Book of abstracts

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University of Ljubljana Faculty of Chemistry and Chemical Technology

EuChemS European Chemical Society

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EUROVARIETY 2021

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Foreword

On behalf of the European Chemical Society, Division of Chemical Education and Slovenian Chemical Society, it is my honour and absolute pleasure to welcome the attendees to the 9th European Variety in University Chemistry Education Conference.
The organizing committee, European Chemical Society, Division of Chemical Education and Slovenian Chemical Society has gone to great lengths to plan a memorable event and to ensure the presentations and content meet a high technical standard.
We hope to share information, ideas and insights and above all, to learn from each other how to teach chemistry effectively at the university level in the three afternoons during the plenary lectures, the oral and poster presentations and the workshops.
Taking into account the global COVID-19 pandemic, this is exclusively a virtual conference. We had been quite optimistic until a few months ago and hoped it could have been organised at least as a hybrid one. The COVID-19 situation in Slovenia has recently been improving but the decision made by the Division was that it is safer to organise the conference online only. Let us hope that in two years' time, we will be able to meet face-to-face at our next Eurovariety conference.
This conference includes a forum of researchers and university teachers in chemistry and chemical education. The programme and the book of abstracts are available online and we hope you will find the whole experience professionally challenging and informative. There are 13 topics of this conference and proposals submitted from all over the world covers them all.
The conference also includes the competition for the best poster, so do not miss it. The selection Board is going to assess the posters and the best one will be awarded a voucher for free books at the Royal Society of Chemistry books: Advances in Chemistry Education. I would also like to emphasize that each conference attendee will have a 35% discount fot the Royal Society of Chemistry books.
In the name of the Local Organising Committee, I would like to thank all those who made this meeting possible and in particular the speacers, the Scientific committee and president of the Division of Chemical Education at EuChemS Dr. Rachel Mamlok-Naaman for her support in making this event possible.

Welcome to EUROVARIETY2021.

Iztok Devetak
Chair of Organising Committee

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- Katarina Mlinarec, University of Ljubljana, Faculty of Education
- Nina Zupanc, University of Ljubljana, Faculty of Education

Conference topics

1. COVID-19 and teaching and learning chemistry at university level
2. Innovative approaches in chemistry teaching at university level
3. Application of ICT in tertiary chemistry education
4. Beyond traditional lab work at tertiary chemistry education
5. Mentoring chemistry students
6. Industry and other outside university partners in tertiary chemistry education
7. Green chemistry and sustainability
8. Ethical guidelines in tertiary chemistry education
9. Chemistry students learning outcomes and assessment of their competencies
10. Developing teaching competencies of university chemistry teachers
11. Context and inquiry-based chemistry teaching and learning of non-chemistry students
12. Developing competencies of primary and secondary school chemistry pre-service teachers
13. In-service chemistry teachers and professional development programmes at university level

July 7 2021				
13.00	**Conference opening**			
13.30-14.30	**Plenary 1: Ilka Parchmann** *Context-based learning at the university - an interface between chemistry, chemistry teacher and public education*			
14.30-16.10	**Time (Central European time zone)**	Parallel session 1 *(20 min, 15 min presentation and 5 min Q&A)* Chair: Martin Rusek	Parallel session 2 *(20 min, 15 min presentation, 5 min Q&A)* Chair: Gabriel Pinto	Parallel session 3 – Slovenian chemistry teachers *(15 min, 10 min presentation, 5 min Q&A)* Chair: Vesna Ferk Savec
	14.30-14.50	**Teaching and learning chemical kinetics as part of a physical chemistry course to chemistry majors** G. Tsaparlis, C. Stroumpouli	**Complementing laboratory work with virtual labs, home experiments and visualization** S. Herzog	14.30-14.45 **Sourdough bread as science investigation** R. Flander
	14.50-15.10	**Freshmen students' ability to perform basic chemistry calculations** M. Rusek, M. Frolíková, K. Vojíř	**Context and inquiry-based chemistry teaching and learning for engineering students** G. Pinto	14.45-15.00 **Encouraging creative approaches in teaching and learning chemistry in primary school** L. Javoršek
	15.10-15.30	**Using Static Colored Visual Representations of Chemical Bonding: An Analysis of Students' Responses Using the SOLO Taxonomy** E.T. Pappa, G. Pantazi, G. Tsaparlis, B. Byers	**A Whole Team Approach to Embedding a Culture of Feedback between Student & Staff Partners in First Year Chemistry** F. Heaney, D. Rooney, O. Fenelon, T. Kraemer, E. Dempsey, S. Barrett, C. Boylan, K. Doherty, L. Marchetti, J. Curran. T. Velasco-Torrijos	15.00-15.15 **Learning with the help of a fabricated model of the atom** T. Bervar
	15.30-15.50	**Identifying significant indicators that predict success in online general chemistry courses** Y. Feldman-Maggor, R. Blonder, I. Tuvi-Arad	**Two Successful Hooks for Learning Organic Chemistry at University Level** K. Mackey, G. P. McGlacken	15.15-15.30 **How fusion energy could save the world electrical energy need-motivation and authentic task for students on a secondary level chemistry** R. Rudež
	15.50-16.10	**An indicator of inquiry skills of the pre-service science teachers in inquiry-based analytical chemistry courses: a case study of achievement goal orientation** B. Feyzioğlu	**Problems and Problem Solving in Chemistry Education** G. Tsaparlis	15.30-15.45 **Research on the usage of face masks considering the sustainable (environmental) aspect** V. Švab

				15.45-16.00 **Experimental investigation of the coloration of substances** P. Flajnik
				16.00-16.15 **Groundwater protection** M. Hrovatin, K.Koprivec
16.10-16.25	Coffee break			
16.25-17.25	**Publishing Workshops**	**Acquaintance with Chemistry Teacher International (CTI)** J. Apotheker, R. Mamlok-Naaman	**A Manuscript's Journey: writing, submission and publication in CERP!** G. Lawrie	
17.30-19.30	**EuChemS Div ChemEd Annual General Meeting**			

July 8 2021			
13.00-14.00	**Plenary 2: Charlie Cox** *Acid-Base Chemistry: Longitudinal Study Across the Chemistry Curriculum*		
14.00-16.00	**Time (Central European time zone)**	Parallel session 4 *(20 min, 15 min presentation, 5 min Q&A)* Chair: Seamus Delaney	Parallel session 5 *(20 min, 15 min presentation, 5 min Q&A)* Chair: Natasa Brouwer
	14.00-14.20	**Sustainable Development Goals – Teachers' transition from Learners to Developers** S. Rap, R. Blonder	**STEM Future Faculty Perceptions and Decisions about Selected Instructional Innovations – The Role of Perceived Characteristics** A. Kraft, M. Stains
	14.20-14.40	**Green analysis of phosphate in diverse matrixes using a smartphone-based detector** R. S. Hernández, A. Pastor, A. Morales-Rubio, M. L. Cervera	**Exploration of the Relationship between Departmental Climate around Teaching and Adoption of Learner-centered Instructional Practice** Lu Shi, M. Stains
	14.40-15.00	**Situating sustainable development within chemistry education through systems thinking oriented outreach activities in primary and secondary schools** S. Delaney, M. Schultz	**Exploring the relationships between pedagogical content knowledge about resonance and student learning outcomes among Organic Chemistry teachers in the United States** M. Stains, D. Xue, J. Mitchell-Jones, E. Atieh
	15.00-15.20	**On-line vs. traditional pre-service teachers' achievements in chemistry lab work** L. Vinko, I. Devetak	**Roadmap for continuous professional development of STEM lecturers** N. Brouwer, S. Grecea, J. Kärkkäinen, I. Maciejowska, M. Niemalä
	15.20-15.40	**How to write a lab report: A hands-on approach to improve chemistry undergraduate writing skills** N. García Doménech, A. Sanz Arjona, J. O'Donoghue, P. N. Scully	**Women in Science** R. Mamlok-Naaman

	15.40-16.00	Project-Based Learning in Times of COVID-19 – Both a Challenge and an Opportunity V. Ferk Savec, K. Mlinarec	
16.00-16.15	Coffee break		
16.15-16.30	**A Word from the Sponsors**		

16.30-17.30	**Workshop sessions** (55 min +5 min Q&A)	Workshop 1: **Teaching Efficient Experimentation in Chemistry** V. Kraft	Workshop 2: **New chemical compound 3D modelling tool for students and chemistry teachers** D. Dolničar, B. Boh Podgornik	Workshop 3: **Impressive Science Teaching Experiments (ISTE) presenting "Tsipouro", the Traditional Greek Spirit, in the University Laboratory** D. Korakas	Workshop 4: **Creative Connections': helping students link ideas between topics both in-class and online** M. Coffey, J. Leinster	Workshop 5: **Online support of organic chemistry classes with Zosimos** E. Biró, Z. Szabó
17.30-19.15	**Poster session**	*5 min for poster presentation and 2 min for Q&A* Chairs and poster evaluators: Rachel Mamlok-Naaman, Karolina Broman, Stefanie Herzog **1.** K.U. Antela, M.L. Cervera, R.S. Hernández, I. Adam-Cervera, A. Pastor, A. Morales-Rubio: **Laboratorio RPG Docente: A game-based learning** **2.** S. Kieferle, I. Devetak, S. Hayes, J. Essex, M. Stojanovska, S. Markic: **Diversity in Science towards Science Inclusion - A topic for pre-service chemistry teacher education** **3.** I. Koter: **Stimulating university chemistry students' interest in nuclear and radiochemistry by problem-based laboratory** **4.** K. Vo, E. Yuriev, M. Sarkar, P. White: **Student engagement with problem-solving scaffolds in chemistry: teaching associates' perspectives and practices** **5.** M. Slapničar, I. Devetak: **Strategies for solving the chemical problem of redox reaction of sodium chloride synthesis from elements: An eye-tracking analysis** **6.** C.Piperidi, A. Kontogianni, K. Akrida-Demertzi, G.Tsaparlis **Are Industrial Foods Always Good for a Healthy Diet?** **7.** J. Küsel, S. Markic: **Using Participatory Action Research in Higher Education for Developing Interactive Learning Media**				

8. M. Slapničar, M. Vošnjak: **Mentoring gifted high school graduates, future students in the natural sciences: An example of good practice**

9. M. Vošnjak, M. Slapničar: **The role of outside university institutions in the teaching of chemistry content in the different years of study of natural sciences**

10. K.U. Antela, M.L. Cervera, A. Morales-Rubio, M.J. Luque: **Green Extraction Method for Azo Dyes Determination by Using Sheep Wool**

11. C. Piperidi, K. Akrida-Demertzi, P. G. Demertzis, G. Tsaparlis: **Chemistry Students' Knowledge and Awareness About Basic Food Constituents, their Features and Role**

12. N. L. Burrows, J. Neugebauer, S. R. Mooring, A. Nehring: **Students` Profiles in the Chemistry Laboratory Environments: Moving from a Phenomenographic to a Quantitive Assessment**

13. T. Ilioska, J. Hočevar, M. Rihtaršič, A. Mavsar, J. Zabel, Ž. Mole, E. Kerpan, J. Koler, J. Pust, M. Starešinič, J. Iskra: **3D Printed Models for Chemical Education**

14. J. O'Donoghue, N. Garcia Domenech: **Creating Shared Experiences for Outreach in a Virtual World**

15. C. Mönch, S. Markic: **Exploring Future Chemistry Teachers' Pedagogical Scientific Language Knowledge**

July 9 2021

13.00-14.00	**Plenary 3: David Read** *Chemistry Education in 2020/21: Mitigation, Evolution or Revolution?*		
14.00-16.00	**Time (Central European time zone)**	Parallel session 6 *(20 min, 15 min presentation and 5 min A&Q)* Chair: Luca Szalay	Parallel session 7 *(20 min, 15 min presentation and 5 min A&Q)* Chair: Dragica D. Trivic
	14.00-14.20	**Effective ways of teaching experimental design skills** L. Szalay, R. Borbás, Z. Tóth[3]	**Flipped organic chemistry – in the light of Corona** K. Broman, D. Johnels
	14.20-14.40	**Development of pre-service chemistry teachers' ability to notice even under lockdown** L. Honskusová, M. Rusek	**Lessons from COVID-19 Times – Should Prospective Teachers Develop Their Own Online Classrooms Already During Their Tertiary Education?** K. Mlinarec, V. Ferk Savec
	14.40-15.00	**Peer Assessment Using the Example of a Student Recording an Experiment** N. Golob	**Pre-service chemistry teachers' perception of the educational processes during the COVID-19 pandemic** D. D. Trivic, V. D. Milanovic
	15.00-15.20	**Investigation of Pre-service Chemistry Teachers' Pedagogical Content Knowledge Regarding Acids-Bases** İ. Şahin	**Teaching and learning chemistry during the quarantine – the case of the laboratory working** B. Dojer

	15.20-15.40	**Bringing Chemical Biology to First-Year Organic Chemistry: Adapting Workshops to Remote and Online Contexts** J. L. Kiappes	**Development of TPACK and self-efficacy for online Instruction by advanced degrees lecturers during the COVID-19 breakout** R. Blonder, S. Rap, Y. Fledman-Maggor
	15.40-16.00	**Combining Virtual Reality and Zoom to visualize chemical structures in 3D and develop the spatial ability of university chemistry students** K. Broman, E. Chorell, M. Holmboe	**Inquiry-based Learning in Education of Prospective Chemistry Teachers** Š. Hrast, K. Mlinarec, V. Ferk Savec
16.00	**Closing ceremony**		

Plenary lectures

ILKA PARCHMANN
Leibniz Institute for Science and Mathematics Education, Kiel University, Germany

Prof. Dr. Ilka Parchmann is Professor for Chemistry Education at Kiel University and Head of the Department of Chemistry Education at the Leibniz Institute for Science and Mathematics Education, IPN, in Kiel. She is currently the speaker of the IPN research line for enrichment learning and science communication. From 2014 to 2020, she was elected as Vice President for teacher education, science outreach and higher education at Kiel University.

Prof. Parchmann has a teaching degree as a secondary school teacher for chemistry and biology, and a PhD and further qualification in chemistry education. Her fields of research and development build on this expertise and combine design-based research approaches with investigations of interactions and effects in science outreach and learning environments. Exemplary programs forming interfaces between science and science education are Chemie im Kontext for school learning, the Kieler Forschungswerkstatt as a laboratory for students and (future) teachers and the Kiel Science Outreach Campus as a framework and network for co-design approaches.

Prof. Parchmann has also been and still is involved in several network activities both locally and internationally. Until 2014, she was Chair of the Division of Chemical Education of the European Association of Chemical and Molecular Sciences and Chair of the German Association for Chemistry and Physics Education GDCP.

Context-based learning at the university - an interface between chemistry, chemistry teacher and public education

Ilka Parchman
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Context-based teaching and learning has a long tradition in the educational discourse (Sevian, Dori & Parchmann, 2018). In practice, especially on university level, it seems still much more common to use contexts rather as applications to refer to than as a content to explore and to teach fundamental chemical principles. The main goals and achievements of real context-based learning address motivation and interest, these would be most relevant for non-majors in university courses. In addition, however, context-based education offers other opportunities as well: a context can point out different fields of activities and applications of chemistry e.g. for different career pathways (like professional chemists in research or industry, chemistry teachers, chemists in legal professions). They can also offer differentiation according to levels of competence by enhancing the degree of explanation or the grade of open inquiry. Last but not least they connect the chemistry of a learning situation to the chemistry needed in a societal debate and political decision making. Thereby, context-based learning can form interfaces between the learning of chemistry, the teaching of chemistry and an education in chemistry for future experts and citizens.

The so called third mission at the university (see e.g. https://www.sciencedirect.com/science/article/pii/S0040162520311100) points out the importance to enhance communication and collaboration among experts (from different fields), stakeholders in industry and politics and citizens. Science communication, internal and external, has lately been highly visible again in this time of a pandemic. It is as important in on-going challenges to be solved by sciences in societies approaching the UN Sustainability Goals. Chemistry has to play an important roles in many fields, climate change, mobility, nutrition or water supply are examples. In the global science education community many examples have been worked out to show how such contexts can be used to teach, learn and apply the variety of basic concepts in chemistry as well as measures of inquiry (e.g. http://www.kcvs.ca/). How can these approaches be used as good practice examples for a movement towards more interfaces between chemistry learning for future experts, teachers and citizens?

The talk will explore and discuss examples from different levels of university teaching and outreach activities, starting with university-school programs, moving towards team teaching and co-design courses for science and science teacher students and finally showing how career opportunities are offered connecting science reseach to science outreach in research education programs. Further discussion during the conference would be most welcome!

References

Sevian, H., Dori, Y. J., & Parchmann, I. (2018). How does STEM context-based learning work: What we know and what we still do not know. *International Journal of Science Education*, *40*(10), 1095-1107. https://doi.org/10.1080/09500693.2018.1470346

CHARLIE COX
Duke University, Department of Chemistry, USA

Dr. Charlie Cox was born in North Carolina and attended North Carolina State University where he worked with Maria Oliver-Hoyo doing research on incorporating SCALE-Up activities into the general chemistry classroom. Afterward, Charlie attended Clemson University for his Ph.D. and worked with Melanie Cooper analyzing problem solving pathways in general and organic chemistry. Following graduate school, Charlie was a lecturer at the University of New Hampshire and Stanford University where he taught across all divisions of chemistry and developed new laboratory and lecture pedagogy. Charlie moved to Duke University in August of 2020 where he is the Director of Undergraduate Studies and an Associate Professor of the Practice of Chemistry. Charlie's research group is currently analyzing students' longitudinal progression across the chemistry curriculum with a specific emphasis upon acid-base chemistry, kinetics and thermodynamics, and study strategies and motivation.

Acid-Base Chemistry: Longitudinal Study Across the Chemistry Curriculum

Charlie Cox
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Acid-base chemistry is a central concept in the chemistry curriculum. In introductory chemistry, students develop models for describing the structures of Arrhenius and Bronsted-Lowry acids and bases. Additionally, quantitative calculations are emphasized involving pH, titrations, and buffers. In organic chemistry, acid-base models are evolved and refined to include a discussion of Lewis acid-base theory and qualitative models for predicting acidity and basicity based upon structure. These concepts are used to build connections with nucleophiles, electrophiles, and leaving groups to explain organic reactivity. In analytical, physical, biological, and inorganic chemistry, acid-base models are revisited and further refined to explain concepts including separations, ionic strength, protein structure, and transition metal complexes. The goal of our research is to outline a longitudinal approach in which we analyze students' conceptual understanding and progression across the curriculum. The key outcome is the identification of misconceptions and the development of instructional interventions. The data presented in the talk will analyze how students' understanding of acid-base concepts impact their abilities to analyze and make predictions regarding organic structure and reactivity. A mixed methods research approach was utilized that includes survey instruments and interviews. The surveys were implemented in both semesters of organic chemistry in a year-long sequence. The surveys utilized a paired-item approach in which students were asked to answer multiple-choice items and provide justification for their selections. Additionally, students were asked to include a confidence rating with regard to the certainty of their answers. Interviews were conducted with a small cohort of students to correlate and expand upon survey responses and conclusions. The talk will expand upon the goals of the project, outline the research methods, discuss the survey and interview data, and propose potential interventions in both introductory and organic chemistry to address misconceptions identified.

DAVID READ
University of Southampton, UK

Dr. David Read is Professorial Fellow in Chemical Education at the University of Southampton. David was previously a schoolteacher at a secondary school and has led on the development of innovative teaching methods and the use of learning technology in chemistry and more widely at Southampton. David is currently admissions tutor for the Science Foundation Year and Director of Outreach in Chemistry, and works closely with those involved in public engagement in the department. David is partly seconded to the Centre for Higher Education Practice (CHEP) at Southampton, where he is Education Collaborative Lead (Partnership with Faculties), supporting the development and delivery of training activities for academics and organising the University’s Festival of Learning and Teaching. David works closely with teachers in the local area on the development of teaching resources and research projects, and was awarded a National Teaching Fellowship in 2017.

Mitigation, Evolution or Revolution?

David Read
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Chemistry teaching at university level has been continually evolving in recent years, with technology providing creative educators with ever more elaborate tools to support the delivery of content and students' engagement with it, as well as the assessment of the extent to which they have met the intended learning outcomes. The COVID-19 pandemic has led to a significant acceleration of these existing trends, driving change that might otherwise have been inconceivable.

What will be the long-term impacts of the year we have just been through? Will we simply return to the old normal when circumstances permit, or will the novel online approaches we've implemented take root and become part of a new normal that differs greatly from what existed previously?

This interactive presentation will explore the implementation of a number of innovative approaches on an introductory chemistry course at the University of Southampton (UK) during the period of the pandemic, and the evaluation of their impact from the student perspective. The goal is to share ideas for future best practice, backed by evidence of effectiveness. The presentation will draw on the experiences of the audience via interactive participation tools and will be framed by other published work in the field.

References

Read, D., Watts, J. K. & Wilson, T. J. (2016). Partial flipping to support learning in lectures. In J. L. Muzyka and C. S. Luker (Eds.) *The Flipped Classroom Volume 2: Results from Practice* (pp. 55-79), American Chemical Society.

Read, D., Barnes, S. M., Hyde, J., & White, J. S. (2019). Nurturing reflection in science foundation year undergraduate students. In M. K. Seery and C McDonnell (Eds.) *Teaching Chemistry in Higher Education* (pp.7 -21), Creathach Press, Dublin.

Talanquer, V., Bucat, R., Tasker, R. & Mahaffy, P. G. (2020). Lessons from a pandemic: Educating for Complexity, Change, Uncertainty, Vulnerability, and Resilience. *Journal of Chemical Education, 97*(9), 2696-2700.

Oral presentations

Parallel session 1

Teaching and learning chemical kinetics as part of a physical chemistry course to chemistry majors

Georgios Tsaparlis* & Charalampia Stroumpouli
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The present study focused on the teaching a university course of chemical kinetics in a department of chemistry as part of the physical chemistry course. The course followed closely Peter Atkin's approach from a Greek translation distributed freely to the students (Atkins, 1989). The aim of the study was to analyse, evaluate and interpret students' answers to the final examination in chemical kinetics. The results of the study of students' errors and conceptual difficulties are reported, which resulted from the recording, statistical analysis and evaluation of the students' responses in eight (8) consecutive final examinations. Three performance groups were identified, each including the listed topics:
Group A, high performance: (a) characterization of the steps in a chair-reaction mechanism, (b) integrated first- and second-order rate laws; and (c) the Lindemann-Hinshelwood mechanism. The average performance of these three groups was ≈85%.
Group B, intermediate performance. (a) half-life time of a reaction, (b) instantaneous rate of formation and the extent-of-reaction variable, (c) the Michaelis-Menten mechanism, and (d) theoretical rate law not asking for a final formula. The average performance of these four groups was ≈ 74%.
Group C, low performance: (a) determining the experimental reaction rate law and calculating the reaction rate constant on the basis of an experimental-data table, (b) extracting the theoretical rate law, and (e) the Arrhenius equation. The average performance of these three groups was ≈54%.
Students' errors and misconceptions have also been identified. It is concluded that the teaching of chemical kinetics must place great emphasis on problem solving and the systematic training of students with a variety of problems. It is very important, that the students themselves try to solve the problems. On the other hand, it is very important to help students with guidance and suggestions from the teachers, as well as to encourage collaborative learning in groups of fellow students.

Reference

Atkins P. W. (1989). *Physical Chemistry*, 3rd Edition, Oxford University Press. Translated into Greek: Part III (Vol. III) *Change*, P. Papagiannakopoulos and M. Kosmas, translators. Foundation for Research and Technology – Hellas (FORTH), Crete University Press, Heraclion, Crete, 2005.

Freshmen students' ability to perform basic chemistry calculations

Martin Rusek*, Markéta Frolíková & Karel Vojíř
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The ability to solve chemical calculation problems is a key prerequisite for a number of chemical disciplines as well as laboratory activities within chemistry teacher education (Srougi & Miller, 2018). However, previous results (Rusek et al., 2021) showed students have not mastered these at upper-secondary schools was proved not to be accurate. Specific problematic areas were therefore searched for. For this reason, this research aimed at students' ability to solve specific types of chemical calculations and the influence of the assignment type on their performance. In order to find out what areas need to be addressed in the corresponding university course, a sample of freshmen pre-service chemistry teachers (N = 22) took two tests at the very beginning of the winter semester 2020 and at its end. The research tool (*test*) included: dilution problems, mass fraction, molar concentration, calculations from chemical equations and calculation of pH. Two tasks for each calculation type were included in the test: word-problem and a form of values and quantities. The test was assessed by an expert panel (N = 8). Also, 12 students chosen based on their performance were also *interviewed* after passing the course.

The results showed, the students' initial skills were rather poor. Only the mass fraction and molar concentration tasks were solved by the majority of the students. Only up to one third solved the pH or chemical equation calculation tasks. Considering the level of the tasks, this pointed to their unsatisfactory upper-secondary school preparation. The mistakes stemmed mostly from the students' use of a memorized formulae they only tried to substitute numbers in. Second the most common reason for their failure were numerical errors, in case of logarithm students' inability to convert pH to *c*. Only in case of the calculations from chemical equations, a significant difference with a small effect-size between the word-problem and values-formulated task was found ($p = .02$, $r = .297$). As far as the post-test - pre-test difference was concerned, students did significantly better on the post-test showing they learned something in the course. Statistically significant difference with a large, resp. medium effect-size was found for all types of calculations except from the already well-solved mass fraction tasks ($p < .001$, $r = .728$ for pH, $p < .001$, $r = .728$ for dilution problems; $p = .006$, $r = 498$ for molar concentration and $p = .006$, $r = .495$ for chemistry equations calculations).

In the interviews, the students mentioned learning to "use the formulae" rather than think about the problems. They also expressed their satisfaction with the course on the basis of the teachers' attitude as well as clarifications which help them understand the principles. The results revealed upper-secondary school chemistry education could be improved in the way chemistry calculations are being taught. Also, the university course's focus on particular calculation types can be changed as students master some of them already and more time needs to be dedicated to more problematic ones.

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Using Static Colored Visual Representations of Chemical Bonding: An Analysis of Students' Responses Using the SOLO Taxonomy

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Chemical bonding is a core concept in chemistry, which remains complex to teach and difficult to learn (Tsaparlis, Pappa, & Byers, 2018, 2020), and static visual representations (VRs) of chemical structures have proved invaluable in aiding students' understanding of this topic. The efficacy and problems associated with the use of static colored VRs of chemical structures and chemical bonding resulting from accurate quantum mechanical calculations (see Figure 1) are the subject of the present study, which involved a sample of 1st year, 2nd semester chemistry students at the University of Ioannina, studying the elective course "Science Education" (N = 31).
Although the situation with respect to polar and nonpolar covalent bonding appeared satisfactory, difficulties were encountered with concepts related to ionic bonding. Persistence of a covalent-ionic bond dichotomy was apparent in the thinking of many students, showing the difficulty of accepting the continuum of bonding type. Most students did not employ multistructural thinking (in the sense of the SOLO taxonomy – Biggs and Collins, 1982), when providing explanations about variations of bond polarity, rather they restricted themselves to consideration of only a single factor, aspect or feature.
On a positive note, many students expressed positive views about the information provided by the colored quantum mechanical VRs and their features. Finally, our students' lack of previous experience with these VRs makes us believe that a more systematic and extensive coverage would be likely to lead to improved outcomes.

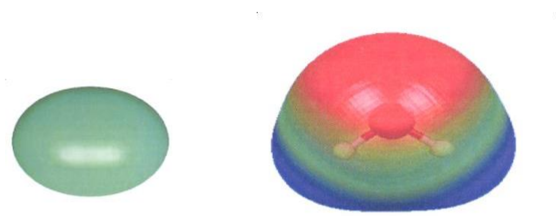

Figure 1. Electrostatic potential maps for the hydrogen molecule (H_2) (*left*) and the water molecule (H_2O) (*right*), resulting from quantum mechanical calculations of high accuracy (Jensen, 2010). The color figures are used with permission from the author.

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Identifying significant indicators that predict success in online general chemistry courses

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This study examines undergraduate online chemistry courses and aims to identify factors that predict students' success. In recent years, online learning has become extremely popular. Yet despite the impressive proliferation of online courses, their completion rate is considered low, compared with traditional face-to-face learning. Existing studies identified several factors affecting success in online courses (Davise et al, 2018). Here we focus on the role of one of these central factors: self-regulated learning (SRL). SRL is indicative of success in a variety of academic settings, particularly in the context of online learning environments. The reason for this is that online learning enables and facilitates students' autonomy and creativity by empowering them to control when, what, and how to study. Therefore, students' lack of SRL skills may prevent them from accomplishing their expected learning goals. Our research focused on six aspects of SRL (Barnard et al., 2009): goal setting, environment structuring, task strategies, time management, help-seeking, and self-evaluation. For the analysis, we collected data from three online general chemistry courses offered at the Open University of Israel from 2016 to 2019, totaling 804 undergraduate students. We implemented a mixed method approach that combines semi-structured interviews and educational data mining techniques (Feldman-Maggor et al, 2021). A logistic regression was applied by using different SRL characteristics, educational backgrounds, and demographic status variables to create a model that predicts success in these courses. We found that completing the course successfully was strongly associated with specific learning behaviors. Additionally, we found that from the fifth week onwards, we could predict with high probability the likelihood that a specific student will succeed in a particular course. We discuss recommendations for institutions and lecturers regarding the benefits of implementing these models in order to identify SRL behavior in online courses and to design future pedagogical interventions that could decrease the dropout rate. Our findings emphasize the importance of time management and how learning choices that students make during the course affect their potential for success in university studies. This research paves the way for further development of online teaching strategies and specific course designs that will encourage students to take control of their learning and increase persistence rates.

Acknowledgments
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An indicator of inquiry skills of the pre-service science teachers in inquiry-based analytical chemistry courses: a case study of achievement goal orientation

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Inquiry skills are expected to develop in learners due to the nature of the inquiry-based learning environment. However, not every learner performs the same in terms of inquiry skills in this environment. While questioning the reason for this situation, it should be taken into account that the development of inquiry skills consists of a very complex process involving many cognitive and motivational factors. Achievement goal orientation is a motivational model widely used in many education studies (Jagacinski & Duda, 2001; Linnenbrink &Pintrich, 2000). On the other hand, it has been limited in studies related to chemistry and even inquiry skills. In this study, the reason for the different performance of pre-service science teachers' inquiry skills was examined within the framework of achievement goal orientation. In this study, it is thought that achievement goal orientations play a role as an indicator in the fact that pre-services science teachers interact with the inquiry-based learning environment at different levels and consequently show different performance outcomes. In this research, the inquiry skills as a learning outcome of pre-service science teachers with different goal orientations in inquiry-based analytical chemistry courses were examined in a case study. In this study, three pre-service science teachers with different goal orientations (mastery/MO, performance-approach/PO, avoidance of performance-approach/AP) identified using the purposive criterion sampling method were studied. The pre-service science teachers' inquiry skills and goal orientation were monitored for a period of 14 weeks with reflective diaries, experiment reports, and interviews. And the inquiry skills performances according to experiment reports in the phase of lesson preparation, exploration, and sharing of courses were reported for each week.

While there was a significant change in the performance of PO in inquiry skills score in the 4th, 7th and 10th activities, this change in MO was observed in the 2nd, 3rd, 4th, 7th activities and, 8th weeks. AP's score has changed significantly since the 8th week, but the score could not reach the level of MO and PO at the end of the activities. In this study, it was determined that goal orientation was determinant in pre-services science teachers' understanding of the characteristics of the inquiry learning environment and the level of interaction with this environment. While PO and AP adapted the learning environment according to them, It has been determined that MO followed and tried to understand the characteristics of the learning environment in the first week. MO focused on his own cognitive level and learning for the inquiry process, whereas PO focused on being the best in the classroom and getting the best marks. AP, on the other hand, focused on keeping its mistakes and deficiencies not visible. The differences in their cognitive focus caused the inquiry-based learning environment to perform differently in terms of inquiry skills in preparation, exploration and sharing stages.

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Oral presentations

Parallel session 2

Complementing laboratory work with virtual labs, home experiments and visualizations

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In their first semester studying chemistry, students usually have to pass a module with a laboratory focus. At the university of Kiel, this module is designed for chemistry majors as well as pre-service chemistry teachers and students with a bio-chemistry or even chemical business focus. Except for the first group, the other students often wonder why they have to delve into the laboratory work right in the beginning and might not all see the relevance for their future careers (cf. Andersen, 2020). In order to enhance this relevance while at the same time trying to reduce the relatively large dropout rate in this subject (42% according to Heublein et al., 2017), regular lab sessions were accompanied by virtual laboratory experiments, so-called home experiments as well as two visualizations. The home experiments were relatively easy-to-do experiments that students could do without laboratory equipment while employing an inquiry-based approach, most of which used everyday materials and phenomena. The visualizations asked to visually explain the same phenomenon for two addressees differing in their chemical knowledge, i.e. one for 10-year old children and the other for laboratory instructors. While originally the home experiments and visualization were only intended for the pre-service teacher group, due to fewer laboratory sessions because of the Corona regulations, it was decided that all students were to do all parts.
Students were given instructions on how to complete each task and what to hand in for each format: for the home experiments photo protocols were expected and for the visualizations students could use animated slides, stop-motion videos or any other medium they chose. In order to evaluate this trial, the coursework material was assessed. At the same time, students were asked to judge their skills as well as their level of anxiety and their perceived usefulness of the different parts with scales adapted from Pyatt and Sims (2012) in a pre-post-questionnaire. Pre-service teachers were also given items to assess their perceived relevance and their self-efficacy beliefs for using experiments in their future classroom (adapted from Rabe et al., 2012).
As the semester just ended, the questionnaires have not been evaluated yet but results will be discussed in the presentation. The visualizations show that students in all groups can gauge what kind of differentiation is necessary to explain a chemical phenomenon to people with no and those with an advanced level of chemistry knowledge. A preliminary analysis shows that it is not the pre-service teacher group that overall best solved this task, as one might have expected. Examples of the visualizations and home experiments will also be presented along with a discussion of the intention of showing all students the relevance of explaining everyday phenomena to different audiences.

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Context and inquiry-based chemistry teaching and learning for engineering students

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Often students are insufficiently interested by chemistry, because they perceive science education as "irrelevant" both for themselves and for the society (Dillon, 2009). This work is part of a research program intended to help teachers include connections between students' daily experiences and chemical topics. The idea is that by bringing tangible examples we provide opportunities for students to apply science to familiar contexts in hopes that they will appreciate chemistry more and will be motivated to study concepts in greater detail. I summarize here the results about contextualized open-ended problems and cases carried out with first-year engineering students in the last few years, applicable to other educative levels. The goals were to use modern educative tools (such as inquiry-based learning); to facilitate the learning of concepts (stoichiometry, combustion, fuels composition, conversion factors...); to detect alternative conceptions and misconceptions in students; to collaborate on the developing of competencies (problem solving, data analysis, teamwork…); to improve teachers and students' motivation; and to promote science literacy, social responsibility and the understanding of Science-Technology-Society (S-T-S) relationships.

The contribution of CO_2 emissions to climate change is frequently mentioned in media. Through different questions and problems, students discuss quantitative aspects related to the emissions, such as its relationship with vehicles fuel consumption (Oliver-Hoyo & Pinto, 2008), and its decrease by using domestic condensing boilers (Pinto, 2013) or solar power (Pinto, 2009).

As an example of simple but useful experimental experience, students do research at home about the variation of the rate of melting ice cubes in different aqueous solutions. This case serves to discuss physicochemical concepts (Pinto & Lahuerta, 2015). It is useful for motivating and also as a starting point to observe how properties of simple substances (water and sodium chloride) influence complex phenomena, such as thermohaline convection currents in oceans, caused by density gradients, as well as involved current topics, such as the circulation of microplastics at the bottom of the seas.

Other case is the critical analysis of pseudoscientific deceptive information about products (a common salt contained in a glass ampoule or a "special" bottle made with a glass "containing silica") that, according to the suppliers, "change" the bond angle and other properties of water, with "healing effects".

Students' responses are not always positive: some complain that "these topics are not part of the course syllabus" and prefer more conventional problems. But most part of them express keen interest in this type of "tangible" chemistry where concrete examples of everyday life put textbook chemistry in context. Further, such kind of cases promote training in critical thinking and in "consumer chemistry", and enable students to realize the relevance of chemistry outside the classroom, which is especially relevant for engineering students.

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A Whole Team Approach to Embedding a Culture of Feedback between Student & Staff Partners in First Year Chemistry

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Feedback can be a very powerful tool for improving the student learning experience and for informing teaching practice (Al-Bashir, 2016). However, to maximize the impact on teaching, learning and course development such feedback must be gathered, analysed and the conclusions shared in a timely manner. *Ad hoc* approaches can lead to missed opportunities to effectively address challenges.

In this presentation we will discuss an innovative approach to developing a feedback culture with first year university chemistry students. Our approach, framed around laboratory practical and workshop activities, involved embedding a weekly feedback meeting into the course structure. It aimed to (i) educate students on the purpose and value of feedback (ii) identify the most effective feedback channels for experimental subjects and (iii) create a feedback culture with students as partners in the teaching and learning process. Weekly one hour sessions were scheduled for small groups (12 x ~25 students). Feedback facilitators (drawn from the department postgraduate cohort) liaised with teaching academics, technical and demonstrating staff to design a unique programme for each weekly class. Engagement software platforms included Padlet and anonymous in-class surveys/questionnaires. Each week facilitators completed templated documents summarising feedback on instructor and student led topics. Staff reviewed and reflected on same and took relevant action where appropriate and feasible. MS Teams was used to host the weekly meetings and as a repository for the shared documents (Figure 1).

The innovation in our programme was to combine pre-lab/workshop content with post-lab academic feedback and in so doing to create, in each week of the semester, a structured, yet informal opportunity for students and facilitators to discuss and identify teaching and learning topics for development. This framework has allowed for timely identification of challenges faced by the students and has been especially valuable considering the particular difficulties faced in transitioning to university against the back drop of restrictions imposed by the COVID-19 pandemic.

Our results highlight the affordances of feedback in shaping and improving the teaching and learning experience and the value of integrating robust feedback mechanisms directly into course structure.

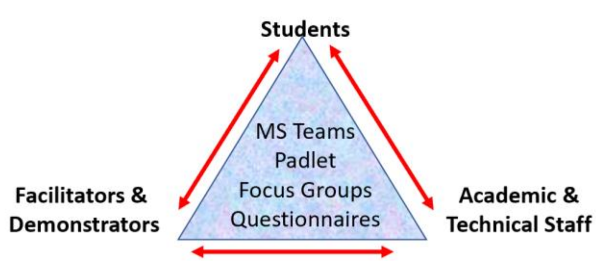

Figure 1: Graphical representation of project communication and flow of decision making mechanisms.

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Two Successful Hooks for Learning Organic Chemistry at University Level

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Organic synthesis is a critically important facet of the chemical sciences. Organic chemistry graduates and postgraduates are highly sought after, especially those possessing ability or training in organic synthesis. The teaching of organic synthesis at third level has well-documented challenges (O'Dwyer, 2017),1 especially more recently when carried out remotely (Gomes, 2020).2 At University College Cork, we have adopted a number of strategies to engage students at the mid-Degree stage. These include research-led teaching (McGlacken, 2020)3 and the application of a number of 'Hooks' (Major, 2018)4 to grab students' attention early in a 3rd year lecture course (McGlacken, unpublished).

In the first approach (research-led teaching) we adopt a cutting edge synthetic strategy, termed C-H Activation or C-H Functionalisation. Despite the 1000's of research publications on C-H Functionalisation, as far as we are aware, there was no example in the undergraduate literature. Our research was carried out over a 2-year period at University College Cork, Ireland (by volunteers) and at the Technical University of Vienna (TU Wien), Austria, as part of a Master's Degree programme. New experimental conditions were devised to allow the chemistry to be carried out safely and efficiently over a 2-day period. Furthermore, a new greener perspective was taken in our approach. Student feedback was very positive and a number of the participants are now undertaking PhD studies in Organic Synthesis.

> **Student Feedback:**
> **"…surprisingly motivational!.........I have been questioning my course choice but this lecture `made me realise I'm in the course I want! First time in a while I have been glued to the projector screen. Thank you"**

In the second approach (enhancing engagement), in order to inspire students to engage and thus learn, we devised a short history of organic synthesis and delivered it to a Year 3 cohort. Crucially, we focused on the 'Faces (people) of Organic Synthesis'. This introduction involved a story-telling approach, focusing on the characters of the discipline, from the 1950's through the 'glory days' of the 1970's and 80's and right up to today. The feedback was 100% positive and glowing responses were noted. Students noticed, in particular, the change in the nature of the main Actors from mostly older men in the mid to late 20th century, to a more gender and age balanced set in the last few decades.

Overall, both approaches proved surprisingly inspirational for students, and were a most timely intervention in their Degree program. We believe both approaches could be applied across all disciples of the sciences and beyond.

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Problems and Problem Solving in Chemistry Education

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Problem solving is a ubiquitous skill in the practice of chemistry, contributing to synthesis, spectroscopy, theory, analysis, and the characterization of compounds and remains a major goal in chemistry education. It is also central to the teaching and learning of chemistry at secondary, tertiary and post-tertiary levels of education. A fundamental distinction should be drawn, on the one hand, between real problems and algorithmic exercises and the differences in approach to problem solving exhibited between experts and novices on the other. As an important higher-order thinking skill, problem solving also constitutes a major research field in science education. Recent developments in education research occur in the area of quantitative/ computational problems, but also in qualitative problem solving.

This proposal aims to present the aim and the contents of an edited book (Tsaparlis, 2021) on problem solving in chemistry education. The following situations are considered, some general, others with a focus on specific areas of chemistry: quantitative problems, qualitative reasoning, metacognition and resource activation, deconstructing the problem-solving process, an overview of the working memory hypothesis, reasoning with the electron-pushing formalism, scaffolding synthesis skills, spectroscopy for structural characterization in organic chemistry, enzyme kinetics, problem solving in the academic chemistry laboratory, chemistry problem-solving in context, team-based/active learning, technology for molecular representations, IR spectra simulation, and computational quantum chemistry tools. The book concludes with methodological and epistemological issues in problem solving research and other perspectives in problem solving in chemistry. A foreword by George M. Bodner is included. Figure 1 shows the front cover of the book. Number of chapters: 18. Number of pages: 468.

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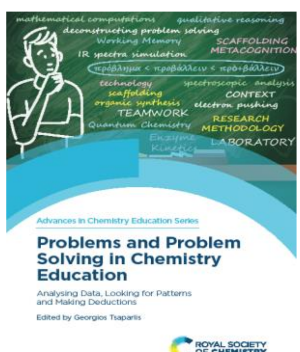

Figure 1. The front cover of the book.

Oral presentations

Parallel session 3 - Slovenian chemistry teachers

Sourdough bread as science investigation

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Part of the compulsory program in primary school is to promote the cross-curricular links among different subjects, days of science in particular make this possible.
We organize these days despite the distance learning due to the COVID-19 epidemic. As a learning support we use Moodle activities (lesson, database, forum), videoconference Zoom, applications Padlet and Animoto.
We organize these days like science experiments for 9th graders. They do some research on the first day and present the results on the second day. Because some experiments with living beings last for a long time, we have at least a one week long break. In the meantime children are encouraged to work on their project, they search for better solutions, do some extra measurement, etc. Pupils are also stimulated to upgrade their knowledge, be innovative, to come up with individual contributions in the presentations and actively participate in the forum at the end of the second day.
We offer different workshops to the children (alcoholic fermentation, use of organisms to produce yoghurt or sourdough bread, principle of stability in aircraft, movement on the slope) but we follow the same objectives like being able to plan a simple scientific investigation (form the question, hypothesis, variables, etc.), being able to use tools and technology for experimenting, collecting and presenting data with critical evaluation, being able to share and present new information. They choose the workshops according to their interest.
At sourdough workshop pupils discussed how to make a bread with water and flour without buying a yeast in the shop. According to the statements pupils form their own questions, hypotheses, variables and make a plan. Teacher also prepare sourdough starter and present his work as a timeline to make it easier for the children.
During making sourdough pupils also acquire other skills through the following activities:
- Bake a sourdough bread and pancakes.
- Taking pictures about their work to gather the right material for the final report.

On the second day they write a report using the scientific ideas, think how to improve the experiment and how to apply it in every-day life. The results are presented in the Moodle activity “database”, as a videos or powerpoint presentations.
Most of the pupils did their investigations well and use powerpoint for a report. The worst activity was forum. When we returned back to school, we discussed about the results in the classroom.

Encouraging creative approaches in teaching and learning chemistry in primary school

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Developing creativity is one of the general goals of the chemistry curriculum in primary school (Bačnik et al., 2011). Creativity is also one of the key transversal skills that, with the support of formative assessment, enables the student to create their own learning path and participate in the teaching process. Due to the abstractness of certain chemical concepts, the use of different visualization aids, including different models, is crucial for the development of spatial representations and understanding of the structure and properties of matter.

In teaching chemistry in the eighth grade of primary school, during the time of distance education, we included the creation of models in the learning of ionic and covalent bonds. Pupils researched the types of bonds and made a model showing the formation and type of chemical bonds in a compound. The models were presented in a videoconferencing lesson.

We have developed performance criteria - what is characteristic of a good model of chemical bond formation. Performance criteria included the design plan of the model, key features of the model, professional correctness, and characteristics of a good presentation of the model. Students documented their model of bond formation with photographs from different angles. In the process of making the model and preparing the presentation of the model, they had the opportunity to improve their product based on the feedback from the teacher and classmates.

Each student had a different ionically composed or molecularly composed substance. They used their own notes, textbook, or online information to find information about the substance and the type of bonding. Before making the model, the students had to acquire a certain knowledge about the structure of atoms, ions and understand the concept of bond formation. Feedback, guidance, clarification or additional explanation was provided in writing or by videoconference. The research encouraged self-initiated research on substances and the use of ICT to produce animations of ionic or covalent bond formation.

The task encouraged students to explore, collaborate, find different sources and creative ideas. In the process of making and presenting models, we combined creativity with other transversal skills, with communication, collaboration, effective thinking and problem solving. Students developed self-regulation skills and the use of various digital skills (Bejat Krajc et al., 2018).

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Learning with the help of a fabricated model of the atom

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The acquisition of abstract concepts presents a great difficulty to students. For this reason, I decided to teach the learning content of Atom Structure in a different way. The students made their own models of the atom, in which they deepened the acquired knowledge about the structure of the atom. Before making the atom model, the students were taught the purposes of making the model. The main goal of making one's own model is a better visual representation of the structure of the atom and the ways of binding it into molecules. Atom models were made by students at school and at home during the epidemic. The acquired knowledge about the structure of the atom was presented using their model and the periodic table. After six months, I checked the success of the acquired knowledge by using their own models with a non-standardized written test of knowledge. Through research, I found that students' knowledge declined slightly compared with the grades they aquired by examination of assessments, but it is still relatively high regarding the time elapsed since the assessment of substance structure knowledge. Given that the models of atoms were made by students independently during their work at home in the time of pandemic, I can conclude that the independent production of the model of the atom positively contributed to the level of acquired knowledge about the structure of the atom. With the results of the research, I can confirm that teaching and mastering abstract concepts by making one's own atom model is very effective.

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How fusion energy could save the world electrical energy need - motivation and authentic task for students on a secondary level Chemistry

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There is a lot of debate and predictions over which way should Slovenia take towards removable and clean electrical energy. For the year 2030 there is goal to reduce green house emission for 36 % and to increase energy from renewable sources to minimum 27 %. In the presentation I will briefly review electrical energy production in Slovenia over last 10 years and predictions for the year 2030. (Ministrstvo za infrastrukturo, 2021; Energija v Sloveniji in svetu: statistika, 2021)

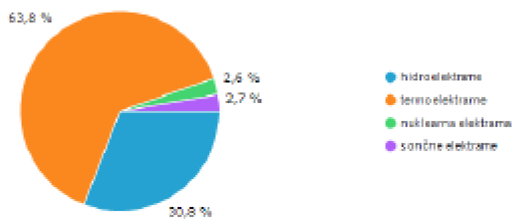

Figure 1: Electric energy produced in Slovenia by different sources (Energija v Sloveniji in svetu: statistika, 2021)

To achieve self-efficient, green and reliable (not whether dependent) energy, major promising research field is fusion energy. The project ITER is one of the biggest and most ambitious projects in the world in regard to the nuclear fusion. In the project is involved 34 nations of the world and is located in southern France. Slovenia is also part of the project with participant form IJS, Faculty of Mechanical Engineering and Cosylab. The main goal of the ITER project is to produce a ten-fold return on energy from chemical reaction between deuterium and tritium isotope. In the second part of the presentation I will discuss what is fusion and what will ITER do. (ITER, 2021; Ribe, 1975).

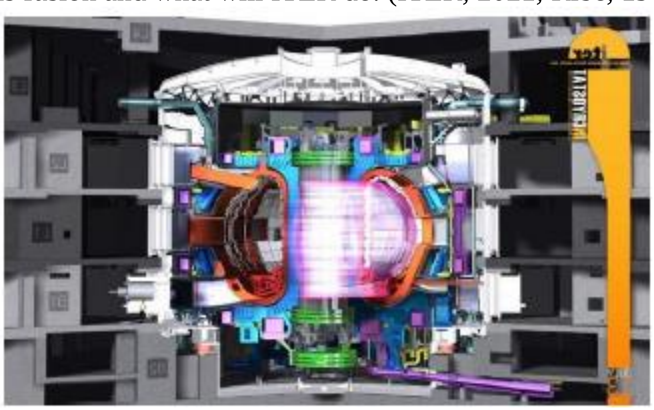

Figure 2: Iter fusion reactior sheme (ITER, 2021)

The third part of the presentation will be focused on a chemistry process behind the fusion energy. I will discuss chemistry behind production of tritium and deuterium as a main fuel for fusion reactor and fusion reaction between tritium and deuterium taking place in fusion plasma reactor. I will present some simple equation and authentic task, that can be used to understand and to motivate secondary level students. There are advantages and also limitations will be discussed that do not allow jet to operate. All the equations and procedures will be viewed as part of the Slovenian Chemistry curriculum (Siegel, 2017; Britannica, 2021; Reis, 2020).

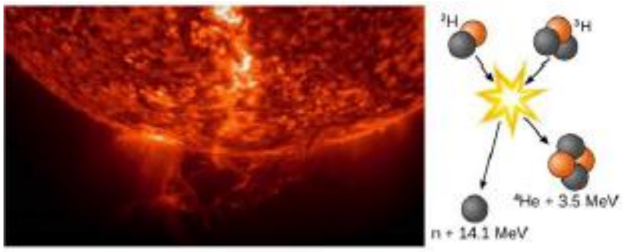

Figure 3: Chemical reaction in fusion reactor (Reis, 2020)

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Research on the usage of face masks considering the sustainable (environmental) aspect

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The analysis and comparison between the gross mass with the volume of single-use hygenic masks discarted confirmed the hypothesis that facial masks do in fact contribute to the growing volume of mixed municipal waste. That further causes environmental and financial problems. The aim of the research was to find possible solutions to sustainable management and the tracking circular approach to resource use when using and handling single-use hygienic masks. The research showed that different aspects (environmental, economic, social) have given depth to the outlook we have on circular approach of resource use. Single-use mask usage should be limited as everything points to complete opposite with the manufacture and the usage of them. If the only criteria nowadays is the price of the product, the research showed that the cost of these cheap products on the environment and the general community is immense. Lastly, local manufacturers of fabric face masks should be endorced. Those are based on circular resource use and affect the environment positively.

A new vision and paradigm of education emphasizes a well-rounded, interdisciplinary approach to knowledge acquisition and various skills needed for sustainable future, a change in values, life-style and over all behavior. Therefore, the matter which was to be the subject of this research paper was aimed primarily at the waste that resulted in various prevention measures taken against Corona virus. One of the aspects is the amount of mask disposal in the municipial waste and consequently on landfills. Working with the Center ponovne uporabe (CPU Reuse) and using survey as the chosen method of research, we were able to establish that people in general do not know of the environmental impact of single-use items. This confirmed the hypothesis set.

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Experimental investigation of the coloration of substances

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The grass is green, the strawberries are red, the solution of copper sulphate is blue. There is a lot of chemistry beyond these facts. The purpose of this paper is to present an example of practice of inquiry based learning (IBL) with experimental investigation of the coloration of compounds.

The presented example of the IBL was carried out with a group of 50 high school students taking Experimental sciences as their Interdisciplinary Theme Study (ITS). It was a semi-open research, where the field of research (coloration of substances) was selected in advance, and the students independently searched, selected and researched possible influencing factors and methods to investigate them. Students worked in small groups, and the research phases were carried out with the help, monitoring and guidance of a chemistry teacher and laboratory assistant.

The objectives of the activity were to deepen their understanding of the concepts of coloration, to introduce UV-visible spectroscopy and thin layer chromatography (TLC), and to gain an experience with experimental research in the field of chemistry and biochemistry.

The whole process consisted of three main phases. First, prior knowledge was identified, necessary additional theoretical information was provided and UV-visible spectroscopy and TLC introduced. In the action phase, small groups of students formulated specific research questions in the field of coloration of compounds, conducted theoretical and experimental research ans formulated the answer to the research question. In the third, evaluation phase, students in each team summarised their findings, evaluated the process and results and give short presentations to the rest of the group. The evaluation phase was finished with the reflection of the whole process.

Students have different attitudes towards IBL. Many are immediately excited, but some are afraid of a lesser-known and therefore less predictable way of learning at first. But at the end, everyone is happy and proud of their experiments, results and findings.

Evaluating one's own research and experimental work is one of the most demanding phases of learning through research. In my experience, when asked to "critically evaluate" students use most of their intellectual capacity to finding faults and shortcomings, and they need to be persistently encouraged to identify strengths.

In learning through research, students gain deep knowledge and understanding in the subject area. Skvarč (et al. 2018) emphasizes that students also develop lifelong competencies, thinking skills and form personality traits.

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Groundwater protection

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There is no surface water in the Karst. The watercourses have sunk into the hollow underground world, where they formed numerous caves by deepening and changing their directions.

Picture 1 Intermittent lake Cerknica

There is quite good legislation regulating water protection and environmental protection In Slovenia. In practice, the situation is a bit different - mainly due to the indifference of individuals who dump waste in the karst abysses. They are not aware that the waste decomposes there and seeps into the groundwater. It often contains various chemicals that are transferred to the underground world and further into the groundwater by the seeping rainwater. The Karst underground world is also heavily contaminated by spraying pesticides and fertilizing excessively. Contaminated water flowing from the surface threatens the quality of the karst water and can leave visible black spots on rocks and flowstone in the underground caves. (Željan, 2021).

Picture 2 From darkness to light

Picture 3 Waste in water

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Oral presentations

Parallel session 4

Sustainable Development Goals – Teachers' transition from Learners to Developers

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In 2015 all the United Nations member states adopted 17 Sustainable Development Goals (SDGs), with the aim of implementing them by 2030 (UN, 2015; UNESCO, 2017). These goals are designed to ensure a better life for future generations while eradicating poverty, protecting the planet, and ensuring that no one is left behind. The goals address a multitude of societal needs, including education, health, social security, and work opportunities, as well as global warming and environmental protection.

In recent years, there has been a call in the field of chemistry education to incorporate sustainability in general and the SDGs, in particular, as part of the chemistry curriculum. In this way, students can be educated as future scientists and responsible citizens in order to collaborate and work on different topics, as well as to better understand and solve major global challenges (Mahaffy et al., 2019). However, when teachers discuss environmental issues in class, many of them tend to repeat unsubstantiated scientific claims (Plutzer et al., 2016).

Hence, the "Speak to me in Numbers" program was developed. This program deals with the education of SDG-related scientific content through an evidence-based approach to data analysis. Each module focuses on a different SDG challenge that presents students with related authentic data (in different mathematical representations) along with a scientific background. Students analyze each issue using high-level mathematical skills and come up with data-based solutions. After drawing their conclusions, the students suggest ways that they can influence society, based on the same data, and act accordingly.

In this regard, in our presentation we will showcase a 28-hour course that was developed to train teachers to teach the SDG program and adopt the pedagogical approach whereby they based their teaching on data and open discussions. The course does not deal with the transfer of knowledge, rather, the teachers, as students, discuss the SDGs and their associated data; thus, through this process, they learn the relevant science. When the course was completed, the teachers developed a module based on the program's pedagogical approach and explored their teaching in class. Analysis of the questionnaires and interviews held with the teachers revealed that the course had affected the teachers' stances regarding SDGs, as well as on their behavior and awareness of the SDG dilemmas they had faced. Moreover, the teachers' argumentation of issues related to the SGDs increased and there was a higher linkage between the data and conclusions following the course. In addition, we found that teachers' perception of the importance of SDG content incorporated in the context of chemistry teaching increased. The results add to the literature on teachers' PD, showing that teachers' professional development increases when they engage in the development of classroom education content (Blonder et al., 2008; Loucks-Horsley et al., 2010).

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Green analysis of phosphate in diverse matrixes using a smartphone-based detector

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Phosphate analysis is a very common procedure in Analytical Chemistry, due to its wide appearance in all sorts of matrixes: environmental, industrial or clinical samples may contain phosphate. Hence, a green and affordable methodology to carry out these measurements is required. Here we propose a home-made analytical device which allows for phosphate analysis using molybdenum blue reaction and a smartphone detector. Using cheap 96-microwells lab plates, a desktop lamp and a smartphone camera, color analysis was carried out using Matlab® to obtain phosphate concentration in natural water, eye drops, solid detergents, and blood samples. Results were compared with UV-Vis spectroscopy (Radojević, 1999) and good statistical correlation between both detectors was found.

Experimental conditions were optimized, such as lighting sources, optical distance, well-volume, color spaces (RGB, CIE Lab, CIE XYZ…) and camera parameters (ISO, White Balance…) since those have been proven to be significant in image treatment (Capitán-Vallvey, 2015). Final procedure takes up 20 minutes, and up to 20 samples can be analyzed in only one photograph. An automatic Matlab® script which was developed in the lab supplies color parameters of all 20 wells, making the process simpler and more time efficient. Overall, 96 samples can be analyzed with only 6 image captures. Analytical parameters were obtained for the proposed method, being LOD 0.023 mg P L^{-1}, RSD < 2.1 % for all the studied samples, and a wide linear interval ranging from 0.2 to 4.0 mg P L^{-1} (UV-Vis method only covers from 0.2 to 1.0 mg P L^{-1}). Recovery studies were made, and results were quantitative between 90-110 %. These results compare with the ones found in the bibliography, but the proposed method is more time-saving.

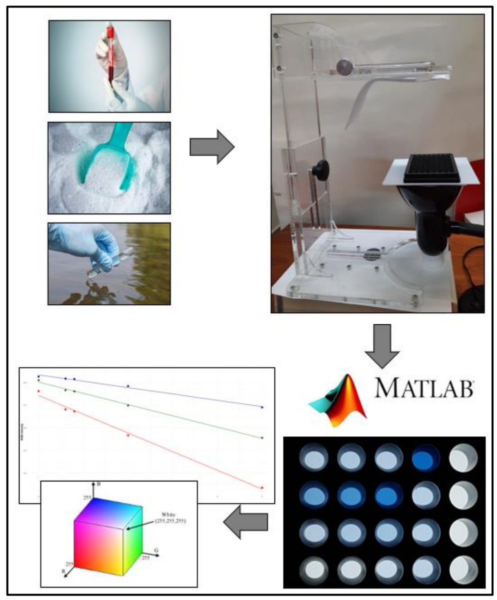

Figure 1: Graphical abstract of the proposed procedure.

Overall, this proposal can contribute to carry out phosphate analysis in different matrixes, either solid or liquid, both in screening and in quantification mode. The very low sample volume which is required (only 300 µL) reduces the reagent consumption and waste generation by 160 times when compared to the reference method, and the smartphone detection has been shown to mimic the UV-Vis reader with a much lower price and a negligible energy usage.

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Situating sustainable development within chemistry education through systems thinking oriented outreach activities in primary and secondary schools

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The incorporation of systems thinking into chemistry education (Mahaffy et al., 2019) has been recently promoted within the chemistry education community as an approach to teach holistically and to improve awareness of the relevance of chemistry to sustainable development challenges at secondary and tertiary levels. Our contribution to this ongoing international effort is the Elements of Sustainable Chemistry project, which has engaged with contemporary chemical scientists to implement and evaluate systems thinking-oriented hands-on outreach activities for schools. An important part of the project is the involvement of undergraduate and postgraduate university students as volunteers. To date, seventeen students have attended one or more school event, been part of laboratory preparations or have developed additional online resources for schoolteachers as part of an undergraduate community engagement unit.
This presentation reports on a set of hands-on outreach activities focussed on 'endangered elements', which are over-utilised in industry and in danger of disappearing within the 21st century. The activities give school students the opportunity to develop an appreciation of how a circular economy keeps products, components and materials at their highest utility and value. The activities were piloted at disadvantaged high schools in regional and remote areas. During these school visits, the university student volunteers mentored upper secondary chemistry students. Evaluation of these activities in seven schools with over 1000 students so far, includes student pre- and post-views of perspectives on sustainability, circular economy and 'endangered elements', post-surveys with university student volunteers who were directly involved in the school outreach events, as well as teacher perceptions of these resources and the applicability of the systems thinking approach to chemistry education.
Findings show increased student motivation and engagement with chemistry, and evidence that through this outreach, learners are repositioned to realise the relevance of sustainable development to chemistry teaching and learning. The university students reported developing their own leadership skills and chemistry understanding, and for some who planned on teaching careers, participation offered valuable opportunities to interact with students.

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On-line vs. traditional pre-service teachers' achievements in chemistry lab work

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The global COVID-19 pandemic is having a significant impact on peoples' everyday lives. A lot of adaptations had to be made in order to cope with the pandemic in different areas including teaching in schools and faculties (Ghazi-Saidi, Criffield, Kracl, McKelvey, Obasi, & Vu, 2020). While some activities in the faculties, for example lectures and seminars, can easily be transferred into on-line environment, lab work on the other hand requires a more specific approach. Moodle and Microsoft Teams can be used to apply chemistry lab activities (Fergus, Botha, & Scott, 2020; Meng, Song, Li, Tan, Yan, & Zhang, 2020).

The aim of this presentation is to illustrate how the on-line laboratory activities effected students' achievements on the final exam in comparison to the traditional face-to-face lab work and how the achievements at prelab quizzes implemented in Moodle and the number of experiments videos views also implemented in Moodle, influenced students' overall achievement at the end of the lab work.

31 non-chemistry pre-service lower secondary school biology and home economics teachers (students) participated in an obligatory chemistry course Chemistry 1 including lectures (30 hours) covering general chemistry concepts, seminars (15 hours) covering chemical calculation tasks introduced by the lectures and laboratory work (15 hours) covering practical activities of topics covered by lectures. Before participating in the laboratory work, students had to complete a pre-lab activity which comprised theory review, experiment videos (7 altogether) and a quiz (7 altogether), for each laboratory lesson. Laboratory activities were then led by the teaching assistant via MS Teams using the same videos of experiments than in the pre-lab activities which would be conducted face-to-face in normal circumstances. Students had to write down main observations and conclusions in their individual laboratory manual, which were later discussed and alongside that, a thorough explanation of the experiments and the theory behind them was provided by the teaching assistant. After finishing laboratory work students had to take the final exam on the first or second term.Results indicate that there are differences between on-line vs. traditional students' knowledge based on their results on two lab final examinations. Students to achieve at least 55% of all points to pass the exam. When comparing the overall results of both traditional (1st exam 44.8% - 31% of students passed the exam; 2nd exam 55.6% - 80% of students passed the exam) were more successful than on-line (1st exam 36.5% - only one of twelve students passed the exam; 2nd exam 58.5% - 56% of students passed the exam) students. Though on-line students had higher average achievements on the second exam than traditional students.Results of on-line lab course show that there are no significant differences, between students who had above average and below average achievements on the pre-lab quizzes in both of their exam results.

When comparing the average views of pre-lab experiments videos, students who passed the 1st exam watched the videos altogether 30 times and students who did not pass watched them 30.3 times on average. On the second exam there is a slightly bigger difference. Students who passed the second exam watched the videos 22.6 and students who did not pass watched them 17 times on average.

It can be concluded that on-line lab work may cause slightly lower students' achievements on the final exam in comparison to traditional face-to-face lab work. Also, the pre-lab activities did not have the desired effect on students' achievements.

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How to write a lab report: A hands-on approach to improve chemistry undergraduate writing skills

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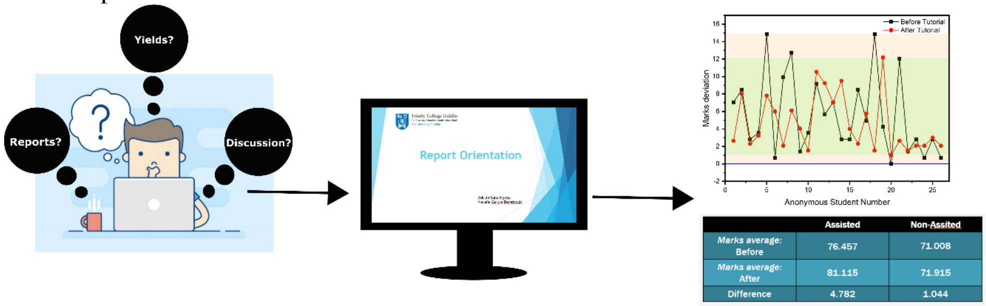
Writing a scientific lab report is an important skill that students develop during their undergraduate course. However, first year science students struggle significantly with this task. There usually isn't a clear guide to follow when writing a lab report for the first time and this skill is also not developed fully in high/secondary school. There are several examples where implementing a course or guide for students to improve their scientific writing skills has resulted in better lab reports[1–3]. However, to the best of our knowledge, this hasn't been implemented in most universities. Prior to this study, the School of Chemistry at Trinity College Dublin did not have any guide for undergrad students on how to write a lab report. Students were mainly learning on a trial and error basis, where they implemented the corrections from demonstrators into their lab reports after submission. However, the level of feedback and requirements varied significantly from one demonstrator to another, resulting in a lot of confusion for the students. Nonetheless, this study identified a few common mistakes that could be avoided by providing students with a guide and/or some tips on writing lab reports. This created a common ground to build on report writing skills later.

For this purpose, a tutorial on "How to write a scientific lab report" was prepared and delivered. The tutorial was developed to give tips and explain the structure of a lab report. The material was broad and not specific to chemistry, as we wanted to focus on the general aspects of a lab report such as presenting data in a clear way or discussing results as a whole as well as understanding possible shortcomings. Attendance at the in-personal tutorial was voluntarily and the performance of the students that attended the tutorial was compared to those who did not attend.



	Assisted	Non-Assited
Marks average: Before	76.457	71.008
Marks average: After	81.115	71.915
Difference	4.782	1.044

Figure 1. Figure showing how the tutorial evolved from students being confused about writing the report to the tutorial to the statistical outcome after the presentation.

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Project-Based Learning in Times of COVID-19 – Both a Challenge and an Opportunity

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Project-based learning has a long tradition in the education of prospective chemistry teachers. The implementation of project-based learning has changed due to the occurrence of the Covid-19 pandemic, which made it impossible to carry out the study process in the faculty. In this paper we describe how we adapted the course "Experimental and Project-Based Learning" to distance learning in the academic year 2020/21. The main adaptations relate to the use of ICT in the study process. In addition to the online classroom Moodle that we have used in previous years, we have also used the collaborative environment MS Teams to support the study process. In addition to conducting videoconference sessions with the entire student group, MS Teams also provides the opportunity to work in smaller project groups. The purpose of introducing channels in MS Teams for which of the project groups was also to enable collaborative document editing for the development of the project portfolio. The sample represents the whole generation of students, prospective primary school chemistry teachers enrolled in the 4th year of the study program at the University of Ljubljana, Faculty of Education (N = 12). During the study course students were involved in four examples of project-based learning. Two projects were smaller and two were larger, for which they also developed a project portfolio during the academic year. At the end of the academic year, all students wrote a reflection on their experience of the course. For this paper we analysed the project portfolios for two larger projects and the students' reflections using qualitative research methods. In their reflections, students indicated that before the implementation of the mentioned study subject, they had no experience with project-based learning, neither in the field of chemistry, nor otherwise. Among the reasons why we should use project-based learning in chemistry lessons, students pointed out that this approach involves students more actively in the learning process, stimulates their interest in learning chemistry, and promotes cooperation and communication among them. Students also pointed out that by managing portfolios in the process of project-based learning, they learned a new way of assessing students' knowledge. The research also indicates that students see the importance of monitoring learner progress and assessing it throughout the development of project-based learning as opposed to focusing only on the final product or presentation. Students rated the course adaptations to distance learning implementation as appropriate and indicated that the use of the MS Teams environment facilitated good and effective collaboration among project team members. In their role as future chemistry teachers, students also pointed out some concerns about the use of project-based learning in the chemistry classroom. These were mainly related to the fact that project-based learning requires more time and the students' own willingness to participate.

Oral presentations

Parallel session 5

STEM Future Faculty Perceptions and Decisions about Selected Instructional Innovations – The Role of Perceived Characteristics

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Science, technology, engineering, and mathematics (STEM) education research has supported a shift in teaching and learning that calls for the use of student-centered and evidence-based practices, yet lecture still dominates practice in the United States (Stains et al., 2018). Some studies have investigated instructors' views of barriers and drivers that may impact the implementation of these practices in their classrooms (Shadle et al., 2017; Sturtevant and Wheeler, 2019). Many factors may contribute to an instructor's thinking, but these evidence-based instructional practices (EBIPs) are not one size fits all; each has unique features that may lend itself better to use in one environment or for some particular topic over another. As such, looking holistically at barriers and drivers of the various EBIPs may not be as beneficial as investigating instructors' views on a practice individually. Indeed, some studies have noted that instructors' personal experiences or feelings can impact their planning and decisions for their instructional practices (Andrews and Lemons, 2015; Erdmann et al., 2020). In this study, we sought to understand how future STEM faculty members (STEM upper level undergraduate and graduate students enrolled at a research-intensive institution who are interested in pursuing a career in academia) perceive a selected set of EBIPs and what factors about these practices play a role in their decisions to incorporate them in their teaching. Two theoretical frameworks guided this study. The first is the Diffusion of Innovations (Rogers, 2003), in particular the persuasion stage of this model in which perceived characteristics of an innovation inform the decision to adopt/reject the EBIPs. The second model that helped guide this study is The Teacher-Centered Systematic Reform Model (Gess-Newsome et al., 2003) which highlights that several factors inform an instructor's practice. An instrumental, multiple case study method was imployed with six future faculty as they were introduced to and had experiences with the selected EBIPs during a course in which they were enrolled in the Spring of 2021. The results of this study will provide a nuanced description of the factors that impact the decision-making process faculty members engage in when considering the adoption of reformed practices. These findings will be beneficial for instructional reform programmers/developers whose aim is to disseminate instructional reform in STEM courses at the postsecondary level.

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Exploration of the Relationship between Departmental Climate around Teaching and Adoption of Learner-centered Instructional Practice

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Instructional change in STEM courses at the postsecondary level has been advocated for decades with a particular focus on adoption of learner-centered instructional practices. One of the barriers for instructional change identified by faculty and often raised in the literature is the departmental climate around teaching (Shadle et al., 2017; Sturtevant & Wheeler, 2019). However, the relationship between the departmental climate around teaching and instructors' adoption of learner-centered instructional practices has not been fully explored.

We addressed this gap by leveraging research on institutional/organizational climate literature (Bouckenooghe et al., 2009; Landrum et al., 2017) , both within and outside education, to develop a survey that helps 1) characterizing the different types of psychological collective climate around teaching that faculty in STEM departments at postsecondary institutions perceive, 2) testing whether departmental collective climate can be measured within these departments, and 3) exploring the relationships between adoption of learner-centered instructional practices and psychological collective climate/departmental collective climate around teaching(Chan, 1998).

The survey was collected from 166 instructors from 22 departments at 21 institutions across the U.S. Analysis of the survey data led to 1) the identification of four types of psychological collective climate around teaching by using mixture model clustering(Fraley & Raftery, 1998), 2) only one construct could be used to compare departmental collective climate across the three departments with the highest response rates by considering inter-rater agreement(O'Neill, 2017) and intra-class coefficients(Klein & Kozlowski, 2000), and 3) neither psychological collective climate nor departmental collective climate predicted STEM faculty's instructional practices.

Our results suggest that the link between climate around teaching within a department and faculty members' use of learner-centered instructional practices is more unclear than previously thought, and departmental collective climate around teaching may be difficult to measure because most elements that define a climate (e.g., policies, practices, expectations) are lacking when it comes to teaching. Absence of these elements may contribute to the highly autonomous and independent approach to teaching that is seen in higher education and thus the lack of instructional innovation at scale.

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Exploring the relationships between pedagogical content knowledge about resonance and student learning outcomes among Organic Chemistry teachers in the United States

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In this era of instructional transformation of STEM courses at the postsecondary level, the focus has been on educating science faculty about so-called evidence-based instructional practices, i.e. practices that have been empirically proven to enhance student learning outcomes. However, a lot less attention has been given to university chemistry teachers' thinking about their teaching especially at the topic level (Teo, Goh, and Yeo, 2014). This knowledge is critical in order to provide more effective pedagogical, subject-specific training that meet the teachers' needs. In order to address this gap in the literature, we implemented a mixed-method study that explored variations in the pedagogical approaches to teaching resonance among organic chemistry teachers and the relationship between these approaches and students' conceptual understanding of this concept. Specifically, we employed a semi-structured interview protocol to characterize the enacted and personal pedagogical content knowledges (Carlson and Daehler, 2019) of organic chemistry teachers for the topic of resonance. We also assessed students enrolled in the courses of these interviewees on their conceptual understanding of resonance, especially as it pertains to the hybrid structure. We found large variations in the enacted and personal pedagogical content knowledges among this group of teachers despite the commonalities of their learning goals for the students. Student data also points to a relationship between the enacted pedagogical content knowledge and the quality of students' conceptual understanding. The results point to a lack of collective pedagogical content knowledge among these group of organic chemistry teachers. Resources and pedagogical training should be developed to support this essential component of pedagogical content knowledge in order to provide more uniform learning outcomes for students.

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Roadmap for continuous professional development of STEM lecturers

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Despite the ongoing systemic integration under the Bologna agreement, higher education systems in Europe are still different across various countries and have different areas of emphasis when considering professional development of lecturers. At many European universities the professional development is mostly elaborated from the pedagogy point of view. The lecturers are left alone to apply by themselves the obtained pedagogical knowledge to their own teaching practice while the teaching context has an important role in how we teach and what we teach.

In the Erasmus+ project STEM-CPD@EUni five European Universities and European Chemistry Thematic Network (ECTN) work together to empower continuous professional development (CPD) in a local university STEM teaching practice by introducing a new actor, the CPD-Ambassador (Brouwer, 2020). The project aims at the integration of technological, pedagogical, and content knowledge (TPACK) (Mishra, 2006) in a local teaching practice to improve the quality of STEM teaching and to enhance students' learning experiences. We have defined three dimensions which characterize the practice of the CPD- Ambassadors in their local context:

- Dimension 1: STEM-teaching competences
- Dimension 2: CPD attitudes
- Dimension 3: CPD activities

To define the needs and expectations of the lecturers and the educational management staff about CPD within these three dimensions, we have conducted a survey. 420 Lecturers from 80 universities from 26 countries, and 46 educational managers from 31 universities from 11 countries in Europe have generously responded on this survey from December 2020 to end of January 2021.

The participants evaluated each of the 66 statements in the survey from two different perspectives: (a) general importance for teaching and learning quality in university STEM and (b) use / practicing of it in the personal teaching practice (lecturers) or in the programme teaching practice (education managers). Based on the results of this survey we have created a roadmap about STEM-CPD including the recommendations and guidelines for the CPD-Ambassadors.

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Women in science

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According to the UNESCO Institute for Statistics (UNESCO, 2016), fewer than 30% of the world's researchers are women. A three-year global project (2017-2019): "*A Global Approach to the Gender Gap in Mathematical, Computing, and Natural Sciences, How to measure it? How to reduce it?"* was funded by the International Science Council; it involved eleven scientific partner organizations (Roy & Santamaría, 2020). The main goal of the project was to investigate the gender gap in STEM disciplines from different angles, globally and across disciplines. The project consisted of (i) a global survey of scientists with more than 32,000 responses; (ii) an investigation on how gender affected the millions of scientific gaps in the Mathematical, Computing, and Natural Sciences at various levels.

Chiu and Ceca (2020) analyzed the results of a global survey disseminated to 32,000 scientists, of which 50% were male and 50% female. They showed how it contributed to understanding the gender gap, and to identifying the various factors that cause it. The results confirm that the gender gap in science is very real: it exists across all regions, disciplines, and development levels. Women's experiences in both educational and employment settings are consistently less positive than men's. Recommendations for improving the situation were based on the survey's findings. The recommendations address a variety of groups: (1) instructors and parents of girls in primary, secondary, and higher education, e.g., to avoid books and social media that reinforce the gender gap in science; (2) educational organizations, e.g., to avoid books and social media that reinforce the gender gap in science; (3) scientific unions and other worldwide organizations, e.g., to encourage the presence of women in editorial boards of journals in your discipline and publish reports on the proportion of papers published by women.

Despite marked advances towards gender equality and the empowerment of women, especially during the last century, progress has been slow and disparities persist around the world. Unfortunately, science is not immune to such inequalities, with women representing only a third of researchers globally; they often face gender-based discrimination and a lack of equal opportunities. In order to change this dreadful situation, it is necessary to act at both the educational and the economic levels (Bystydzienski & Bird, 2006).

The presentation will deal with the situation of women scientists in Israel, with examples of chemistry women in academia.

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Oral presentations

Parallel session 6

Effective ways of teaching experimental design skills

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Our research group has been working for six years on finding efficient ways to teach experimental design skills. 'Step-by-step' instructions have been modified to practical activities which require one or more steps to be designed by the students (Szalay and Tóth, 2016; Szalay *et al.*, 2020). Many pre-service chemistry teacher students have been involved in the work by trying the student sheets at the time of their own lab practices, and occasionally by instructing primary or secondary school students who had been invited to participate on an 'open lab practice' at our university. Five pre-service chemistry teacher students have successfully been graduated, whose theses works were written about their own contribution to this research. Some of the graduated students who already teach chemistry in secondary schools have become permanent member of our research group. 41 in-service chemistry teachers have been involved in the work by piloting our student sheets with their classes. Professional development courses have also been organized for in-service chemistry teachers to disseminate the method and the results.
The current longitudinal study, investigating the approach's effectiveness (a) for younger students and (b) over a period of time is still going on, because of the hindreance caused by the Covid-19 pandemic. The research model modified at the beginning of the second year of the present project has been used since September 2017 with over 800 students. According to plans, they spend six lessons in each schoolyear carrying out practical activities using worksheets we provide. The participating classes were allocated to one of three groups. Group 1 is the control group. Students simply follow the step-by-step instructions. Groups 2 and 3 are experimental groups. Group 2 students follow the same instructions, but their worksheets explain the design of the step-by-step experiments carried out. Group 3 students follow the same instructions, but one or more steps are incomplete and students are required to design these steps. Group 3 students are given prompts and clues before they start planning and carrying out the experiments. The impact of the intervention on the students' experimental design skills and disciplinary content knowledge is measured by structured tests. The latest statistical analysis of the results shows that both types of instruction (used in case of Group 2 and Group 3) had a significant positive effect on the results of the students disciplinary content knowledge and experimental design skills in the second school year of the project. However, the development seemed to stop in the third year of the project, when a student's achievement was influenced mostly by their school ranking. It is also assumed that ability scores are probably confounded by motivational levels.

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Development of pre-service chemistry teachers' ability to notice even under lockdown

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Teacher's ability to reflect on lessons is considered one of the main competences which has the potential to improve education. Teachers who are able to provide a constructive feedback to their colleagues' as well as their own lessons keep improving the system. These teachers' competences are usually summarized under the term *professional vision* (Sherin, 2007) and contain two components: selective attention, and knowledge-based reasoning. The presented study is a part of a design-based research which has been aiming at an Observation Practice Course's (OPC) evidence-based improvement. In this contribution, the last year of the courses online version is described. The aim was to evaluate this online course's effect on the student's professional vision and compare it with years when the students went to schools to observe the lessons. The study used a pre-test post-test design. Pre-service chemistry teachers ($N = 11$) watched a video-segment of a chemistry lesson and reflected on it in a written form. The reflections were later divided into information units (IUs) and analysed using the original tool by Sherin and Van Es (2009) completed with Shulman's (1986) PCK and the annotation-analysis-alteration method (Slavík et al., 2014). Students' statements in the IUs were categorized into following dimensions: actor, pedagogical-content and parsing strategy. The difference between numbers of IUs between pre- and post-reflections was tested using Wilcoxon Single Rank Test with the *r* for the effect size. The results showed the students became more proficient in writing reflections – the overall number of IUs almost doubled. Their selective attention increased significantly in their attention to teacher ($p = .003$, $r = .632$) as well as teacher in interaction with students ($p = .007$, $r = .570$). In their reflections, the students annotated ($p = .004$, $r = .607$) and also analysed ($p = .049$, $r = .42$) the lesson significantly more after the OPC. Their attention was also significantly more focused on pedagogical dimension ($p = .004$, $r = .632$) together with pedagogical-content dimension ($p = .005$, $r = .598$). Especial the shifts in student-teacher interaction and pedagogical-content dimension suggest the students' improvement in observing lesson activities rather than following the content-driven lesson structure. The only dimension of suggested lesson alterations remained unchanged showing potential limitations of the OPC. Also, more attention needs to be given to the students' content recognition as it seems they remain oblivious in this respect. Therefore, it seems that, in spite of running online, the course had a positive effect on the students and can be considered a good start before them doing their first in-school practice.

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Peer Assessment Using the Example of a Student Recording an Experiment

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Through the prepared activity for students, we followed "student-centred learning and teaching that primarily concerns the capability of students to participate in, influence and take responsibility for their learning pathways and environments, in order to have a transformative learning experience and thus achieve the expected learning outcomes" (Klemenčič at all, 2020).
One of the major highlights of the course from selected chemistry chapters for future elementary teachers is the understanding and meaningful preparation and implementation of fair experiments for students. As part of the lab exercises, students must conduct a few experiments to answer a simple research question: What affects sparkling water? In conducting the exercise for each generation of students, we find that they have difficulty in determining constants and dependent and independent variables and thus in designing a fair experiment in a meaningful way. In teacher-centred learning, summative assessment, which measures student performance at the end of the course, is the most important form of assessment and it is difficult to change student outcomes at the end of the course. When implementing the course in 2020, when most lab exercises were distance learning due to the epidemic, we chose student-centred learning and teaching and offered students photo materials and a brief verbal explanation for the exercise. Students independently prepared various water samples with different hardness levels and several different liquid detergents for foams and home appliances. The conduct of the experiment was documented with videos or some photographic material and submitted for peer evaluation in the Moodle online classroom.The Moodle Workshop is a powerful peer assessment activity. Students add submissions which are then distributed among their peers to be assessed based on a rating scale previously communicated with the students. When considering a larger group of students, we use the "workshop" activity, in which we assign an agreed number of students assignments to a randomly selected student for assessment based on known criteria. The assessment is anonymous to the student, but not to the teacher, and provides the opportunity for a brief verbal justification of the assessment and a suggestion for improvement by the student. In our experience, the use of the "workshop" is successful, allows for final improvements, saves time when presenting experiments to the group, or even replaces group discussion during a live lab exercise. Indeed, the above is usefully bridged into the non-contact hours of student work with ICT.In the context of teacher self-evaluation, we find greater contribution of the teacher in the initial stage in preparing the necessary steps and monitoring the Moodle workshop in the online classroom. We find better knowledge in the final evaluation of conducting a fair experiment and thus determining dependent and independent variables and constants in the generation of students that learn this part of the subject with a student-centred approach. We also find that in this way, future teachers will be better prepared for the challenges of learning and teaching fair experiments, as well as for conducting distance education under less than ideal conditions in terms of laboratory resources.

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Investigation of Pre-service Chemistry Teachers' Pedagogical Content Knowledge Regarding Acids-Bases

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Teachers have a vital role in students' education. Therefore, it is important that teachers should have necessary qualifications, knowledge and skills in different domains (Goodnough & Hung, 2009; Van Driel et al., 2002). One of these domains is the pedagogical content knowledge (PCK). Shulman (1987) introduced pedagogical content knowledge (PCK) as ''…that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding'' (p.8). PCK is one of the knowledge that teachers should have in order to teach effectively (Magnusson, Krajcik& Borko, 1999). So, in teacher education programs, pre-service teachers should have sufficient experience that helps to enhance their PCK. The aim of the study is to search development of pre-service chemistry teachers' pedagogical content knowledge regarding acids-bases topic. In the present study, I aimed to enhance pre-service chemistry teachers' PCK with respect to a specific topic in the school experience course enriched with actual teaching experience, CoRe application, observation form developed by considering PCK components and microteaching lesson study. Also, I purpose to understand the influence of components of school experience course in teacher education program such as CoRe, actual teaching practice, observation form, microteaching lesson study on this development of preservice chemistry teachers' PCK. Data is collected by semi-structured interviews, content representation forms (CoRe), classroom observations and field notes, then data is gathered from 2 female students at last year from METU. In that sense, the study is applied at the school experience course in chemistry teacher education program. At the beginning, I introduced the PCK and the CoRe to make pre-service teachers familiar with the constructs. After explanation of CoRe and PCK, pre-service teachers were asked to form groups involving two pre-service chemistry teachers in a group and they were asked to prepare a CoRe on acids-bases topic in groups. These groups are involved in the microteaching lesson study. After preparation of the first CoRe in groups, one person in a group of two teach acids-bases. After the instruction, the other people in the group make reflections on their instruction by the help of the tutor and their classmates as well. After the reflections, all the two pre-service teachers come together and prepare a second CoRe and another person in the group reteach the topic. All the instruction is video-taped and observation notes have been taken during instruction. All the reflection sessions made after instruction is audio-taped. Semi-structured interviews are applied on individually after the preparation of the CoRes and data is analyzed qualitatively.

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Bringing Chemical Biology to First-Year Organic Chemistry: Adapting Workshops to Remote and Online Contexts

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From the perspectives of students, introductory courses, focusing on core concepts and problem-solving approaches, can feel disconnected from the global challenges and fundamental questions that inspired them to pursue science generally, and chemistry more specifically. Particularly for those students majoring in the biological sciences, organic chemistry can seem tangentially related to their subject. This talk will present an example of practice that addresses how organic chemistry enables the unraveling of biochemical puzzles. A series of workshops were developed to accompany a first-year organic course that serve a dual purpose of emphasizing the utility that first-year concepts have for contemporary and cutting-edge research, while consolidating material at key points throughout the academic year. Each workshop includes exercises similar to "typical" introductory course questions, but also ones that challenge students, while working together in small groups, to answer the same questions approached by researchers. By centering each workshop on a biochemical research endeavor, the students readily recognize the relevance of organic chemistry to their course. Initially developed as classroom sessions, these workshops have been adapted to a remote format over the past year. This talk will discuss the adaptations and online tools used to preserve the key aspects of the original workshop design: (1) synchronous student collaboration; (2) research-centered questions; (3) student-led discussion and peer-to-peer teaching (with the instructor in a facilitator role). Zoom breakout rooms allow the students to discuss questions in small groups, while Miro (an online whiteboard) allows the students to collaborate by typing and drawing, both electronically or by uploading images of work on paper. As well as producing an artefact that students can continue to develop asynchronously after the workshop, the online whiteboard allows the instructor to observe student progress unobtrusively. The format works effectively either for groups completely online, for those in the same location but socially distanced, or a combination of the two. More generally these workshops present an avenue to integrate aspects of topics that are typically considered advanced such as chemical biology, materials, and others into introductory courses in a scaffolded and accessible way.

Combining Virtual Reality and Zoom to visualise chemical structures in 3D and develop the spatial ability of university chemistry students

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To be able to visualise chemistry in three dimensions is an important competence to master, and through this, chemists can predict how and why chemical compounds react. Chemistry experts are used to apply this spatial ability, i.e., visualisation through the move between 2D and 3D, without realising it, whereas novices as students often find spatial ability challenging (Harle & Towns, 2011). Spatial ability is a competence that is possible to develop thorough practice (Kozma & Russel, 2005), and in this project, university chemistry students had the possibility to use virtual reality, VR, to visualise organic molecular structures, see figure 1.

Figure 1. (a) Bachelor students using VR headsets to visualise chemical structures and practice spatial ability. (b) The teachers collaborated to stream the visualised structures through VR and Zoom.

During the first chemistry course at a bachelor programme in life science, students were given the opportunity to meet 3D visualisations of chemical structures in a workshop. Due to the Covid19 restrictions, the teachers could not help students to be active VR users. Instead, one teacher applied the VR application, Oculus Rift combined with Nanome software, and streamed the visualisation over Zoom. The other teacher, and the students, used simple VR glasses with their smartphones to see the 3D projected molecules, and the teacher explained what was presented.
This design-based research project (Anderson & Shattuck, 2012), where the chemistry teachers and a chemistry education researcher collaborated. They designed an intervention from where examples of the visualisations will be presented together with survey results on students' responses of the application of digital techniques as a way to practice their visualisation competence and spatial ability.

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Oral presentations

Parallel session 7

Flipped organic chemistry – in the light of Corona

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Flipped teaching is an instructional strategy that has become popular in university chemistry all over the world (cf., Seery, 2015). With the use of online video lectures students watch before coming to class, and student-centered problem-solving activities at campus with the teacher available to scaffold, the strategy is "flipped" in relation to more conventional teaching where teachers give lectures at campus and students do their homework afterwards. In Sweden, large chemistry groups are rare, instead a flipped approach has been introduced with the aim to change and renew one specific chemistry course.

In a longitudinal project, an organic chemistry course has been followed for five years where students' affective and cognitive learning have been explored through surveys, observations and interviews (results from the two first years are presented in Broman & Johnels, 2019). The outset was a chemistry course that had had the same structure and setup for more than 20 years. Course evaluations had previously been quite negative, and students' examination results had been low. Therefore, a change was requested by both students and the teachers at the chemistry department. In a design-based research, DBR, project (Anderson & Shattuck, 2012), the collaboration between university chemistry teachers and a chemistry education researcher has made it possible to develop the course further and make a bridge between research and practice. During the five cycles, the course has been studied from both a teaching and research perspective.

With the use of video lectures that students were requested to watch before coming to class, teacher-led lessons were arranged in another way than conventional lectures, i.e., student-centered problem-solving activities. One way to motivate the students to watch the lectures pre-class, was online quizzes that were open every evening the day before the content was needed at the problem-solving lessons. A successful quiz result gave bonus points for the final exam. These video lectures have also been a feasible way to help students during the COVID19 pandemic since they have to take their courses remotely (cf., Fung & Lam, 2020). In this presentation, the longitudinal flipped teaching project is described exploring a university organic chemistry course at bachelor level, focusing primarily the two last cycles to problematize how flipped teaching can be extra valuable during a pandemic where all teaching was forced to be digital. During spring 2020 the COVID19 affected the end of the course with the final exam, whereas during spring 2021, the whole course was influenced by the restrictions that all teaching, besides laboratory work, was digital. Both students' and teachers' perspectives will be elaborated.

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Lessons from COVID-19 Times – Should Prospective Teachers Develop Their Own Online Classrooms Already During Their Tertiary Education?

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In the light of the COVID-19 pandemic, considerations of the role of the subjects in which prospective chemistry teachers are trained to use ICT have taken on a new dimension. This paper presents the adaptation of the implementation of the study course "Information Tools in Chemistry Instruction" in the academic year 2019/20, intended for first-year students of the University of Ljubljana, Faculty of Education. In the course, students are introduced to the importance of using ICT to support visualization in chemistry teaching and learning and are able to use the acquired knowledge and skills of chemistry-specific ICT tools in didactic courses. Reflections on the adaptation of the course to distance learning have led to the conclusion that it would be useful to place the previous implementation of the course, based on testing the acquired knowledge of the use of specific ICT tools for teaching and learning chemistry, in a broader and more integrated context, linked as much as possible to school practice. Therefore, we decided to introduce as an essential adaptation the development of individual online classrooms for students to learn how to integrate the knowledge acquired in the course. The sample represented the whole generation of students enrolled in the 1st year of the study program at the University of Ljubljana, Faculty of Education for prospective secondary school chemistry teachers (N = 29). During the course "Information Tools in Chemistry Instruction" students acquired knowledge, skills and experience related to different ways of using ICT in the field of chemistry and chemical education. The competences acquired by the students in the course were used in the development of individual online classrooms to support the teaching of a selected chemistry topic in the context of everyday life situations. At the end of the academic year, all students wrote a reflection on their experience of the course. We used qualitative research methods to analyze 29 individual online classrooms developed by students and their reflections on what they found most important from their perspective as future chemistry teachers. In addition to measuring technological pedagogical content knowledge (TPACK) through performance assessment (Akyuz, 2018), students also participated in a survey to assess TPACK for preservice teachers (Schmidt et al., 2009). Students were successful in integrating various ICT tools into the activities presented in their online classroom, however in the future a little more attention should be dedicated to integrating all three levels of chemical concepts. At the end of the course and after developing their own online classroom to support teaching and learning of the specific chemistry topic in the context of everyday life situations, students highlighted the opportunity to reflect on the purpose of using different ICT tools. In the future, it would be necessary to consider how to develop students' objectivity in assessing their current knowledge and competencies and to point out areas for improvement so that we can support them in relation to the use of specific ICT in chemistry teaching and learning.

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Pre-service chemistry teachers' perception of the educational processes during the COVID-19 pandemic

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The COVID-19 pandemic and the suspension of face-to-face learning at the University of Belgrade - Faculty of Chemistry (UBFC) influenced the education of all chemistry students. The realization of the experimental part of the studies presented a major challenge within all study programmes (Huang, 2020; Youssef *et al*., 2020), while the realization of school practice was an additional challenge within the education of pre-service chemistry teachers. In order to examine the pre-service chemistry teachers' views on the quality of the educational processes during the pandemic, we developed a voluntary anonymous online survey using Google Forms. Six pre-service chemistry teachers, students of the fifth year of the integrated undergraduate and graduate academic studies at the UBFC, participated in the research. The survey consisted of four parts with 42 questions altogether. In the first part, the students' demographic data were collected. In the second part, the respondents were given several sets of questions regarding ICT. In the third part, using a five-point Likert scale, the respondents expressed and then explained their views regarding the general impact of the pandemic on their learning, the effectiveness of online lectures and theory exercises within different chemistry and chemistry didactics courses, and the effectiveness of assessments. In addition to this, they estimated the effectiveness of the laboratory exercises, which were conducted face-to-face during one part of the semester, and the school practice in the pandemic circumstances. In the last part, the respondents assessed the advantages and disadvantages of online teaching and its impact on the development of teacher competencies. They put forward some suggestions on how to improve online teaching and their views on the combination of online and face-to-face teaching in the future. Respondents had no experience with online teaching/learning before the pandemic, but now they spend two to eight hours a day engaged in these activities. All students usually use the PDF and PPT presentations which accompany lectures, five of them use the Faculty's e-platform, while YouTube videos, e-books, educational applications and web sites and the recordings of online lectures are used less frequently. The effectiveness of online instruction within chemistry courses was rated 4 (Agree) by most students (five out of six). Similarly, students rated the effectiveness of the online instruction within chemistry didactics courses as 4 (three out of six) and 5 (two out of six). The effectiveness of online theory exercises was rated the same for both chemistry courses and chemistry didactics courses: grade 5 was given by three out of six students, grade 4 was given by two students and grade 3 by one student. Three out of six students rated the effectiveness of school practice as 3, two students as 4, while one student rated it 5. The students singled out the lack of contact with pupils at schools as a major obstacle. However, the preparation for online teaching helped them gain some useful experience for their future practice. None of the students fully enjoyed online teaching and most of them were more comfortable during face-to-face instruction due to better social interaction.

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Teaching and learning chemistry during the quarantine – the case of the laboratory working

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The coronavirus pandemic has caused unprecedented changes in all areas. In the field of education, the situation has led to closure of the educational institutions in countries all over the world. Most of the educational workers had to make a big change (through the night) in teaching on all levels of education. Our educational system was designed in different times when nobody could even think about what can happen.
Since last year the distance learning has become a part of everyday's life. The situation has forced us to change and make online even the laboratory work.
On the Faculty of Natural sciences and Mathematics on the Chair of educational chemistry the students of educational chemistry, biology, ecology and physics should have laboratory work by different subjects. We knew the situation was hard for all of us, so we decided to make the laboratory work as real as possible even though students were not presented in the lab. Each laboratory course was performed online by the program MS Teams in front of the students. All of the experiments were made in front of the camera, so the students could actually see all the reactions refering to the course. During the laboratory work students were solving calculation tasks, writing the reactions, observing experiments and cooperate with the assistant. The experiments that have lasted too long were recorded or photographed and students had to study them till next term. The results of the tasks were submitted to assistant and the feedback to the students.
After finishing the laboratory work students had to write the partial exam of the laboratory exercises which was also performed online. Most of the students were successful but we are aware that that kind of work does not bring any advantages, specially not for the future chemistry teachers.

Development of TPACK and self-efficacy for online Instruction by advanced degrees lecturers during the COVID-19 breakout

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The present research describes the process which advanced degree lecturers in the Weizmann Institute of Science experienced when they switched to online teaching during the COVID-19 breakout. The study uses a twofold theoretical framework of TPACK (Technological Pedagogical Content Knowledge) (Mishra & Koehler, 2006) and self-efficacy (Bandura, 1986) in online teaching (Blonder et al., 2013). It draws its data from pre- and post- questionnaires comprising questions and an attitudes questionnaire. We found that the lecturers focused their efforts on learning and applying technological and techno-pedagogical knowledge, and almost did not mention a need for TPACK to teach the required content. Their perceived self-efficacy did not change throughout the online teaching experience. We propose a model to describe factors affecting a sense of self-efficacy in online teaching. The findings of the COVID-19 semester differ from those described previously in the literature about online teaching. We suggest, therefore, that the conclusions of the present study and of other studies of online teaching during the COVID-19 epidemic not be applied universally to online teaching.

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Inquiry-based Learning in Education of Prospective Chemistry Teachers

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Inquiry-based learning (IBL) represents a teaching approach in which students can construct their knowledge and develop research and inquiry skills by using the methods and practices of professional scientists (e.g. Minner, Levy, & Century, 2010). The role of the teacher, i.e. being a guide in a self-directed learning environment, is crucial for successful IBL (e.g. Lazonder & Harmsen, 2016). Therefore, it is important that prospective teachers gain experience in implementing IBL in direct contact with students during their studies.

The research focused on a course of the second Bologna cycle in which prospective lower secondary school chemistry teachers develop and implement IBL teaching units about topics related to chemistry in everyday life. The analysis of students' perceptions regarding the implemented IBL teaching units in the academic year 2017/18 showed that the majority of students mentioned a perception of positive effects on mental processes in IBL (Hrast & Ferk Savec, 2018). However, it was interesting that higher order thinking skills (HOTs) were not perceived as frequently as lower order thinking skills, despite IBL being recognized as an approach to promoting HOTs (e.g. Mubarok, Suprapto, & Adam, 2019). To address this issue, more detailed instructions for the development and implementation of IBL teaching units have been specified in the 2019/20 academic year. The aim of our research was to evaluate the importance of the change in instructions for prospective teachers by monitoring and comparing students' perceptions of learning processes and learning outcomes in IBL teaching units implemented by prospective chemistry teachers. For this purpose, students (ages 12–15) completed Spronken-Smith's et al (2012) survey after one of the IBL teaching units in which they participated. The survey was completed by 150 students (84 students in 2017/18, 66 students in 2019/20) and quantitatively analyzed using chi-square tests. The results indicate a significant difference in students' perceptions about HOTs creating between the two academic years. Students who participated in 2019/20 perceived the use of HOTs creating during IBL teaching unit to a greater extend than students who participated later, χ^2 (2, N = 150) = 6.75, p = .034. There was also a significant difference in students' perceptions of specific learning outcomes. Students who participated in 2019/20 were more likely to perceive intended learning outcomes, such as questioning their assumptions, making decisions about what they would study, and thinking about how they are learning during the IBL teaching unit than students who participated in 2017/18, G^2 (3, N = 150) = 8.88, p = .031; G^2 (3, N = 150) = 19.00, p < .001; G^2 (3, N = 150) = 8.30, p = .040, respectively.

The findings indicate that developed IBL teaching units can promote HOTs, although the achievement of this goal depends on various factors, including the focus in the instructions provided to prospective teachers, which are consequently reflected in the implementation of IBL. Therefore, it is important for prospective teachers to be able to practice and evaluate this way of teaching as part of their university education. In the future, it would be beneficial to further investigate the role of the teacher in the development and implementation of IBL.

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Workshop presentations

Acquaintance with Chemistry Teacher International (CTI)

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Chemistry Teacher International (CTI) is a peer-reviewed Open Access journal that was set up in cooperation between the Committee on Chemistry Education of IUPAC, the Division of Chemistry Education of EuChemS and DeGruyter. The journal aims to be a platform for teachers of all levels, focusing on good practices in the classroom and chemistry education research. One of the aims of the journal is to bridge the gap between chemistry education research and chemistry education practice. The journal was also conceived to be a platform for articles based on the best presentations during conferences organized by the CCE or the Division on Chemistry Education.
The first issue of the journal was published in 2019. The second issue contained articles based on presentations during the ECRICE in Warsaw. In 2020 two issues were published, with each 10 articles. The first issue of 2021, volume 3, containing 15 articles was just published. A special issue with articles about polymer chemistry, containing 13 articles will be published before June 1st. The third regular issue of volume 3 will appear in June, again with 15 articles. In September another special issue is foreseen with articles about Green Chemistry and Sustainable Development in Industry. Chemistry Teacher International has initiated steps to become recognized within the Social Science Citation Index. The first step is being recognized as an emerging journal. Other steps taken at the moment will be that articles published in the journal can be found in the relevant search engines.
In our workshop, we would like to discuss the objectives of the journal, which are: (1) bridging the gap between research and education, (2) creating a platform for all IUPAC and Division of Chemistry Education activities in the field of education, and (3) building an international journal not linked to a specific area or nation.

A Manuscript's Journey: writing, submission and publication in CERP!

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During this workshop, participants will be guided through a range of activities that can assist them to develop a manuscript for submission to our journal, Chemistry Education Research and Practice (CERP). Gwen Lawrie (current Editor) and Associate Editor team members will share insights into the requirements and common missing elements of CERP articles. Topics that will be covered and related activities will include different aspects of a manuscript's journey to submission (Figure 1):

- **First impressions and the review journey:** A brief landscape view of the scope, aims, structure of articles sought for CERP and insights into the manuscript review process.
- **What counts as a research article in CERP?** We will share what the editorial team and reviewers look for in research and evaluative studies (Seery *et al*, 2019). This will be considered across different education contexts (secondary, tertiary, pre-service teacher development and outreach engagement). Participants will work with exemplars to recognise links between these elements.
- **Writing a methodology and including ethical considerations:** Participants will be guided in communicating their own research methods and statements of ethical considerations (Lawrie *et al*, 2021).
- **Data display: a picture or table paints a thousand words!** We will consider examples of how to convert lengthy written 'results' sections into a variety of representations that enable readers to better access and appraise research findings.
- **Making 'Recommendations for Practice' practical:** many authors write generalised statements of recommendations for practice based on their findings and are subsequently required to translate these into more specific recommendations. We will provide tips on how to avoid these revisions.

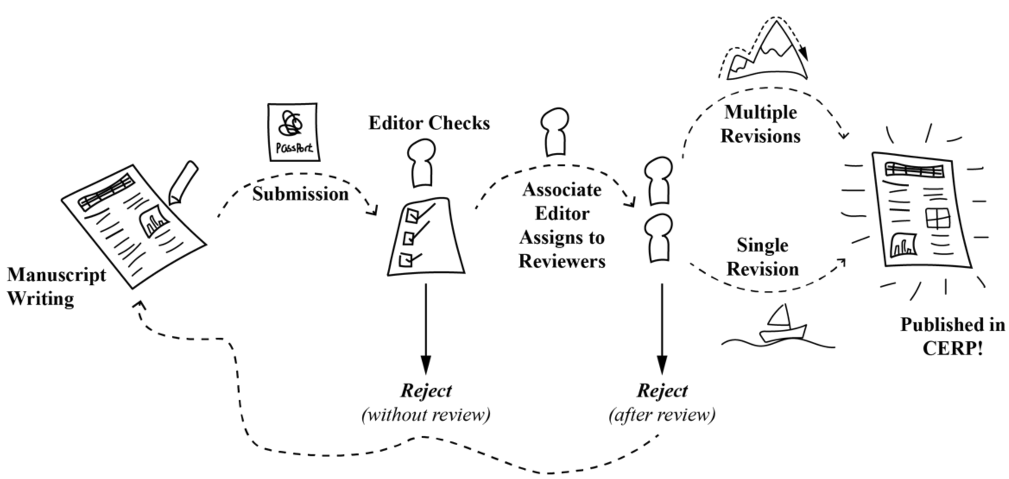

Figure 1: A manuscript's journey towards publication in CERP

Bring along your next research manuscript that is in development so that you can consider how it might be structured and edited for submission to CERP. During this session, we will move between whole zoom room discussion and breakout room activities, however, there will also be opportunity to ask questions related to your own work.

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Teaching Efficient Experimentation in Chemistry

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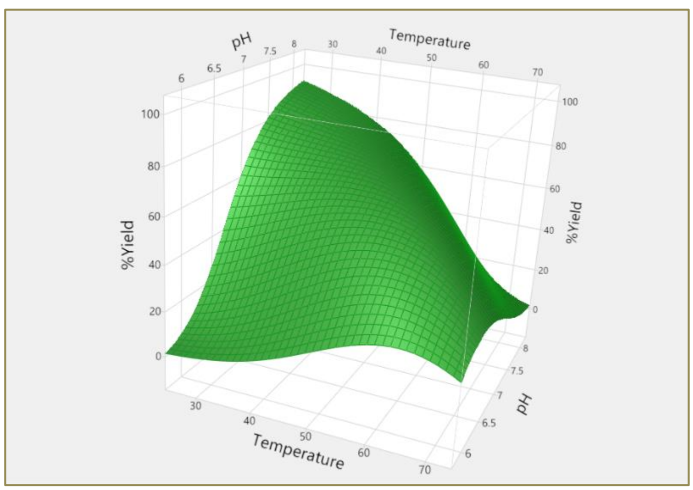
Design of Experiments (DoE) is the most effective way to empirically learn about technologies when there are many variables or factors to consider. Despite this, higher education curricula rarely teach these methods. In this engaging hands-on workshop, you will be introduced to DoE and you will see how it has enabled chemists and chemical engineers to develop better solutions, faster.

During this webinar you will learn:

- Why chemists should learn about DoE
- How to get started with teaching DoE
- What barriers may be encountered
- Best practices teaching DoE in chemistry

This workshop will provide you with a solid theoretical understanding of the design and analysis of experiments complemented by live demonstrations and a broad range of free teaching resources. All workshop content will be made available to the participants. A fully functional thirty-day trial version of JMP can be downloaded from www.jmp.com/trial if required.



Design of experiments enables you optimize processes with models
to understand complex behaviors in systems with multiple variables.

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"Teaching Design of Experiments to chemists: lessons from Imperial College London". On-demand webinar; Chemistry World (2020): https://bit.ly/3pTGvJe

"The Integration of Big Data Analytics into a More Holistic Approach"; White Paper by Roger W. Hoerl; SAS Institute (2019) https://bit.ly/3bHc8Ri

"Statistical Thinking for Industrial Problem Solving - A free online course with certification"; MOOC module "Design of Experiments"; SAS Institute (2019): https://bit.ly/3qO3Zkt

New chemical compound 3D modelling tool for students and chemistry teachers

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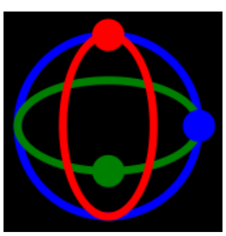
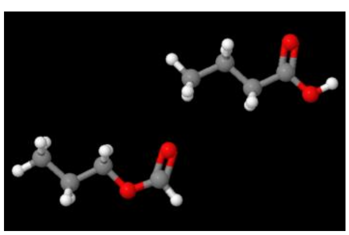
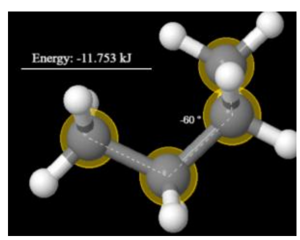
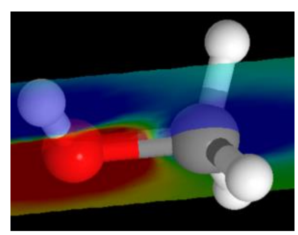
Studies on all education levels of chemistry education show that in order to construct correct mental models, students should be engaged in the construction and manipulation of 3D visualizations (Barak, 2013). We developed a new ICT tool for 3D modelling and visualization of chemical compounds, based on HTML5, CSS3 and JavaScript languages, and Jsmol molecular visualization software (Hanson et al., 2013). The tool is designed primarily for 3D models of smaller organic molecules, which can be uploaded from local files, or from the PubChem database. A special section is dedicated to 350 compounds found in essential oils. The user interface comprises menus and toolbars for easy access. Models can be edited, or new ones created through the 3D model editor, which also enables transformations into different conformations and optical isomers. Multiple models can be displayed simultaneously, while individually manipulated. A new widget tool was created for directional rotation (Table 1 (a)). Automatic comparison of two models is possible, e.g. identification of isomers (Table 1 (b)), or superimposition of one model onto another. Energies for various configurations can be calculated and compared, and for each branch rotation the optimal configuration indicated (Table 1 (c)). Functions for measuring distances, angles and dihedral angles, and display of different types of symmetries are provided. Displays of electrostatic potential can be projected on a vDW surface or on planes (Table 1 (d)). In the exercise section, users can directly interact with 3D models and receive automated feedback for tasks, including substructure identification, model comparison or structure editing/creation. The new chemical compounds 3D modelling tool aims at improving 3D visualization competencies of future chemistry teachers, as well as helping in-service chemistry teachers designing teaching materials with 3D visualizations and interactive tasks.

Table 1: Some features of the new tool

(a) Directional rotation widget	(b) Isomer type identification task	(c) Configurations with energy calculation	(d) Electrostatic potential projected on a plane
			

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Impressive Science Teaching Experiments (ISTE) presenting "Tsipouro", the Traditional Greek Spirit, in the University Laboratory

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The ISTE teaching approach is based on the constructive model, where the knowledge that students have acquired from the previous classes and their experience can be implemented in all levels of education, from kindergarten to the university.

Using ISTE, students build new knowledge based on their previous experiences, because they engage in experiments that are directly related to everyday life. In this way they are not mere recipients of information, but learning is a product of conceptual changes, which comes after a more important interest in the lesson and the cognitive conflict to which they are subjected.

The yearlong teaching experience of the writer has revealed that, when implemented in school, the ISTE model can stir up students' interest and willingness to learn, help the teacher to evaluate students' knowledge and views, help students to refrain from misinformation and pave the way for the evaluation of many students who would otherwise be indifferent to natural sciences.

The ISTE teaching approach is also based on David Ausubel's Theory of Assimilation, according to which new ideas and concepts can be learned effectively only through their assimilation into pre-existing concepts and ideas, which provide the necessary mental support (Ausubel, 2000).

Instead of following the simple procedure, using the glass distillation apparatus of the laboratory (Kahl *et al.*, 2014), we use a copper still (alembic) for the distillation process.

The stages of the ISTE method are the following:

1) The lesson starts in a way that sparks students' interest and provides a conceptual framework for the learning activity. In our case, the learning objective is to introduce students to the method of distillation, using "tsipouro", a traditional Greek spirit (Apostolopoulou et al., 2005).

2) Active participation of students in the experimental process, so as to enhance their occasional interest and encourage them to become more cognitively active. Engagement is effectively encouraged via questions and teamwork. For example, students will learn how to assemble and use a copper still (alembic) for the distillation process. Besides the desired ingredients derived from distillation, that is, ethyl alcohol and aromatic substnces, certain undesired substances are also present which are dangerous to consumers' health (Soufleros et al., 2005).

3) Constant feedback contributes to the students' motivation by providing information about their learning at a given time, while helping them to understand the efforts they made and experiences they gained. The brainstorming technique can be employed to introduce students to concepts like alcohol content and measurement, hazards stemming from alcohol abuse, chemical substances, safety regulations and legislation, and so on.

4) Homework: at the end of the presentation, the ISTE approach suggests that we ask questions and give students comprehension exercises and motives for further learning and consolidation, as well as exercises that require the study of bibliography (200–300 words). For instance, we can ask students to prepare presentations on similar alcoholic distillates from around the world.

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‘Creative Connections’: helping students link ideas between topics both in-class and online

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Higher Education programmes are often taught in modules which can result in "silo thinking”, and students can neglect aspects of learning in prior modules as they focus on their current modules (Biggs and Tang, 2011). 'Creative Connections' is a game-based learning (GBL) resource which helps students think how different parts of their course interact with each other, and how they might apply to their wider development (Fung, 2017), mitigating “silo thinking” in an engaging way.

‘Creative Connections’ comprises a physical game-board: a hexagon holding a central card insert. The insert contains six individually-coloured and -numbered segments, each with a phrase defining a concept, module name or other user-defined subject based around a central topic. To play, two dice are rolled: one numbered and one colour-spotted. The dice roll defines a number for one sector of the hexagon insert, and a colour for a second sector. Students discuss a suitable connection between these two sectors of the hexagon; this discussion can be tutor-facilitated or left to the students independently. Successful connections are physically indicated by a colour-band placed across pegs on the game unit. Students capture their connection ideas on a tabulated sheet for future reference.

The resource is fully adaptable for tutor-defined topics. The resource card inserts are available as PowerPoint files with alterable text, making the resource suitable for any combination of academic and skills-based topics, at any level of study, and can be adapted for any language. This latter feature has enabled the continued use of the resource in a purely online format during the 2020-21 COVID-19 restrictions, since PowerPoint-generated files could be shared and presented on-screen during online delivery of sessions via Microsoft Teams.

‘Creative Connections’ offers a structured space for students to think and discuss how different concepts/parts of their course influence others, and how their learning in one area can apply elsewhere. Thinking across traditional module boundaries and verbalisation of connections between different areas of study will develop student holistic thinking, mitigate compartmentalisation and improve student communication skills. As a GBL tool, ‘Creative Connections’ can be played in small teams or solo (for revision) in an engaging way which can help with learning motivation (Pirker and Gütl, 2015). Alternatively, it may be implemented not using a GBL-approach if preferred, as a tutor-defined visual resource to structure class discussion.

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Online support of organic chemistry classes with Zosimos

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Organic chemistry is one of the fastest-paced courses a chemistry student has to take. The subject relies heavily on structural representations. Interpreting, manipulating, and switching between the numerous structural representations is a complicated task for many students. To be able to predict the reactions and properties of organic molecules, students must practice organic chemistry little by little every week, and practice solving molecular representation and reaction drawing problems.

We would like to present Zosimos (https://zosimos.io/), in the form of a workshop. Zosimos is an online chemistry educational tool that allows chemistry teachers to do practice and test with their students. Zosimos allows chemistry students to improve their knowledge of a wide range of organic structural representations (such as e.g. structural formulas, Lewis structures, three-dimensional representations), combine them in reactions, and get immediate feedback on their progress.

Workshop participants will be shown how to:

- Insights from real classroom research experiences
- Set up a virtual class
- Create interactive online organic chemistry quizzes and exams (nomenclature, reaction mechanism, three-dimensional representations)
- Share quizzes and exams with the students
- Review the results of the students
- Options to use Zosimos with other Learning Management Systems (like Moodle, Canvas, Blackboard...) will also be explored.

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Poster presentations

LaboratorioRPGDocente: A game-based learning

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The situation caused by COVID-19 has forced the emerging of digital learning as an alternative to conventional learning (Chaturvedi, 2021). Gamification uses game dynamics as an innovative didactic strategy and inside them we can find the game-based learning that integrates the game in order to get some behaviours according to educational objectives. The content which is teaching is created as a transverse immersion element (Pegalajar, 2021). Inside the video games area there are a lot of categories such as strategy, logic, arcade or, the most important one for this work, simulation. These games, due their realism, can allow to develop a variety of abilities and to understand how to work the simulated environments. The objective of this work is to create a realistic game-based learning that allows students to make lab practices (qualitative determination of cations) and to evaluate the satisfaction degree of the game. To do so, RPGMAKER program will be used to develop it (Figure 1) and satisfaction surveys will be made to evaluate the results. Despite the early stage of the game, consumers point to high expectations about it. The video game presents certain parameters very well evaluated such as realism and the teaching experience (Figure 2). The video game has provided such positive and promising results that it will be continued, implementing improvements, and covering other educational fields, from high school to university.

Figure 1: Capture of the game

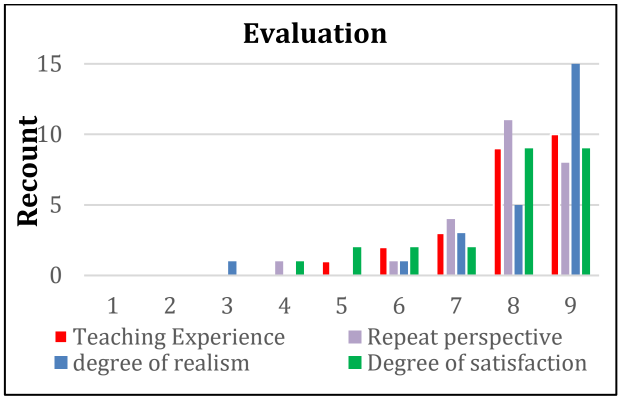

Figure 2: Histogram of some of the parameters evaluated

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Diversity in Science towards Science Inclusion - A topic for pre-service chemistry teacher education

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With the project *Diversity in Science toward Social Inclusion* (DiSSI), we seek to develop and implement innovative methods, tools, and activities to foster inclusive science education in general and chemistry in particular. This will be achieved (i) through the development of good practice material and further innovation in concrete learning settings and (ii) through the support of pre- and in-service teachers in addressing different dimensions of diversity in their (future) class and reflecting with them on the impact of diversity in science learning in general and chemistry in particular.

In the poster, the focus will be on strongly engagement of pre-service chemistry teacher education through seminars or participation in the development process during the project. The pre-service chemistry teachers will participate in the project by working with the school students and being involved in the teacher education seminars. For the in-service teachers, all partner universities will offer workshops presenting similar content. In addition, the in-service teachers will experience the DiSSI approach to inclusive chemistry teaching, which will be tested and refined through two rounds of evaluated interventions. The focus will be on accompanying students to the non-formal education offered by the universities. Through these activities, the teacher candidates will get to know the DiSSI teaching approach for inclusive chemistry education. They will learn about the theoretical background of inclusive chemistry teaching, the need for new ways of dealing with diversity, and they will acquire new teaching skills through working with the concrete teaching material and developing new teaching sequences based on the existing examples of good practice. This will sensitize (future) teachers to their students' needs and provide them with the skills to implement what they have observed in their own practice. This will increase the use of effective inclusive practice in their future chemistry teaching.

In the poster, the initial activities and the concept of the entire project will be presented, as well as the approaches to indicate how preparing pre-service teachers can be undertaken within this project.

Stimulating university chemistry students' interest in nuclear and radiochemistry by problem-based laboratory

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This study describes our experiences in problem-based learning (PBL) incorporated as a revised postgraduate nuclear chemistry laboratory course. Although the issues related to nuclear and radiation chemistry are generally interesting for students, the practical implementation of this subject is less enthusiastic. Student laboratories at our Faculty generally rely on the expository style, where students complete a provided procedure in the lab. It does not create an appropriate learning environment that engages students and is not conducive to applying the acquired knowledge. The students' nuclear chemistry laboratory is often found as boring and of little use, as it consists, in large part, of a monotonous recording of the results and their tedious processing.

This year, a revising laboratory course was proposed by introducing a problem-based learning approach as a potential solution for students' lack of motivation and engagement (Robinson, 2013). Its aim was to involve students in the experimental design, with more careful consideration of why each step of a particular procedure is being completed. It also aimed to make students aware of the limitations of individual methods and apparatus and the importance of preparing samples for analysis.

Here, neutron activation analysis, gamma spectrometry and beta and alpha radiation studies were applied by students to solve specific research problems related to the determination of natural and artificial radioactivity of various materials and food.

The work presents the effects of the first year of using a modified form of running this laboratory. An analysis of how students perceive this method and an attempt to compare the effectiveness of this form of teaching with the traditional one, where students performed only specific measurements according to detailed instructions, will also be presented.

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Student engagement with problem-solving scaffolds in chemistry: teaching associates' perspectives and practices.

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Problem solving is a fundamental skill in chemistry. Yet students have difficulties solving problems in chemistry. These difficulties may be instructor-driven. Instructor-driven difficulties could stem from some teaching practices, such as expecting students to apply procedures without showing their reasoning or solely focusing on worked examples. Such practices could inhibit the development of problem-solving skills. To address these challenges, our group developed a scaffold (Goldilocks Help) to support both students and instructors through structured problem solving (Yuriev, Naidu, Schembri, & Short, 2017). This study explored how teaching associates (TAs) used the problem-solving scaffold and how this practice affected their teaching and perceptions of student learning. Data was collected from interviews with TAs and analysed using the framework approach (Ritchie & Spencer, 1994). Teaching with the problem-solving scaffold was found to be beneficial, albeit with initial student resistance. The scaffold provided a common thinking structure between the instructor and students. This enabled the TAs to easily identify mistakes and address specific areas of concern. However, TAs also experienced students' attention shift from content to the scaffold. The students unproductively viewed the process as requiring two separate actions: (1) solving the problem and (2) demonstrating problem-solving skills, as opposed to an integrated activity. Through constant reinforcement and prompting during and prior to solving the problem, students continued to grasp how to effectively internalise the scaffold to assist their learning. Understanding students' interaction with problem-solving scaffolds will add to the field of education research to inform innovations in teaching and learning to optimise engagement strategies.

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Strategies for solving the chemical problem of redox reaction of sodium chloride synthesis from elements: An eye-tracking analysis

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Chemical problem solving leading to comprehension learning is a demanding and complex learning activity (Sevian et al., 2015), where a solution leads to several challenging stages that the student must solve through the appropriate use of information and reasoning (Yuriev et al., 2017). It is well known that novices, unlike experts, use a simple algorithm to solve contextual problems. In solving, they usually do not connect more levels of representation than experts do effectively (Parchman et al., 2017; Yu et al., 2015).

The purpose of the study was to find out what chemical problem-solving strategies students use and how these problem solving strategies differ between non-experts *(participants with poor prior chemical knowledge who solved the problem using the non-expert path)* and experts *(participants with good prior chemical knowledge who solved the problem using the expert path)*. Fifty-five pre-service chemistry teachers between the ages of 19 and 24 participated in the study (M = 22.0; SD = 1.1). Participants participated in the study voluntarily. Solving the contextual problem of the redox reaction of sodium chloride synthesis from elements was tracked using the Tobii Pro X2-30 eye-tracker and the thinking-aloud technique. The obtained audio-visual data were analysed using a qualitative research approach.

The main results obtained by qualitative analysing participants' eye movements and expressed thinking process during solving a chemical problem using a non-expert fixation path (*Fig*. 1 and 2) by the participants: (1) more attention to the instruction of the problem, (2) more connections between the instruction and other areas of interest, (3) more attention to the macroscopic than to the submicroscopic and symbolic levels of the representation, and (4) a greater number of connections between different areas of interest within the same level of representation than between different levels of representation.

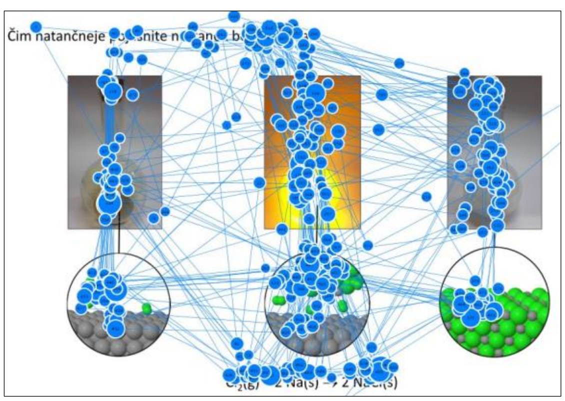

Fig. 1 Non-expert path of fixations in solving a chemical problem (student with poor prior chemical knowledge).

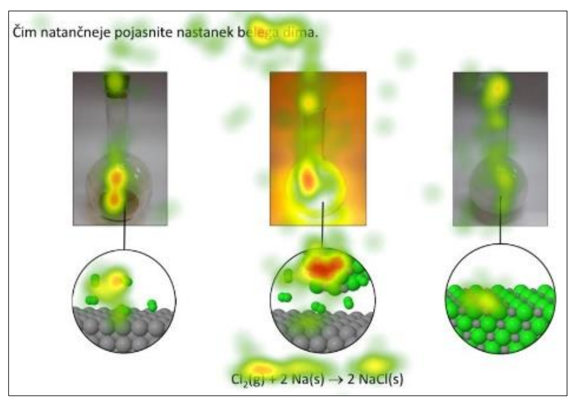

Fig. 2 Heat map of fixations to the area of interest in solving a chemical problem (student with poor prior chemical knowledge).

Participants who solved the problem using the expert path (*Fig*. 3 and 4) of fixations made a smaller number of fixations to the areas of interest they observed for longer time. During the problem-solving process, they repeatedly focused on the areas of interest that comprise critical information for successfully solve the problem.

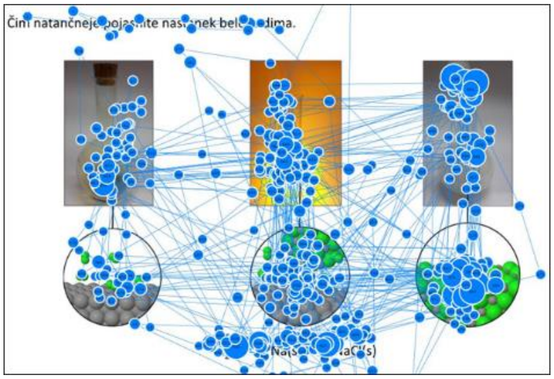

Fig. 3 Expert path of fixations in solving a chemical problem (student with good prior chemical knowledge).

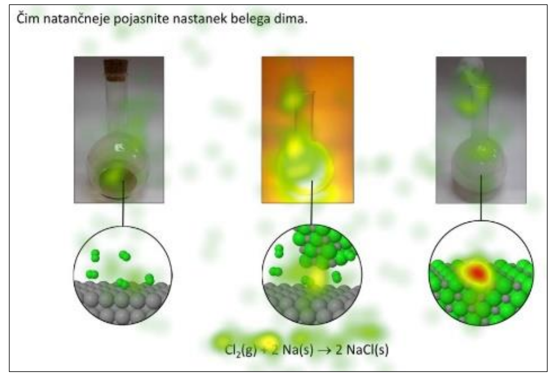

Fig. 4 Heat map of fixations to the area of interest in solving a chemical problem (student with good prior chemical knowledge).

The teacher should guide the student to a correct solution of the problem by explaining and presenting the expert path of the problem solving process. In order to understand the chemical content correctly, the teacher must help the student develop problem-solving skills, thus encouraging the student to learn with understanding.

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Are Industrial Foods Always Good for a Healthy Diet?

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An innovative approach to the applications of food chemistry in everyday life, chemistry students' knowledge and views were sought about the chemical constitution of industrial foods, their nutritional value, as well as the purpose, the necessity and the possible bad effects on health as a result of the use of chemical additives in these foods. This topic belongs to the so-called "relevant chemistry education" (Eilks & Hofstein, 2015), which originates in the instructional program of the famous American philosopher, psychologist and education reformer John Dewey.
In the present proposal we present part of the findings, concerning students' views about the content of industrial foods as described in the labels of these food, as well as their views and knowledge about healthy diet and the basic constituents of foods (see Figure 1). The study was carried out in academic years 2014-15 and 2015-16 with students attending the compulsory practical course on "Analysis and Technology of Foods" at the University of Ioannina. This course is taught in the 6th semester (3rd year) of the chemistry major program, consisting in total of eight semesters (four years). A total of 249 students had attended the above course of which 223 students answered two written optional written questionnaires each (response rate: 89.6%). 83 of the students were males (37.2%) and 140 were females (62.8%). The students had been informed in advance about the research nature of the study, their voluntary participation and the fact that no effect whatsoever would carry their participation or non-participation to their overall evaluation and grading of the course.

Figure 1. The food pyramid for a healthy diet. Grains are at the base level, above which lie vegetables and fruits, and then dairy products, meat and fish. At the top level are fat, oil, salt and sugar.

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Using Participatory Action Research in Higher Education for Developing Interactive Learning Media

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For the further development of teaching and learning with digital media in higher education, new concepts are needed that build on modern educational theories and didactic concepts (e.g. Otterborn, Schönborm, & Hultén, 2018). These concepts need new and appropriate learning media based on digital technology to be effective for students. This is supported by the European Commission (2020) in its Digital Education Action Plan (2021-2027).

For closing the named gap, digital learning media, so-called LearningBits, have been developed. LearningBits can be used, e.g., for reflection of the content, sensitization for a topic, repetition, practice and consolidation of content. They are interactive, adaptive and oriented towards game-based learning. This learner-centred media can be used in multiple learning situations (e.g., pre-and post-course, synchronously as well as asynchronously, at home and the university) and are independent of a single course. For the design, implementation and evaluation of LearningBits, the Participatory Action Research approach for university teaching in the context of pre-service science teacher education is used (Tolsdorf & Markic, 2018).

A mixed-methods design based on a self-developed qualitative and quantitative questionnaire is used to assess the potential of LearningBits in supporting pre-service teachers` learning and learning activities. 149 pre-service science teachers participated the study. The results show that LearningBits support pre-service science teachers in their learning and thus, can contribute to the success of digital learning in higher education. Pre-service science teachers indicated that LearningBits facilitate the introduction to lessons through problematizing of and sensitizing for content. The LearningBits enable independent of time and place a repetition and reflection, as well as the illustration and deepening of content. The quantitative study results confirm the pre-service science teachers' qualitative statements and show that the LearningBits supported their learning activities. The usefulness, learning effectiveness and attractiveness of the LearningBits was emphasized, particularly concerning repetition and practice.

Based on these results, digital university teaching with interactive digital media seems to be promising. Therefore, the further development, testing, and evaluation of interactive digital media should be realized by university educators. In mid-2021, the LearningBits will be made available as an Open Educational Resource. The results, including an analysis of the individual LearningBits, will be presented in-depth and discussed on the poster.

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Mentoring gifted high school graduates, future students in the natural sciences: An example of good practice

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Mentoring is known as one of the oldest forms of human development. Today, it is considered a common form of education, a dynamic interpersonal relationship that can be either informal or formal (Lindt & Blair, 2017). The role of mentors in guiding gifted mentees varies depending on the stage of development and area of research content. In addition to teaching content, mentors should also attend to the development of psychosocial skills of mentees with active learning by understanding and critically evaluating the results obtained (Subotnik et al., 2021). There are advantages and disadvantages to the relationship between the mentor and the mentee (Keiler et al. 2020). The aim of this paper is to present the mentoring process of gifted high school graduates, as an example of good practice. The paper evaluates the advantages and disadvantages of the online mentoring process, the quality and impact of the mentoring relationship in preparing a research project during the epidemic COVID-19. It also presents online mentoring as an alternative form to the well-known "traditional mentoring", that is usually carried out in educational institutions.

Our study involved 5 gifted high school graduates (average age 18 years) and 2 mentors, teaching assistants at two faculties of the University of Ljubljana (average age 30 years). The data collection instrument was a structured interview with 20 questions divided into three thematic sections. The mentoring process was conducted in 20 two-hour meetings, via the online collaboration environment MS Teams, from October 2020 to February 2021. The purpose of the contact hours was to discuss the work done, the results obtained, and to clarify further research questions.

The results showed that the graduate students rated online mentoring as an effective way of guiding them through the research process. However, they pointed out that "traditional mentoring" would be more appropriate for this type of research. They also pointed out some changes and adjustments that were made within the research process as a result of the online mentoring. For example, the research process did not follow the original arrangements and consequently the research project took a different form in terms of content and implementation. According to the graduates, these changes mostly had a negative impact on the originally defined research plan, as the original empirical research project became a theoretical one. As key competencies of mentors, they mentioned appropriate, professional and didactic skills, experience in mentoring, accessibility, accuracy, consistency and guidance with support in writing and publishing articles.

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The role of outside university institutions in the teaching of chemistry content in the different years of study of natural sciences

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The study of natural sciences contains a lot of chemistry content across different years of study, which can be challenging for students as chemistry is often abstract and therefore more difficult to understand (Kelly et al., 2010). Natural science students are often not given cases that directly relate to the practical application of their studies, and instead learn about chemistry content only in theory (Georgiou & Kyza, 2014). In the case of agronomy study, they are not only present in chemistry subjects but also directly or indirectly in other subjects. For a proper understanding of chemistry content, it is important that it is taught in context (Parchmann et al., 2017), which is more successfully achieved by involving different institutions in students' fieldwork. Fieldwork education is known to be an important and undisputed component that provides the opportunity for integration of theory and practice and allows for the development of professional behaviors in students (Bonello, 2001). The purpose of this study is to present how agronomy students in different years of study perceive the influence of the involvement of outside university institutions in the teaching of chemical content covered in different subjects.
Six final year agronomy students from each cycle of the Bologna program participated in the study: two first cycle students, two second cycle students and two third cycle students. The data collection instrument was a structured interview with 10 questions divided into three thematic sections.
The results showed that the first cycle students connected the fieldwork with the diversity and diversification of the pedagogical process. The involvement of outside university institutions in the fieldwork seems meaningful and important to them in order to understand the chemistry content, but they do not see much importance in these connections. In contrast, the 2nd cycle and especially the 3rd cycle students emphasize the crucial importance of the involvement of outside university institutions for the proper understanding of the chemistry content. The students find this kind of integration very useful as it gives them the opportunity to better understand the content of organic chemistry, biochemistry and chemistry of natural compounds. The 2nd and 3rd cycle students, due to their longer education, have completed several subjects directly or indirectly related to chemistry content; they have also been involved in numerous researches with the aim of creating a diploma or master's degree. All students interviewed recognized the importance of collaboration with outside university institutions in fieldwork, to whom they demonstrated the seemingly useless theoretical knowledge of chemistry acquired in the lecture halls with practical examples.

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Green Extraction Method for Azo Dyes Determination by Using Sheep Wool

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The use of additives in general, and food dyes in particular, is common for the preparation of various food products. These food dyes can be classified as natural or artificial and the legislation regulates the maximum permitted content of the latter. The analytical control of Azo dyes, a type of artificial food dye, are very important since these compounds can produce attention deficit disorders and hyperactivity in children, and these dyes can also cause cancer. Among the methods to measure food dye content are capillary electrophoresis, spectrometry, and liquid chromatography (Sidiquee, 2020). All these procedures involve a large volume of chemical wastes and time-consuming methods, moreover they are also very expensive due to the equipment they use or the price of reagents. The aim of this work is to determine the concentration of azo dyes in food samples with a Smartphone, by using as reference the Arata-Posseto method to extract azo dyes using natural wool (Martínez, 2019). This method only needs HCl, natural sheep wool, water, a heat plate and a Smartphone. The results show that this procedure can determine azo dyes in food samples avoiding the use of expensive equipment or polluting reagents (Figure 1).

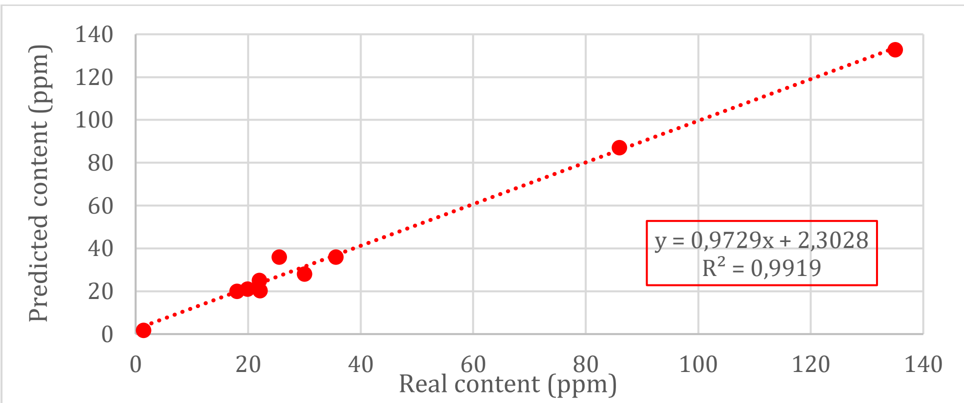

Figure 2: Correlation between predicted allure red content in food samples vs real content

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Chemistry Students' Knowledge and Awareness About Basic Food Constituents, their Features and Role

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We present third-year chemistry students' knowledge and awareness of the main food constituents. The study was conducted for two consecutive academic years (2014-15 and 2015-16), in the Department of Chemistry of the University of Ioannina, within the context of a laboratory course on "Food Analysis and Technology". This course was taught in the 6th semester (3rd year) of the chemistry major program. A sample of 110 students answered a questionnaire on carbohydrates, while another sample of 113 students answered a questionnaire on proteins and fats. Table 1 gives descriptive statistics for the samples.

Table 1. Descriptive statistics for the samples of this study.

	Min	Max	Mean	St. Dev.	N	%
Age	19.0	23.0	20.9	0.9		
Gender						
Female					140	62.8
Male					83	37.2
TOTAL					223	100

Carbohydrates: Questions dealt with their features, the reasons why we consume them, and the consequences for the human health of eating foods rich in carbohydrate. The role of fiber in nutrition was also analysed. The vast majority of students (average 92%) answered correctly the questions concerning features of carbohydrates. Proteins: The majority of students (average 87% / 96% excepting question 3) answered correctly, with the lowest performance (48%) presented in question 3, for proteins of high biological value. Fats: With the exception of question 1, correct answers varied between 82 and 100% (average 87% / 91% excepting question 1).

Conclusion: The results show that the students generally had satisfactory to excellent knowledge and awareness of the topics under consideration.

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Students' Profiles in the Chemistry Laboratory Environments: Moving from a Phenomenographic to a Quantitative Assessment

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Research on the undergraduate chemistry laboratory has explored factors such as students' goals, feelings, and instructional approaches to the laboratory. However, research has not investigated or assessed the various student experiences inside of the chemistry laboratory. Based on a phenomenographic study that established students' perspectives of an Organic Chemistry laboratory (Burrows et al., 2017), this current study used interview data to create a questionnaire to assess seven student perspectives in the chemistry laboratory environment. Questionaries were developed and refined through several iterations of cognitive interviews and pilot studies. These questionnaires were then translated from English to German to be used in multiple universities. In a cross-sectional study, questionnaires were administered to a sample of n = 157 chemistry students from three universities. These questionnaires were analyzed to 1) determine correlations between perspectives and 2) identify subgroups of students across perspectives using latent profile analysis (LPA). The results show that perspectives are correlated in accordance with most of the assumptions from our previous work (Burrows et al., 2017) and provide suggestions for further related perspectives. The LPA identified five profiles which we present and discuss in the poster.

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3D Printed Models for Chemical Education

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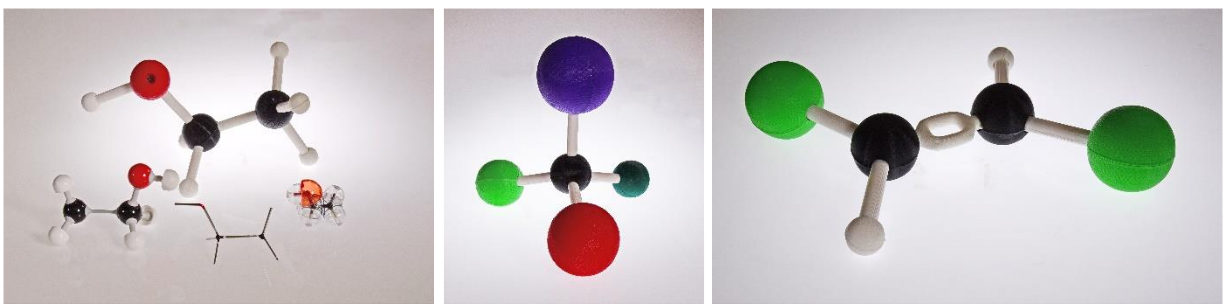
Molecular models are indisputably the tool chemistry lecturers turn for help when it comes to three-dimensional representation of chemical structures. Due to its affordability and commercial availability, 3D printing has become the best tool for making ideas come to life. We designed and 3D printed molecular models to be used as an educational tool for teachers and students. The design is based on the traditional ball and stick models with an interesting twist – use of magnets for atom-bond connection. The models improve visualization, resolve misconceptions, and increase understanding of chemical concepts (*Picture 1*).

The restricted rotation of the double bond, bond formation and dissociation, atom hybridization are all well presented by real size ratio of different atoms and bonds. We used computer software, a 3D printer and magnets for the design, printing and bonding of the models.

Students from Novo mesto Grammar School tested the practicality, accuracy and presentability of the models. Their regular feedback helped refine the models. The positive outcome of the surveys evidently shows the increased interest for chemistry in the classroom. Students were noticeably keener and more open to learning new concepts and building molecules.



Picture 1. Comparison of 3D-printed models with commercial ones (left), real-size ratios of atoms (middle) and restriction of rotation of double bonds (right).

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Creating Shared Experiences for Outreach in a Virtual World

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The School of Chemistry at Trinity College Dublin (TCD) has an established chemistry education and public engagement (EPE) programme. It provides on campus events and visits to secondary schools among others. The majority of these activities, both on campus and external, are organized through the "Chemistry Outreach Module", which forms part of a structured PhD programme. In addition to lectures and assignments, module participants are also required to complete work experience to hone their communication skills, learn from their peers and reflect on their development. The onset of the COVID19 pandemic meant these PhD students lost valuable work experience opportunities and secondary schools lost the benefits of tangible role models, real-world context for the curriculum and hands-on experience.

Shared (group) experiences and connectedness are an important part of social development, reducing feelings of isolation and contributing to a sense of "belonging". Evidence suggests that ordinary experiences shared by a group of people are amplified and retain significant longevity over an exciting experience witnessed individually. The effect is further enhanced when those in the group are familiar with one another, despite great physical distances between them such as sharing an experience online.[1] Shared experiences have been significantly reduced due to COVID19 but Stories from the Lab has helped to alleviate this.

Feedback was gathered through the use of anonymous online surveys which were sent separately to the presenters, teachers and students (through their teacher who act as a proxy) after each session in accordance with ethical guidelines.[2] The surveys consisted of Likert scales and open-ended questions to establish how the sessions assisted each group of respondents.

Stories from the Lab provides 2 of our 3 stated benefits to schools: tangible role models and real-world context for the curriculum. The feedback received to date from all cohorts has been overwhelmingly positive.[3] The flexible format has also ensured its continuation throughout lockdowns for students at home and/or in their classroom. These sessions could continue after the COVID19 pandemic as it would benefit rural schools that previously found it difficult to engage with higher-level institutions.

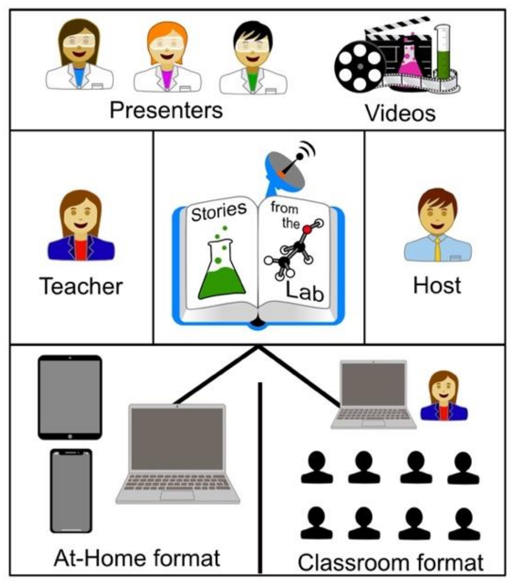

Figure 1: Stories from the Lab Schematic

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Exploring Future Chemistry Teachers' Pedagogical Scientific Language Knowledge

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Though in the last years the importance of language in chemistry is pointed out and much research has been done, it is less known about chemistry teachers' knowledge about teaching and learning the scientific language in chemistry classes. Markic and Childs (2016) discuss the importance of the "*Chemish*" while teaching chemistry. To meet students' needs to understand the language of chemistry, chemistry teachers need to be sensitized about the role of scientific language in chemistry class and therefore trained adequately. We, therefore, claim that (pre-service) chemistry teachers do not only have to develop Pedagogical Content Knowledge (PCK) as described by Shulman (1987) and Pedagogical Language Knowledge (PLK) as described by Bunch (2013) as a part of PCK. Even more, the particular sort of PLK with a focus on the "*Chemish*" needs to be developed: *Pedagogical Scientific Language Knowledge (PSLK)*. The PSLK was defined by Markic (2017) "*as teachers' Pedagogical Language Knowledge (PLK) with the focus on scientific language of chemistry*" (p. 181). While Bunch (2013) defined PLK "as knowledge of language *directly related to disciplinary teaching and learning and situated in the particular (and multiple) contexts in which teaching and learning take place* [author's emphasis]" (p. 307).

In the poster, a pilot study on the PSLK of pre-service chemistry teachers will be presented. While using a qualitative approach with open questions, we analyze the status-quo of the pre-service chemistry teachers' PSLK. The pre-service chemistry teachers were asked to complete three tasks about a few scientific terms used in chemistry class, e.g., reaction, oxidation, and substance. The tasks were (i) to define the word, (ii) to name the issues students could have with the term, and (iii) to explain the term to students in a given grade level. The data is analyzed by qualitative content analysis (Kuckartz, 2018). The results show that pre-service chemistry teachers lack content knowledge (CK) and therefore cannot explain the given scientific terms without unintentionally causing misconceptions. Further, many participants are not aware of the differences in the meaning of words used in everyday life and chemistry context. To enhance the PSLK of pre-service chemistry teachers, we present our approach to investigate the PSLK of experienced chemistry teachers and how we plan to implement it in pre-service chemistry teacher education.

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