The videos are evidence of learning that students keep in their portfolios. The teacher does not use partial grades, pluses, minuses, and other symbols to assess the evidence of learning but exclusively gives students qualitative feedback. The relationship between the teacher and students has an important motivational effect ("Formativno spremljanje, Zavod RS za šolstvo," 2021).

Biology and English

In the new school year, lessons were conducted in the classrooms. Based on the excellent experience with the cross-curricular integration of chemistry and English, the English teacher and I decided to continue with cross-curricular integration. We decided to integrate biology and English and work with the same students as the previous school year. After thorough consideration, we chose the unit on genetics. The topic is up-to-date and engaging, but based on experience, it is quite demanding and abstract for primary school students. This topic presents a big challenge for the teacher, as well.

Due to the complexity of the content, the students first learned the subject matter and reached the set goals in biology class. They learned about genetics, genes, DNA, chromosomes, mutations, mitosis, meiosis, Gregor Mendel, inheritance, and ways of passing traits from parents to offspring. In these lessons, we used different methods and forms of work. Pupils attended live lessons and worked independently or in groups or pairs. There were many animations and video presentations, which were of great help to the students in understanding and mastering the learning objectives.

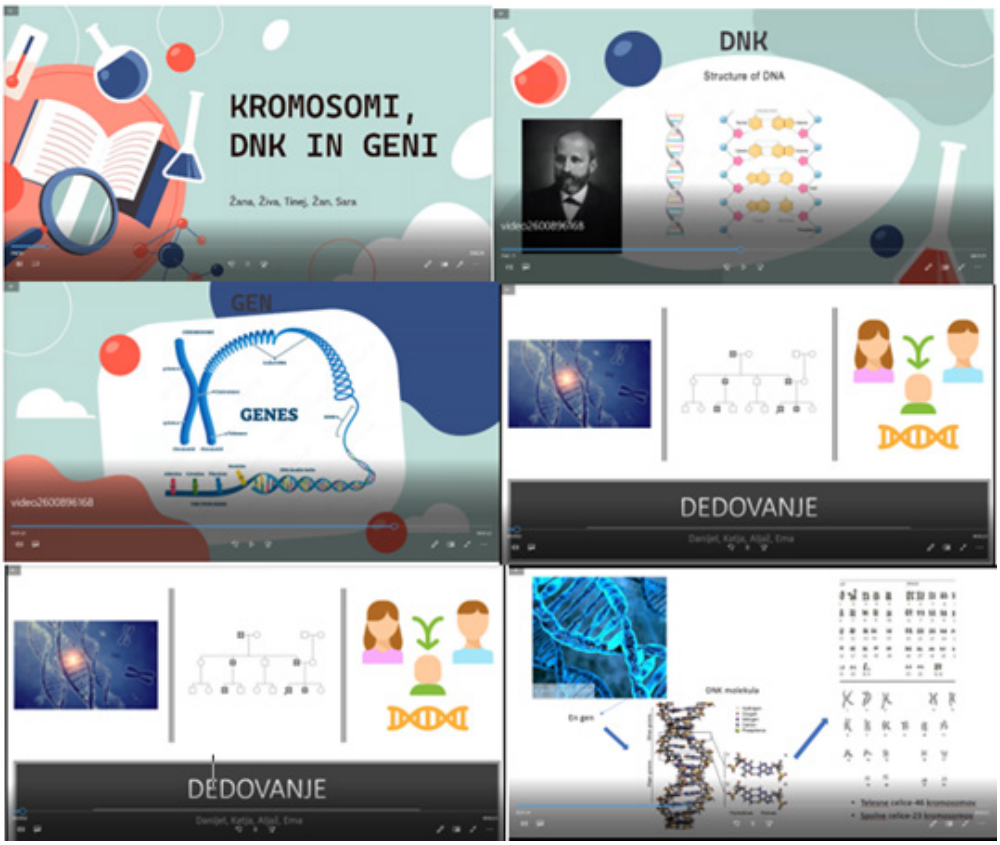
Cross-curricular integration was a part of consolidation and revision. The emphasis was on reading and listening comprehension using ICT and online applications.

The first phase took place in English class. We considered the difficulty level of English and the goals in biology. Both teachers carefully selected the text on genetics in the English language. In the Edpuzzle application, the students watched two video clips in English and did the tasks. This way, the students acquired professional terminology in English.

In biology class, students did the listening comprehension. They watched a video clip of the show Let's Bite Science: What is in Our DNA? Individually, they wrote down the terms used in biology class or read about in the English article. Then we analyzed the terms and created a word cloud. Additionally, we revised and explained the unknown terminology.

The next step was recording a video explaining genetics and inheritance in their mother tongue. The students were divided into five heterogeneous groups (the same as in the chemistry - English integration the previous year). Each group had its own content within the topic of genetics. We reviewed the instructions for making a video, prepared for chemistry class in the previous school year, and adapted them to the new situation. We also reviewed the criteria and adjusted them. Students could work freely and choose the method of presentation on their own. The two essential conditions were that each student in the group must contribute a part of the explanation and that the complexity of the content must be suitable for ninth graders.

Figure 5
Students' Video Explanations on Genetics and Inheritance



The last step before the evaluation was the assessment of their knowledge. Students assessed their knowledge by uploading video explanations to the Edpuzzle online learning tool and preparing ten questions. For homework, students from the other four groups did the tasks prepared by their classmates. In the biology lesson, we analyzed the results and assessed their work. The students provided a self-evaluation of the completed work and proposed improvements to the results (formative monitoring).

Applications

Assessment of Learning Applications according to the SAMR Model

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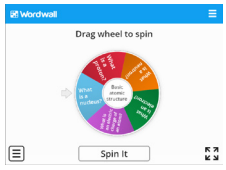
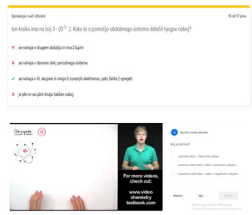
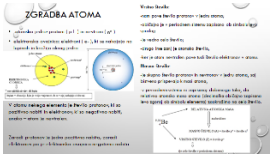
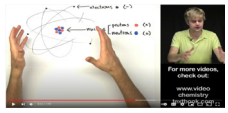
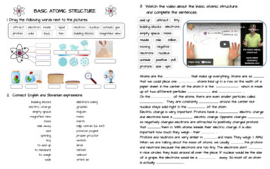
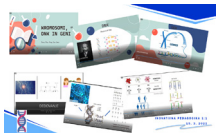
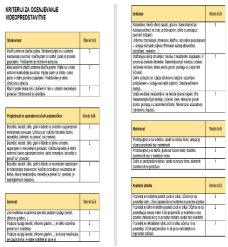
Figure 6
SAMR Model of Introducing ICT into Lessons (Jedrinović et al., 2018).

Table 1

Presentation of Applications according to the SAMR Model

SUBSTITUTION	AUGMENTATION	MODIFICATION	REDEFINITION
WordItOut	**WordWall**	**Edpuzzle**	**Wordwall**
 writing out chemistry formulas	 understanding and interpretation of acquired knowledge	 analyzing and evaluating acquired knowledge	 creating digital tasks with collaborative learning
PowerPoint	**YouTube**	**Liveworksheets**	**PPT / Zoom**
 writing down reference points and explanation of the learning material	 understanding and interpretation of acquired knowledge	 analyzing and evaluating acquired knowledge	 making video explanations
Word	**Blooket**		**Edpuzzle**
 writing down evaluation criteria	 understanding and interpretation of acquired knowledge		 making interactive tasks based on video explanation
	Microsoft Edge		
	synthesizing speech		

Note. Own work of Suzana Kotnjek and Mateja Sukič Kuzma.

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Table 2
Identified Advantages and Disadvantages of the Applications Based on the Used Activities

APPLICATION	ADVANTAGES	DISADVANTAGES
YouTube	- listening comprehension, - another expert's explanation, - authentic use of the English language, - is always available to students, - the possibility of repeatedly listening and stopping the recording,	- there is no authentic teacher-student contact, - complex understanding due to a foreign language, - the teacher does not get feedback on whether the student watched the video,
Edpuzzle	- listening comprehension and visual support, - solving tasks without skipping clips, - feedback for the teacher/student, - the possibility of creating tasks, - use of own or online recordings, - creating closed classes (data protection), - partially free use,	- applications that are too demanding for some students, - technical problems, - the possibility of doing the task only once,
Wordwall	- varied and diverse templates, - suitable for all levels of teaching, - feedback for the teacher/student, - the possibility of creating tasks, - free basic version,	- limited free basic version, - feedback not available by students, only by tasks,
WordItOut	- a variety of shapes, fonts, and colors, - the possibility of writing chemistry formulas, - the possibility of using Slavic letters, - free of charge,	- instructions and use of the application are not available in Slovenian,
Liveworksheets	- digitized worksheets, - a variety of tasks, - the possibility of inserting audio/video clips, - feedback for the teacher/student, - creating workbooks, - use of already created worksheets, - the possibility of creating tasks, - the possibility of solving tasks once or multiple times,	- more demanding task creation, - the teacher must anticipate all possible correct answers,
Blooket	- fun, social and educational, - a quiz in the form of a classic computer game, - contains elements of the unexpected, - free basic version,	- limited basic version, - problems importing a ready-made list of tasks,
Microsoft Edge	- opening pdf documents, - the possibility of creating audio recordings (text to speech) in different languages, - native-speaker-like pronunciation.	- the monotony of speech.

Note. Own work of Suzana Kotnjek, Mateja Sukič Kuzma.

The Development of Digital Competences (DigComp 2.1)

Table 3

The Development of Digital Competences according to DigComp 2.1 (Carretero, Vuorikari, and Punie, 2017)

COMPETENCE AREAS	COMPETENCES	ACTIVITIES
1. Information and data literacy	1.1 Browsing, searching, and filtering data, information, and digital content	- watching an educational video on YouTube, - solving tasks in Liveworksheets, Edpuzzle, and WordItOut applications, - searching for data to create an atom model using the Google browser, - preparing a PowerPoint presentation,
	1.2 Evaluating data, information and digital content	
2. Communication and collaboration	2.1 Interacting through digital technologies	- collaborative learning in small groups using the Zoom platform and the Wordwall application, - preparation and sharing of digital content in small groups in the Wordwall application, - communication using Snapchat and Messenger groups,
	2.2 Sharing through digital technologies	
	2.4 Collaborating through digital technologies	
3. Digital content creation	3.1 Developing digital content	- creating digital content in the Wordwall application, - creating a video explanation using various tools (Zoom, PowerPoint, electronic devices), - creating digital content in the online tool Edpuzzle,
	3.2 Integrating and re-elaborating digital content	
5. Problem solving	5.1 Solving technical problems	- choosing an appropriate tool for making videos and creating digital content, - choosing an appropriate online environment for sharing digital content.

Note. Own work of Suzana Kotnjek and Mateja Sukič Kuzma.

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Conclusions

Cross-curricular integration of chemistry and English took place during the lockdown, while biology and English integration took place in classrooms. All the activities presented in the paper can be combined, adjusted, and used in school, as homework, or in online classrooms. The main emphasis of the cross-curricular integration was on the use of ICT, the upgrading of chemical and biological objectives, the acquisition of professional terminology in English, and the application of acquired knowledge. Formative assessment and flipped learning are also vital parts of cross-curricular integration. Collaboration among colleagues, coordination of the work, and effective communication are essential parts of cross-curricular integration. The activities used in the cross-curricular integration should intertwine, coordinate, and be appropriate for students' abilities and prior knowledge. Above all, the teacher should be a guide and mentor.

The students' feedback was positive and encouraging. In their opinion, this way of learning is more interesting, they are active, and heterogeneous groups enable them to help each other. Students with learning difficulties also believed they could complete their tasks and performed very well in some activities.

The combined use of ICT and online applications, the use of classical teaching methods, distance work, online classrooms, and multilingualism represent an important step toward the school of the future.

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