

European Variety In Chemistry Education 2019: Abstract Booklet

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European Variety in Chemistry Education 2019: Keynote Presentations

Keynote Presentations: A/Prof Gwendolyn Lawrie, The University of Queensland, Australia.

Biography: Gwen Lawrie is an Associate Professor in the School of Chemistry and Molecular Biosciences (SCMB) at the University of Queensland (UQ). Since transitioning from lab-based research into education research in 2008, Gwen's projects have targeted the nexus between education research and teaching practice. Her current research explores how students learn through multimodal representations and the role of student-generated explanations in deeper learning. Her instructional design involves scaffolding collaborative and self-regulated inquiry tasks in large classes to support diversity in student learning needs in blended environments. Gwen is a Fellow of the Royal Australian Chemical Institute and Senior Fellow of the Higher Education Academy. She has received recognition for her teaching and research through several national and professional teaching awards and is the current Chair of the RACI Chemistry Education Division.

Abstract: Sticky Chemistry: scaffolding student thinking about thinking in hybrid learning environments.

Our adventures in designing hybrid learning environments for first year chemistry students has presented many challenges in successfully engaging students in thinking about their thinking (metacognition). There is a balance between student engagement in surface and deep learning connected to the instructional design that we implement. An additional challenge as chemistry educators is to deliver inclusive learning environments that scaffold students with a range of pre-existing mental models in the processes of recognizing, transforming, connecting and constructing representations. I will share our research into the 'stickiness' of online environments, student awareness of their own thinking and how we are translating these findings into practice.

Keynote Presentations: Dr Samantha Pugh, University of Leeds, UK.

Biography: Samantha Pugh is a National Teaching Fellow and the Faculty Lead for Teaching Enhancement. Samantha has an outstanding track record for developing context-based learning and working in partnership with students in the Physical Sciences. She is renowned for inspiring and mentoring colleagues to shape teaching through pedagogic research and scholarship at Leeds and beyond. Samantha's teaching philosophy focuses on student employability. It emphasises the skills and attributes needed for a successful career and students' ability to articulate those attributes. To this end, she has pioneered the use of reflective writing in Physical Sciences at Leeds. Samantha is sector-leading in embedding enterprise and entrepreneurship within the curriculum working collaboratively with employers, to inform curriculum development, increase the number of visiting lecturers, develop new learning resources and create summer internships for students with regional employers. Samantha co-leads the Pedagogic Research in Science and Mathematics Group (PRiSM). The group consists of academics from across STEM that champion evidence-based curriculum development, pioneer undergraduate research in STEM Education, support undergraduate education research summer internships and organise practitioners' seminars.

Abstract: Developing Business Acumen and Employability in Chemistry Undergraduates: What do students really learn?

Employers regularly cite a 'lack of commercial awareness' and a lack of other transferable skills in undergraduate students. To address this issue, we developed a suite of 'employability-focused modules,' one for each undergraduate year of study. The modules were, and continue to be, optional for all Chemistry undergraduates. A context based learning approach was taken in each case.

We developed a first year careers case study, with a focus on working in a Small to Medium-sized Enterprise (SME) in the chemical sector. A second year new product development module was developed, and in third year, an entrepreneurship module was created. In both cases, the focus was on a chemistry-context and students worked in teams, presenting their final product proposition to a 'business panel' in a 'Dragon's Den' style pitch.

In all cases, students were also asked to complete an individual reflective essay on their experiences of the module, which provided their perspectives on the experience at the time. The reflective essays for each 2018/19 cohort were analysed to determine: what students found to be good and bad about the experience, what skills they self-identified, and how the module had impacted on their career decision-making. The findings from this research will be presented.

Keynote Presentations: Professor Peter Mahaffy, King's University in Edmonton, Canada

Biography: Peter Mahaffy is professor of chemistry at the King's University in Edmonton, Canada, and co-director of the King's Centre for Visualization in Science (KCVS), which provides digital learning resources used by over a half million students, educators, and the public from over 100 countries each year. Peter's current research interests include rich contexts for chemistry learning, systems thinking in chemistry education, visualization in science, and climate change science education. He is a past chair of IUPAC's Committee on Chemistry Education.

Abstract: Systems thinking, SOCMEs, and educating about the molecular basis of sustainability?

Systems thinking shows promise in guiding students to see the relevance of their STEM education for addressing multiple emerging global challenges such as sustainability, alternative energy, planetary boundaries, and the UN Sustainable Development Goals. We will report on progress to date on the Systems Thinking in Chemistry Education (STICE) framework, which has been developed by a global IUPAC project team with the goal of moving learners from fragmented knowledge of chemical reactions and processes toward a more holistic understanding of the field. We will discuss approaches and exemplars that can be used by chemistry educators in courses such as gateway post-secondary general chemistry courses, to help students develop a deeper understanding of the molecular basis of sustainability. One tool developed with Tom Holme (Iowa State University) is to use Systems Oriented Concept Map Extensions (SOCMEs), which we will illustrate with examples from planetary cycles of reactive nitrogen and carbon. And the STICE project team welcomes input and feedback on tentative next steps for the IUPAC STICE project, including suggestions arising from the IUPAC CCE meetings in Paris and contributions to a special issue of the Journal of Chemical Education on "Reimagining Chemistry Education: Systems Thinking and Green & Sustainable Chemistry," to be published in late 2019.

O1 Design, implementation, and evaluation of an interactive online lab environment to support undergraduate chemistry labs

Dr Ciorsdaidh Watts¹, Dr Linnea Soler¹, Dr Iain Thistlethwaite²

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The School of Chemistry, University of Glasgow, in collaboration with Learning Science Ltd., have initiated a project to design and develop a blended learning experience. This virtual learning environment allows students to explore interactive technical simulations online, before in-lab practical work begins. It also introduces post-lab auto-graded reports using students' own lab data. These dynamic virtual lab resources promote learning through practice, and provide instant and personalised feedback for each student. One project aim is to encourage students to engage in deeper learning with respect to each experiment, and to promote student confidence and participation in hands-on learning. Hence, these resources are designed to provide a highly interactive and accessible virtual learning experience.

The second aim addresses student feedback regarding traditional word-processed lab reports and marking. Assessment was considered by students to be inconsistent, lacking detail, and was too slow. Through our dynamic online reports we aim to improve the consistency and timeliness of feedback delivered to students, and hence improve the learning experience. The online reports provide rapid and effective feedback without the possibility of inconsistency, and can incorporate targeted, valuable feedback for specific and common errors. Finally, we aim to make more efficient use of staff and student lab time, by removing repetitive marking, and allowing staff to focus on teaching techniques, which develop essential work-related skills for students.

We have noted that the introduction of these new resources has led to a dramatic increase in student confidence and proficiency within the lab, and crucially student satisfaction, attainment, and engagement with practical work have also improved.

Our post-lab online reports developed with Learning Science Ltd., are novel within a Scottish University setting. Therefore, the presentation will give an overview of the process involved, from acquiring funding through design and implementation stages, to results and student evaluations so far.

O2 Determining which cognitive tasks are present in chemistry laboratory experiments

Robin Stoodley
UBC, Canada

Instructors should know the learning objectives of each experiment offered in their laboratory course(s), but it's often less clear if the *overall set of experiments* offers students the variety and breadth of experience to best prepare them for future career(s) in chemistry. Training students to become expert chemists requires them to have frequent, guided opportunities to practice what chemists do. Focusing specifically on preparation for research, I'll introduce Carl Wieman's (2015) list of cognitive tasks involved in experimental research and describe how we used it as a framework to assess the extent to which students receive those opportunities. I'll describe some of the challenges of applying Wieman's list to the chemistry context and present results from determining which cognitive tasks are present in our year 3 laboratory course. Suggestions on adapting experiment(s) to include more cognitive tasks will be made.

Reference: Wieman, C.E. (2015). Comparative cognitive task analyses of experimental science and instructional laboratory courses. *The Physics Teacher*, 53, 349-351.

O3 Evaluative judgement in chemistry practical projects

Anna Bertram

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A common theme in student feedback is a lack of understanding of assessment criteria; this is despite module convenors continually attempting to improve how they are presented. This year we redesigned a third-year laboratory module with an emphasis on evaluative judgement and engagement of students in synthesising module learning outcomes.

Evaluative judgement is the students' ability to make judgements about their own work and that of others (Boud et al 2018). The conceptual work on evaluative judgement provides a useful and integrative conceptual framework for instruction and learning.

The third year practical module requires students to work in teams to undertake two mini-research projects, one in each semester. The format and assessment of both projects is the same but the chemistry differs. At the beginning of both semesters, before each project commenced a series of workshops was delivered.

Activities were designed in which students were asked to reflect on skills already developed and those skills needing further development, these scaffolded exercises paved the way for students to synthesise module learning outcomes and to then consider how these could be assessed. Throughout these sessions 'Padlets' were used to gather student input and structure discussion. Devoting workshops to the understanding of module learning outcomes and assessment criteria has been extremely well received by students.

Students were invited to complete questionnaires before and after these interventions to indicate their confidence and understanding of the module learning outcomes and assessment criteria. Early evaluations show a positive impact on students' ability to understand criteria and expectations. The evaluation is ongoing through the year to establish impact on learning and the student experience of these various activities.

This short presentation will summarise these interventions and the headline conclusions from student feedback thus far.

References

Boud, D., Ajjawi, R., Dawson, P., & Tai, J. (2018). Developing evaluative judgement in higher education. Abingdon Oxon, Routledge.

O4 Preparing students for practical sessions using laboratory simulation software

Richard A. R. Blackburn, Barbara Villa-Marco, Dylan P. Williams
University of Leicester, United Kingdom

Concerned with cognitive overload and problems associated with lack of student preparedness for practical sessions and unfamiliarity with common laboratory apparatus and techniques, we decided to review the measures taken to prepare students for the laboratory. Consequently, The Department of Chemistry at the University of Leicester (UK) has introduced interactive pre-laboratory simulations developed by Learning Science Limited, to provide students with an opportunity to attempt virtual versions of common experimental techniques and equipment. The opportunity to practice, receive live feedback and interactive instruction has seen a high level of engagement from first year students taking part B of their practical course. The resources have been very popular with students (feedback received at Student Staff Committee meetings) with students commenting that they were “faster in the lab thanks to practising (sic.) the techniques with the simulations beforehand”. Additionally, by conducting a student perception questionnaire before and after the deployment of these simulations we have observed increased confidence towards the practical courses and that students now feel better prepared. In addition to those general perceptions, students also reported that these simulations increased their familiarity with specific techniques. Our research continues to ascertain the long-term benefits of these cohorts and tertiary benefits to the both teaching focussed practicals and dissertation linked final year projects. Finally, we can conclude that these simulations not only improved student attitudes but also resulted in increased attainment in the assessed component of the practicals.

Michael K. Seery¹ and Claire Mc Donnell²

¹University of Edinburgh, ²TU Dublin

In 2018, 30 educators from UK, Ireland, and Australia responded to an invitation to contribute to a book celebrating the career of Professor Tina Overton.¹ The purpose of the book is to showcase innovative practice in use in the authors' institutions, and crucially any innovation must have been implemented more than once. Therefore while the compilation is intended as a useful guide for those looking to implement innovative practice, it also serves as a snapshot of innovative approaches in mainstream usage across a variety of universities in a number of countries.

In this presentation, recurring themes that emerged from a text-based analysis of the content of the book are presented. These are aligned with one of three categories:

- Themes associated with the rationale for implementation (what was “wrong” that the approach proposed would address and what evidence was drawn from to support this modification?)
- Themes associated with the impact of implementation (how did the approach work in practice?)
- Themes associated with longevity of implementation (what types of changes were made over time to ensure sustainability?)

In sharing the outcomes of the themes emerging in each of these groups, this presentation aims to both survey current innovative practice in higher education in these countries, as well as identify key rationales and implementation issues so as to provide useful guidance and support for those wishing to implement innovative practice in their own institutions.

1. Seery, M. K. and McDonnell, C. (Eds.), Teaching Chemistry in Higher Education: A Festschrift in Honour of Professor Tina Overton, Creathach Press, Dublin, 2019.

Elizabeth Yuriev,
Monash University, Australia

Two well-known challenges in chemistry education are: developing problem-solving skills by students and teaching of these skills by educators. Extensive chemical education literature deals with the nature of associated difficulties and instructional approaches to address them. One of the main difficulties experienced by students, when solving chemistry problems, stems from the lack of process skills.

We have tackled this challenge by developing and evaluating the problem-solving workflow “Goldilocks Help” (Yuriev et al, 2017). It provides specific scaffolding for students faced with procedural difficulties related to solving chemistry problems. The evaluation showed that the workflow helped to shift students’ beliefs about their abilities to use productive self-regulation strategies in problem solving: planning, information management, monitoring, debugging, and evaluation. In fact, analysis of student work showed that many of them could effectively regulate their problem solving through planning and analysis (Yuriev et al, 2019). Furthermore, students who demonstrated structured problem solving and explicit reasoning in their work were more successful in their problem-solving attempts. However, contrary to their stated values, they still found it challenging to monitor, debug, and evaluate effectively. In this presentation, I will use exemplars of student work as well as aggregated analyses to illustrate these findings.

We propose that it is important to constructively align teaching and learning activities with assessment that explicitly encourages students to demonstrate their reasoning, and other reflective and evaluative practices, during problem solving.

Yuriev et al, (2019) Developing problem-solving skills in physical chemistry, in Seery, M. & McDonnell, C. (eds), Teaching Chemistry in Higher Education: A Festschrift in Honour of Professor Tina Overton. Dublin: Creathach Press.

Yuriev et al, (2017) Scaffolding the development of problem-solving skills in chemistry: guiding novice students out of dead ends and false starts. Chemistry Education Research and Practice, 18, 486-504.

Nimesh Mistry and Ravi Singh
School of Chemistry, University of Leeds, UK.

For chemistry degrees which are accredited by bodies such as the Royal Society of Chemistry, a key programme learning outcome is that students develop the knowledge and skills to become professional chemists.¹

This means that students should be exposed to opportunities to apply their knowledge in contexts that resemble how a real chemist would apply that knowledge, i.e. they should be authentic. We have been interested in the use of experimental design as an authentic learning experience for teaching students how to apply theory in practice.²

In this talk we will discuss our use of a series of workshops in a 1st year laboratory course where students learn how to apply theory, such as organic mechanisms, to design synthetic chemistry experiments.

To make this experience authentic, students are asked to contribute to a medicinal chemistry research project in our department. In groups, students design a full experimental procedure, including reaction set-up, solvent, base and purification to synthesise a potential factor Xa inhibitor.

Procedures are submitted to the research group who run the student-designed experiments and submit the products for biological screening. The results of the experiments and biological activity were fed back to the students at the end of the course.

In addition to the details of the workshop we will provide further theoretical perspectives to rationalise the use of this type of learning activity and our evaluation of student learning.

References

1. Accreditation of degree programmes, 2017, *Royal Society of Chemistry*.
2. N. Mistry, C. Fitzpatrick and S. Gorman, 2016, *J. Chem. Ed.*, 93, 1091-1095.

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It is well known that adding context engages students and improves learning. Adding context also shows students how, and why, knowledge from their subjects is used in potential workplaces to aid them in developing career aspirations and targets. I will briefly talk about how, we spent three years actively engaging external partners to contribute to the redevelopment of our undergraduate laboratory classes (17 units). The partners range from small, medium and large companies, start-ups, benevolent foundations and community health groups.

The Transforming Laboratory Learning project then assesses student perceptions of the different practical experiences to measure the impact of the increase in context, and other related associated programmatic improvements (e.g. more industrially relevant equipment, integrated prelab preparation). I will talk about the main point found using pre-data on unchanged experiments and post-data on redeveloped laboratory classes. The survey consists of 27 closed questions, 1 distractor and 3 open questions.

The changes we have made have resulted in the laboratory classes being perceived as less easy, more challenging, more contextualised (to the workforce or real life), more open and there was more chance for repetition.

One discussion recorded between students captures what we are trying to achieve with this initiative particularly well:

Student 1 *"it felt more relevant than my other units",*

Student 2 *"yeah, more than anything I've done before",*

Student 1 *"it's like a legitimate almost work experience type situation ... the methods that you learn, they feel applicable to the real world."*

Jenny Slaughter and Lynne Bianchi
The University of Manchester, UK

Student-led educational research projects are a key part of chemistry degrees in many institutions. This workshop will describe how a 9-month programme of staff and student meetings were designed to incorporate reflective activities which enabled students to:

- work collaboratively;
- understand their strengths and weaknesses with regard to transferable skills;
- decide on the remit and development of the group;
- determine the roles and responsibilities of academic tutors and students within meetings.

The workshop will showcase two activities which were used to support students to move from being participatory to collaborative. Aligned with the Trajectory of Professional Development (Bianchi 2017), these activities are independent of context and applicable to other teaching environments where there is interest for students to transition from participating to collaborating and leading.

'Skills Mapping' will require participants to discuss and identify the key skills for success, reflect on their own areas of strength and weakness and share them with the group. The collaborative and open nature of this activity requires participants to move from 'self' to 'group-reflection'.

'Reflective review using PMI' demonstrates an example of how frameworks for reflection support students to explore the practical, cultural, curricula, assessment and academic implications in light of their own project work.

The workshop will help participants understand the wider context of reflective activities in Chemistry, with particular emphasis on empowering students to work in teams. Participants will benefit from experiencing reflective activities in action and taking part in discussion of the use and impact of the activities. The workshop will enable participants to utilise aspects of the demonstrated practice in their own setting.

Barry Ryan, Technological University Dublin, Republic of Ireland,
Cormac Quigley, Galway-Mayo Institute of Technology, Republic of Ireland,
Eileen O'Leary, Cork Institute of Technology, Republic of Ireland,
Elaine O'Keeffe, Cork Institute of Technology, Republic of Ireland,
Gary Stack, Athlone Institute of Technology, Republic of Ireland,
Laura Crowe, Cork Institute of Technology, Republic of Ireland,
Tomas Shields, Technological University Dublin, Republic of Ireland.

PeerWise is a freely available online platform that allows students to interact through creating Multiple Choice Questions (MCQs) for peers, as well as answering, commenting and rating these MCQs. PeerWise has been the subject of on-going research from more than ten years. This prior research notes that integrating PeerWise into higher education classrooms has numerous benefits for students, including; a shared community of practice and student empowerment. However, these previous PeerWise studies focused entirely on a single case; in our study we sought to investigate if these benefits could be expanded outside a single classroom or Institution and if these benefits could also be extended to the academics teaching the modules that used Peerwise; our research question was, therefore:

Can PeerWise be used to support asynchronous, multi-institution, student learning and staff development in third-level foundation chemistry?

An action research methodology, utilising mixed methods, was utilised to address this primary research question and aligned sub-questions relating to the benefits and concerns that varied with multi-institutional, and hence multi-cohort, PeerWise engagement. The presentation will outline the findings from the initial action research cycles and how these will inform subsequent cycles, focussing primarily on the impact on student learning and staff development. The triangulated data set explored includes the lived experience of the academics involved and their personal development through the design, execution and assessment phases, supplemented by social network analysis of the students interactions within the collaborative PeerWise ecosystem. Key emergent themes include the value of peer feedback and the first year students' perceptions of peer learning and will be unpacked and explored. Emerging from the action research cycles completed, we will present lessons learned that concentrate primarily on the differences in expectation between academics and student, and outline a new approach to managing students' expectations whilst simultaneously promoting staff development.

O1 Turning chemistry on its head: A brave experiment

Ingo Köper, Don Houston, Joe Shapter
Flinders University, Adelaide, Australia

In science courses in general, but especially in 1st year chemistry classes, the amount of content that is delivered is often overwhelming and too complex for the student to easily cope with. Students not only have to gain knowledge in a variety of different field, they also have to learn new laboratory skills and analytical techniques. In addition to the academic content, it is often difficult for students to connect the fundamental concepts covered to any 'real-life' scenario or application. The view of the 'big picture' is often lacking, even if the lecturer tries to convey this in a lecture, which is in most cases still the most common form of teaching.

Additionally, there is an issue with more and more information being available to everybody through the internet, while our education often still focusses on delivering that knowledge, rather than exploring ways how students can be guided to understanding and using the knowledge provided.

There have been different approaches on how to make 'dry' scientific concepts more interesting and how enhance student engagement, ranging from problem-based learning approaches, case studies or flipped classroom models.

We have recently turned a fairly classic 1st year chemistry course on its head. In the new structure, students are gaining knowledge and understanding purely through the completion of a range of challenges. We have removed all lectures, tutorials and the final exam, and all interaction with the student happens in the laboratory. Throughout the semester, students attempt to complete a range of challenges, both theoretical and practical, find relevant information, propose approaches to solving the challenges, and discuss these and subsequent outcomes with academic staff. Non-graded passes are awarded for completed challenges, and the students pass the course by completing a set number of challenges.

In order to analyse the design, we have conducted structured interviews with students from 2016-2018.

Detailed data analysis is ongoing, but initial assessment of the data suggests a high level of engagement of the students, paired with a better preparation of students for their subsequent studies. Students enjoyed having the freedom to choose and design their own experiments. Additionally, students improved significantly in non-content related aspects such as time-management, organisation, planning and self-learning, with notable impact on their learning in higher years.

O2 Engaging students in employability skills: a comparative study between Scotland and Australia

Dr Debbie Willison
University of Strathclyde, UK.

Funding from the Higher Education Academy allowed the Department of Pure and Applied Chemistry at the University of Strathclyde to develop a toolkit of resources to empower students by enabling them to recognise and market their personal skills set, therefore enhancing their employability. This toolkit has become embedded in our delivery over the past 7 years and students recognise the importance of the skills they gain and enjoy the activities as they involve varied delivery mechanisms to ensure student engagement. The resources are also widely available and over 100 institutions worldwide have accessed them.

The resources are not subject specific and have been designed to be transferable across all disciplines. Interactive materials have been developed in a number of areas, and although each is designed to work as a stand-alone resource, empowering students is the linking concept which binds them together. Topics covered include:

- Personal skills recognition
- Psychometric assessment
- Personal marketing
- Understanding PR & the media
- Social media planning
- Business organisations and ethics
- CV writing
- Assessment centres
- Interview preparation & practice

Results from the analysis and thematic coding of Strathclyde student questionnaires were published in 2017¹ and provided answers to the two following research problems which had been posed.

‘Can students’ self-reported confidence levels in employability skills be improved through the design and implementation of an external-expert centric model?’

‘What are students’ perceptions of such a module and can these perceptions be used to further enhance this students employability programme?’

A range of these resources have also been delivered to students in two Australian institutions (the University of South Australia and Monash University) and a comparative study between the responses from Scottish and Australian students has been carried out.

¹<https://www.tandfonline.com/doi/full/10.1080/0309877X.2017.1394989>

O3 Keeping it simple - an alternative assessment approach for threshold learning outcomes

Reyne Pullen, Luke Hunter and Scott Kable.
University of New South Wales, Australia

An innovative approach to changing the 'traditional' model of assessment has been undertaken at the University of New South Wales, Australia. The new model of assessment introduces a paradigm shift in first year chemistry by splitting the syllabus into two components to represent the threshold knowledge and competencies required to meet a pass grade and the mastery counterparts for merit grades.

One aspect of this overarching project is the development of a threshold-only online program through which we aim to transform traditional lectures into a blended learning experience. The flexibility of this style will advantage the heterogenous nature of a first-year chemistry cohort to provide self-pacing when learning these threshold concepts. The online program will include activities such as interactive videos, adaptive feedback responses, formative tracking of progress, and summative measures of academic success. A similar approach has been piloted in a small first-year chemistry course at UNSW, with positive results for both learning outcomes and student feedback.

A mixed-methods approach has been taken to measure the outcomes of this study utilizing quantitative survey instruments to measure attitudes, motivations, expectations and confidence, and qualitative focus groups and interviews to gain further insight into the results obtained quantitatively. Preliminary data collection and analysis has taken place during 2019 giving insight into the effectiveness of the threshold/mastery approach we have taken.

B1 The green formula for international chemistry education

Glenn A. Hurst,¹ James H. Clark,¹ Louise Summerton,¹ Avtar S. Matharu,¹ Clementine Beauvais²

1: Green Chemistry Centre of Excellence, Department of Chemistry, University of York, UK

2: Department of Education, University of York, UK

Following the American Chemical Society (ACS) Global innovation imperative in 2016 focusing on green chemistry education in rural areas of Brazil, it is clear there is an urgent need to support teachers and students in remote locations across the globe to effectively teach and learn green chemistry and sustainability concepts. Upon production of a White Paper, recommendations included developing experiments utilizing local and low-cost reagents and equipment together with implementing electronic resources for teacher training and to facilitate student blended learning.

To this end, the Green Chemistry Centre of Excellence at the University of York has utilized a students as partners approach to GRASP (Green Reactants and Sustainable Products) our undergraduate curriculum from a top-down programme design approach to greening laboratory experiments. Following embedding green chemistry within our own undergraduate curriculum and considering aforementioned global requirements, we present a portfolio of transferrable green chemistry laboratory experiments applicable at multiple levels.¹⁻⁴ Accessible workshops in green chemistry that incorporate active learning pedagogies for students in higher education and facilitators will be outlined.⁵

Ongoing work to include the production of a green chemistry children's book⁶ with accompanying teacher pack together with an online learning platform for high school students and teachers will be presented. All student-produced resources will be distributed in key regions through our extensive networks in the United Kingdom and United States and have the potential to be translated into other languages for use in non-English speaking countries. Examples include South Africa where established links between the University of York and the University of Cape Town have already led to the successful delivery of the first green chemistry practical exercise in Cape Town together with Brazil by developing the ACS initiative.

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2. Garrett, B.; Matharu, A. S.; Hurst, G. A. Using greener gels to explore rheology. *J. Chem. Educ.* **2017**, 94, 500-504.
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5. Summerton, L.; Hurst, G. A.; Clark, J. H. Facilitating active learning within green chemistry. *Curr. Opin. Green Sustain. Chem.* **2018**, 13, 56-60.
6. The Green Formula. <<https://itunes.apple.com/gb/book/the-green-formula/id1372738926?mt=11>> Accessed March 2019.

B2 GoFis(c)her: A student-designed card game in introductory organic chemistry

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The use of games in chemistry education is known to facilitate the development of engaging, active learning contexts that allow students to collaboratively develop their understanding of the subject (Antunes, Pacheco et al., 2012, Martí-Centelles and Rubio-Magnieto, 2014, Russell, 1999). This study describes the student-led development and evaluation of a card game designed to introduce students at the early stages of chemistry degree programmes to organic nomenclature, methods of structure representation and simple functional group chemistry. The game was designed, evaluated and refined by a team of undergraduate students in the later stages of the degree programme.

The game is played in small groups (usually two or three players) and is loosely based on the established card game Go Fish. The activity was initially piloted with a foundation year cohort (n = 23). The impact of the game was measured through the use pre- and post-tests as well as a questionnaire that measured student agreement with a number of statements. Evaluation of the pilot revealed a small (4%) increase in the average student performance after playing the game. 87% of students agreed that playing the game was a useful learning experience but only 39% agreed that the rules of this initial version of the game were easy to follow.

A revised version of the game was developed that included rewritten rules. This version was evaluated part of the first year chemistry cohort at Leicester (n = 55). Student performance between the pre- and post-test again showed a small (2%) increase but students attitudes towards this version of the game were generally more positive than those of the pilot group. 82% of participants stated that they enjoyed playing the game and 67% agreed that the rules were easy to follow.

References

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- Russell, J. V. (1999). Using Games To Teach Chemistry: An Annotated Bibliography. *Journal of Chemical Education* 76(4) 481.

B3 Science capital in secondary school chemistry

Lilith Rüschenpöhler, Ludwigsburg University of Education, Germany

Silvija Markic, Ludwigsburg University of Education, Germany

Students' engagement with chemistry reflects social structures. The concept of science capital, developed by Louise Archer and colleagues, tries to explain these sociological referring to the resources a student has that are valued in the field of science. These can be social networks (e.g. knowing scientists), economic resources (e.g. access to private tutoring), attitudes towards science, science knowledge and qualifications. In this study, we applied the concept to chemistry education. We investigated in what ways secondary school students use science capital in the field of chemistry. We conducted qualitative interviews with 48 students in Germany and conducted a thematic analysis (Braun & Clarke, 2006). We found (i) that chemistry capital is unequally distributed. Students from non-academic track schools tended to show lower degrees of family chemistry capital than students from academic track schools. In addition, in our sample, many students from non-academic track schools were taught by teachers who were not certified for teaching chemistry, which aggravates the existing inequalities. (ii) In most cases, the family chemistry capital corresponded to the students' degree of engagement with chemistry. Students with low levels of capital tended to show misconceptions, weak personal connections with chemistry, and, in some cases, conflicts between chemistry knowledge and religious beliefs. In contrast, for students with strong family chemistry capital, chemistry tended to be embedded in their personal lives. (iii) However, there were exceptions: some students developed individual connections with chemistry. YouTube channels were an important source of chemistry knowledge and provided role models for some male students. Some female students developed individual connections with chemistry through the embracement of a general learner identity. However, the absence of role models for the girls makes their identities more fragile. The results of the study will be presented in detail and first ideas for chemistry teaching will be discussed.

B4 Maths for chemistry: An alternative approach and student progression

Mamun Rashid
Manchester Metropolitan University, UK

Many of the chemistry undergraduate students agitated when told that they must have to learn mathematics in their first year. One of the most common questions that arise in the induction programme is “I want to be a chemist, why I do have to learn mathematics?”. In the real world, mathematics is an essential core component for the chemistry education and all chemistry students have to use mathematics as a tool to understand important chemistry concepts, physical model scenario and analytical problem-solving.

The first year study at the university level is a period of transition of knowledge and the transition period is often difficult and complex for students. In the first year, students have to understand the fundamental mathematics concepts with the understanding of the chemistry concepts and calculations. The transformation is quite challenging, particularly when students have a different level of mathematics knowledge and understanding. It is quite challenging to introduce and link up the mathematics fundamental concepts and tool to first year students. Therefore, it is necessary to design and adopt a student-centred teaching style with well-constructed assessment structure.

In the last three years, we have applied two different approaches of mathematics teaching to chemistry students. In this session, I will discuss the approaches for the transformation of math understanding for chemistry concepts with the progression outputs. Here, I will briefly discuss the learning and teaching strategies comparing to outputs with the plans for future implementation.

B5 New A levels, new visions for inclusive first year undergraduate teaching

Tom Anderson and Julie Hyde
University of Sheffield, UK.

Changes to England's A-level Chemistry syllabus have profound implications for teaching the first generation of Chemistry undergraduates to have been through the new system, which emphasises a more rigorous approach to laboratory practical classes before university. With established earlier experience in key skills such as the keeping of lab notebooks, can students be offered fewer algorithmic exercises and a higher level of learning challenge at first-year university level? At the same time, students are arriving from a diversity of backgrounds beyond A-level (Europe or further afield) and reforms to undergraduate lab teaching must remain inclusive of this broad community of learners.

In this talk, we will discuss how new innovations in lab teaching were rolled out at the University of Sheffield for the first two cohorts largely comprising students who had experienced the new A-level syllabus during 2018/2019. There will be particular focus on the design and delivery of a new first-year spectroscopy workshop, designed to address an observed deficiency in second year undergraduate students and previously a failure to build on the spectroscopy learned by students at A-level.

Also discussed will be the development of new lab learning materials designed around changes in student reading habits, language issues and to be more inclusive of international students. Designed with the benefit of past student input and feedback, and delivered with the aid of dedicated Graduate Teaching Assistants, 79% of surveyed students judged these new materials to be an improvement. Continued innovation, including the use of new learning technologies, remains the goal as we adapt to new generations of students.

B6 The role of guidance in engaging in chemistry studies: A collaborative action model

Piia Valto and Piia Nuora
University of Jyväskylä , Finland

The first year in University has an important role in students' life. The interaction between students, teaching personnel, the Department activities and University life is essential. In the Department of Chemistry at the University of Jyväskylä, the students' engagement and study motivation are increased by different kind of study activities. We have developed an enhanced study and counselling model for first year chemistry students. This model includes introductory course for chemistry studies, study counselling course and academic study skills course.

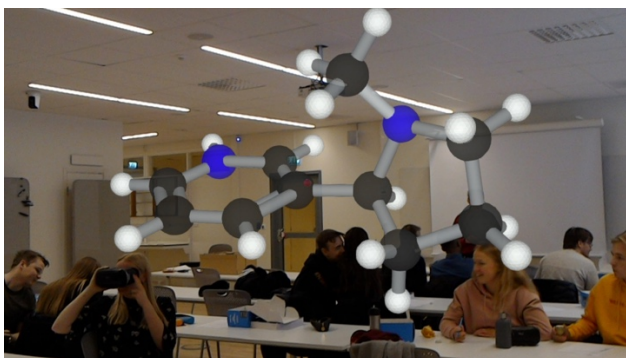
In this presentation, our collaborative action model and its assessment work is presented. The assessment work on the first year experience (FYE) has been carried via questionnaire form at the beginning and after six months studying since year 2015 (n = 106). The quantitative survey data were analyzed for descriptive statistics using SPSS Statistics V24.0. Content analysis was used to examine the answers to the open questions from the questionnaires. Regarding communality, the research shows that first year students appreciate Departments' atmosphere (av. = 4.21, a 5-point Likert scale, 1 = strongly disagree, 5 = strongly agree). Also, the relations between teaching staff and students were valued (av. = 4.28). Based on the survey, the tutoring (av. = 4.11) and orientation (av. = 4.29) is also highly appreciated. The meaningful student tutoring seems to be an essential contributor to enhance FYE. Students value student tutoring at a very high level (averages ranged from 4.09 to 4.29). We have also managed to decrease the dropout rate after first study year from 32 % to 26 % between years of 2013 to 2017, respectively. The results of this study show that students highly appreciate supporting study operators and guidance is needed especially at the beginning of the studies.

B1 Virtual and augmented reality – a way to develop university students; spatial ability in organic chemistry

Karolina Broman, Eva Mårell-Olsson and Dan Johnels.
Umeå University, Sweden.

In this presentation, the role of digital technologies as Virtual Reality (VR), and Augmented Reality (AR) are discussed to explore how students develop their spatial ability. Spatial ability in chemistry is for example the move between 2D and 3D when visualising representations of atoms, molecules, and reaction mechanisms (Harle & Towns, 2011). One of the advantages with VR technology is the availability since a smartphone easily can be converted to a VR headset (Edwards, Bielawski, Prada, & Cheok, 2018), whereas AR technology is much more complicated and expensive, however, the multiple sensory modalities makes it interesting (Goff, Mulvey, Irvin, & Hartstone-Rose, 2018).

In university organic chemistry workshops, 40 students in two groups practiced their spatial ability using VR and AR where they studied 3D images of organic molecules and were asked to draw 2D Lewis structures. We collected data through two questionnaires, one on VR and one on AR, and notes of their drawn Lewis structures. The results show advantages with both types of digital tools, which will be discussed and problematised at the presentation. Implications for teaching will also be considered.



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Harle, M., & Towns, M. (2011). A Review of Spatial Ability Literature, Its Connection to Chemistry, and Implications for Instruction. *Journal of Chemical Education*, 88(3), 351-360.

B2 Facing up to the challenges of teaching chemistry to an academically diverse foundation year

Simon J. Lancaster, Francesca Silve and Charlie Williams
University of East Anglia, UK.

Foundation years were conceived to provide an entry route to degree programmes for mature entry students, students from disadvantaged backgrounds and those changing academic direction. Expansion of university admission targets is increasingly driving the admission of a more typical undergraduate demographic who have narrowly missed the standard for direct admission onto a degree. The role of a Foundation Year is to take students who might have little to no formal education in chemistry up to the standard necessary to begin a science degree.

The first semester “Introductory Chemistry” module had an enrolment of 230 students of which approximately two-thirds had grades B–D in A Level Chemistry. Our challenge was to teach a content-heavy course to the third with little prior experience while stimulating those who ostensibly had little to gain.

We have extensive experience of the peer instruction active learning pedagogy. We reasoned that peer instruction would provide opportunities to assist the less experienced students through interaction with their more experienced peers. However, peer instruction does require contact time that has hitherto been consumed by delivering the body of chemistry content in an A level equivalent qualification. In this presentation we report our student’s engagement with an individually tailored flipping approach in which scaffolded self-assessment directs the extent of their preparation.

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B3 The international year of the periodic table – approaches for chemistry teacher education

Stefanie Herzog and Ilka Parchmann
Leibniz Institute for Science and Mathematics Education, Germany

For 2019, the UN proclaimed the International Year of the Periodic Table. While for chemists and chemistry teachers, the outstanding importance of the Periodic Table is not questioned, a layperson might wonder why the UN emphasizes this fundamental table of chemistry. The IUPAC press release [1] offers several arguments for this by pointing out the relevance of chemistry with regard to sustainable development and solutions for global challenges [2], and additionally refers to people and processes of chemistry in the past, present and future. Therefore, the Periodic Table provides an inspiring framework for chemistry teaching and communication.

The talk will discuss a seminar of a Master of Education program for future secondary education teachers. The course traditionally covers approaches of chemistry education, like history-based learning, inquiry-based learning, and context-based learning [3], and reflects them by referring to general teaching principles, like motivation, interest, goal clarification, or feedback. This term we added the content of the Periodic Table and asked students to reflect the different teaching approaches for this specific content and to design teaching materials, ideally as OERs. The group presentations and discussions showed that this approach initiated a solid reflection both on the content of the Periodic Table, such as its development and relevance for society today, and on the limits and possibilities of the different approaches; thus enabling students to combine content knowledge with pedagogical content knowledge and general pedagogy knowledge.

[1] http://iupac.org/cms/wp-content/uploads/2017/12/Press-Release-International-Year-of-the-Periodic-Table_UN-Proclamation_21-December-2017.pdf

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B4 How can sharing the research on high school chemistry teaching strategies, and models of teacher professional development, contribute to chemistry education at the tertiary level

Rachel Mamlok-Naaman

Weizmann Institute of Science, Israel

By exploring reforms in the high school chemistry curriculum over the last 70 years, one can observe that curriculum development has always based its ideas on focusing on student learning and on current learning theories (Mamlok-Naaman and Taitelbaum, 2019). However, the focus has changed due to studies conducted with teachers and students, and to educational reforms around the world, especially in the US. For example, laboratory activities developed over the years into inquiry-based experiments, in which high-order skills such as asking questions, hypothesizing, or argumentation were embedded. Science in general and chemistry in particular were presented as an accumulation of facts and laws. From the 1990s onward, however, the activities were designed to encourage the students to use scientific concepts, to understand the meaning of models and modeling, to ask meaningful questions (as a future scientist or citizen), and to learn about the nature of science. In addition, new curricula were developed, based on context, relevance and driving questions, referring also to a diversity of teaching and assessment strategies. Teachers underwent professional development workshops, in which they were prepared for implementing new curricula and respective assessment methods (Mamlok-Naaman, Hofstein and Penick, 2007). Over the years, quite a large body of knowledge was developed regarding high school chemistry programs in teaching, learning, curriculum design, and professional development. It is suggested, that sharing this knowledge with chemistry educators at universities and colleges, may contribute both to high school and to tertiary chemistry education. A few examples will be presented in the conference.

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B5 Mind your language!

Philippa Cranwell
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Chemistry is a subject that requires vertical integration of knowledge and an ability to link different concepts and ideas together that may not, upon first glance, seem to be linked. Language used when teaching chemistry is complex for a range of reasons: everyday words have different meanings (Harrison & Treagust, 1996); large numbers of complex Greek and Latin words are embedded in core terms and phrases; and technical language needs to be used carefully otherwise meanings are lost or altered (Childs *et al.*, 2015). In addition, students also need to become fluent with the many different ways in which a concept or idea can be represented during an explanation. This is particularly the case when explaining reaction mechanisms.

In this study, the complexity of discourse used by seven teachers, four based in university and three based in a school, when explaining electrophilic aromatic substitution (S_EAr) was coded according to the strength of semantic density and semantic gravity (Maton, 2017a-c). It was shown that strong semantic density was exhibited by all participants, but the semantic gravity was weaker for those participants based in university, with more concepts, ideas and theories linked in a phrase or explanation. It should be noted that in this study only the oral discourse was analysed. Intersemiosis, i.e. the interactions between the teacher and curly arrows/diagrammatic representation was not investigated, but will be the focus of further studies.

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Harrison, A.G. & Treagust, D.F. (1996), Science Education, 80 (5), 509-534

Maton K. and Doran Y.J. (2017a), Onomázein, March: 12–45.

Maton K. and Doran Y.J. (2017b), Onomázein, March: 46–76.

Maton K. and Doran Y.J. (2017c), Onomázein, March: 77–110

B6 Identifying barriers and supporting understanding for novice students in spectroscopy

Christine Mundy,
University of Pretoria, South Africa

The aim of this study was to introduce a spectroscopic laboratory experiment that focused on reducing the cognitive load experienced by novice students while promoting understanding in spectroscopy. In terms of Cognitive Load Theory, the information processing capacity of students will be influenced by the high inherent difficulty of spectroscopy, their unfamiliarity with spectroscopy i.e. poor existing schema, and, the mental load added by language translation (as the medium of instruction does not coincide with the first language for large proportion of students). This study is situated in a general chemistry course on an academic development programme at a South African institution. Annually, approximately 80% of the 400-500 enrolled students speak English as a second language.

Initially, a wide range of spectral tools was evaluated in terms of cost, efficiency and simplicity. The mini spectroscope designed by Schwabacher (1999) was therefore selected. The first student barrier identified in the laboratory was the ***Demand of the Task*** which included extraneous load components of redundant information and complex Mini Spec construction instructions. The task was refined (with consent) in terms of layout and construction procedure to reduce cognitive and dexterity demands on students. From this point onwards more subtle barriers to understanding spectroscopy emerged through the qualitative analysis of student report write-ups and recordings of collaborative student discussions: ***Terminology***, particularly the interchange between scientific terminology (e.g. quantized and discrete) and colloquial terminology (e.g. jumps and between), presented a definite barrier for second language students. ***Conceptual difficulties*** are pertinent to all novice students, in this study we sought to interrogate student difficulties with the threshold concepts of electron transition and photon energy, as isolated in literature. Finally, ***Scientific fluency*** has emerged as a barrier in understanding spectroscopy: students require support to articulate the links between the macroscopic laboratory observations and the atomic and electronic representations taught in lectures.

B7 Escape room- innovative method to teach concepts related to the periodic table

Vesna Milanovic, Dragica Trivic, University of Belgrade, Serbia
Marina Stojanovska, Cyril & Methodius University, Republic of North Macedonia

Game-based learning [1,2] can be introduced in schools to support the learning experience, thus helping students to connect the previous knowledge and the one learned from the game. Games are fun, engaging and motivating, and if they incorporate chemistry content, they could be a powerful pedagogical tool with a great educational value. Well-designed educational games develop creative thinking, inquiring and problem-solving skills, higher-level thinking skills, collaborative or cooperative learning, self-confidence and decision making [3]. They encourage discussion among students, but also with the teacher, which is a crucial part in developing thinking, clarification and correction of potential misunderstandings and misconceptions.

The escape room method [4,5] has become a very popular innovative method to the chemistry teaching. Motivated by the International Year of Periodic Table [6], we created and performed several escape rooms related to the Periodic Table concepts in North Macedonia and Serbia [7,8]. Namely, we introduced educational games and puzzles among chemistry teachers within the programme for their continuing professional development in two countries. The escape room included five puzzles: Coded Message, Hidden Words, Improvised Chemistry Competition, Cool Chemistry Coffee Receipt and The Queen and the King puzzle.

This is rather novice and innovative teaching practice in North Macedonia and Serbia and we are optimistic to disseminate this idea further together with the teachers in our countries. These educational games and escape rooms have a potential to increase the students' interest and motivation to learn chemistry.

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B8 A framework for the explicit teaching of Johnstone's triangle, to support conceptual understanding in A level chemistry

Niki Kaiser, Norwich Research School Notre Dame, UK

This study examines whether a 'triangulation framework' helps students develop a deeper and more integrative understanding of key concepts in KS5 Chemistry, by explicitly supporting metacognition. Diagnostic questions were used to monitor the conceptual understanding of a group of students ($n = 16$), all of whom were using the triangulation framework as part of their usual lessons and homework. The tested concepts had been identified in a previous study as particularly tricky for students to master. Student responses and confidence measures from the current study indicated that certain concepts were more problematic than others to understand. Furthermore, similar patterns were observed among a group of science teachers ($n = 300$), tested with the same questions. These particular concepts might therefore be candidates to be categorised as 'Threshold Concepts', characterised as troublesome ideas that are vital for deeper understanding. To master them, students must cross a diverse range of "cross-cutting threshold schemas", some of which are implicit or only indirectly linked. The triangulation framework encouraged students to consciously reflect on their learning processes, a key aspect of metacognition, by prompting them to explicitly link the submicroscopic, macroscopic and symbolic levels (often referred to as Johnstone's triangle) for these key concepts. This is something that experts are able to do fluently, but students (as novices) must be supported to do. Interviews and survey data will be used to assess whether the framework is an effective tool for developing students' ability to independently connect apparently distinct ideas, by identifying implicit connections. Preliminary data indicates that it is a straightforward, transferable framework, which could be applied across many areas of Chemistry to support conceptual understanding.

B9 Organic chemistry going 'flipped' – university students' perceptions of a new teaching and learning approach

Karolina Broman and Dan Johnels,
Umea University, Sweden

Flipped learning approaches have emerged since the beginning of the 21st century with intentions to make students' learning environments more active, and thereby, improve learning outcomes as well as student engagement (Reidsema, Kavanagh, Hadgraft, & Smith, 2017). We have studied an organic chemistry university course both quantitatively and qualitatively for three years when changing from a more conventional teaching method to a new pedagogical approach (i.e., flipped learning). Empirical data are presented in Table 1.

Table 1. Collected empirical data.

	Year 1 (2017)	Year 2 (2018)	Year 3 (2019)
Students (n)	36	35	32
Surveys 1–2–3 (n)	33–23–20	32–25–26	32–22–*
Interviews (n)	7	11	*
Observations (n)	5	4	5
Statistics from the learning platform	Yes	Yes	Yes

* Data will be collected spring 2019

In this project, we analyse students' perceived interest (Krapp & Prenzel, 2011) and value (Wenger, Trayner, & de Laat, 2011) when meeting this new approach. How students value the different learning material and how they made use of each other through peer interaction when solving problems together will be discussed according to both constructivist and socio-cultural perspectives. Furthermore, students' own perceptions of how they used the course material related to an analysis from the learning platform of how the material actually was used will be presented together to explore how flipped learning have been applied within the course.

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O1 The effect of the development of the experimental design skills on the students' attitude

Zoltan Toth
University of Debrecen, Hungary

Pre-service and in-service chemistry teachers need to consider how their primary and secondary school students' attitude could be influenced by the instruction methods they use. In an earlier brief empirical research [1] 'step-by-step' experiments were modified to practical activities requiring one or more steps to be designed by the students. Although the results were encouraging in terms of skills development, the intervention was too short to draw conclusions about its influence on the students' attitude. Therefore, the present longitudinal study takes four school years and intends to investigate the effectiveness of the approach in long term. Over 900 students have been involved. All were 12-13-year-old at the beginning of the study.

The participating classes were divided into the following groups:

- Group 1 (control) only carries out 'step-by-step' experiments.
- Group 2 carries out the same 'step-by-step' experiments, but also solved experimental design tasks on paper in the first year. From the second school year, the principles of the experimental design (e.g. 'fair testing') related to the activities were explained for them after doing the experiments.
- Group 3 has to design some of the same experiments than the other two groups do. From the second year, clues of applying the principles of the experimental design related to the concrete tasks were given to them before they started the planning.

The impact of the intervention on the following changes have been measured by structured tests:

- Changes in the end-of-semester science/chemistry grades.
- Changes in how much the students agree with these statements:
 - I like science/chemistry.
 - It is important to prove ideas in the sciences by experiments.
 - I prefer the 'step-by-step' experiments to the ones that I have to design.

The results of the first three years and how they have been used in chemistry teacher education is presented by the poster.

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O2 From research into education: Linking chemistry with chemistry education and digital media

Stefanie Herzog, Leibniz Institute for Science and Mathematics Education, Germany

Norbert Stock; Department of Chemistry, Kiel University, Germany

One criticism in the education of teachers is the separation between the learning of content knowledge (ck), pedagogical content knowledge (pck) and pedagogy, not leading to the expected holistic competence required for teachers. Researchers around the world have therefore analysed and developed approaches of how to better link and reflect models and modules of teacher professionalization programs especially with regard to pck frameworks [1]. A second important issue is the potential gap between ongoing chemistry and chemistry education research and teaching practice, both at universities and in schools. The content of curricula in school and teacher education do rarely interlink basic concepts to state of the art research and societal contexts [2].

This talk will address both demands and present an approach developed at Kiel University as part of the German-wide teacher education quality program [3]. The course combines a chemical research topic, like porous material or switching colours, with a reflection on chemical education research, e.g. on beliefs about the Nature of Science, or learning with representations, and the development and use of multimedia tools, like molecular modelling, simulations or videos. The course applies a co-design and team-teaching model, led by a chemist and a chemistry educator but also involving experts on media or student research labs. The resulting student products are distributed via an Open Educational Resources portal and implemented into an in-service training for teachers after quality control.

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O3 Science pre-service teachers' TPACK and beliefs about learning with digital media

Julian Kusel and Silvija Markic
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Even if the technical possibilities and ICT are given, in Germany one of the biggest obstacles for teachers in using digital media is a lack of expertise and their poor competencies in this area. In order to develop this knowledge and skills, pre-service teachers in general and chemistry in particular need specific education at the early stage of their university teacher education program. However, this is mainly not the case. To close this gap and prepare future science teachers for teaching and learning while using digital media, a concept for a seminar for pre-service teachers of chemistry and primary science is developed, implemented and evaluated. Our seminar is based on a blended learning approach and focuses on individual, student-centered as well as cooperative methods. It discusses new organizational possibilities and digital learning media in science classes. Conceptual focus of the seminar is the development and production of educational videos with lesson plans on a certain scientific topic. The main goal is to provide skills and knowledge about digital media in science classes and change - if needed - students' beliefs regarding the usage of digital media in a positive way.

Next to the feedback for further development of the seminar, the evaluation focuses on pre-service teachers' beliefs and their *technological pedagogical content knowledge* (TPACK) regarding digital media in science education. Different quantitative and qualitative methods were combined in a pre-post-follow up-research design. The oral presentation will focus on presenting the design of the seminar, used methods as well as the results of the evaluation. The implications for the next seminars will be given.

O4 Chemistry self-concept: Psychological patterns and relations with gender and culture

Lilith Ruschenpohler, Ludwigsberg and Silvija Markic
University of Education, Germany

Girls tend to doubt their abilities in science more than boys do. Research shows that the same is true for some minority students – they have lower self-concepts in science. In the present study, we investigated these relations for chemistry with secondary school students in Germany. We employed a questionnaire measuring self-concept, learning and social goal orientations, and the understanding of chemistry language (N=585). We analyzed (i) differences in chemistry self-concept regarding gender and cultural background. This was done with a robust ANOVA using a subset (N=316) of boys and girls without migration background and with Turkish background. In these groups, sample sizes were sufficient. In addition, we analyzed (ii) the relation of chemistry self-concept with learning goal orientations, the perception of the social context, and the scientific language in chemistry. This was done with a multiple linear regression using the whole sample (N=585). (i) We found that among students without migration background, boys show stronger self-concepts than girls. Among students with Turkish background, however, the relation is inversed with girls showing stronger self-concepts than boys. It thus seems that the students' cultural background has an influence on their chemistry self-concepts. (ii) Furthermore, we found strong relationships between self-concept and learning goal orientations, as well as with perception of scientific language in chemistry. In addition, the relationship with the teacher seems to have an impact. This points out the key role that self-concept plays in the students' learning goal orientations. The results of the study will be presented in detail and first suggestions for chemistry teaching discussed.

O5 Teaching of the experimental design skills

Edina Kiss, Luca Szalay and Zoltán Tóth, Eotvos Lorand University, Hungary
Pázmány Péter, University of Debrecen, Hungary

Tried and tested ways of active learning have to be taught to pre-service and in-service chemistry teachers. In our earlier empirical research [1] established 'step-by-step' instructions were modified to practical activities requiring one or more steps to be designed by the secondary school students. The results suggested that many 14-15 years old students benefited from the intervention. The longitudinal study to investigate the effectiveness of the approach for younger students and over a period of time took the form of a four year research project that began in September 2016. 920 students have been involved, who were 12-13-year-old in the beginning of the study. The impact of the intervention on the students' experimental design skills, disciplinary content knowledge and attitude toward chemistry is measured by structured tests. Several chemistry teacher students have been involved in the research.

Since the first school year of the project did not produce the expected results, in the year 2017/2018 and 2018/2019 the student sheets of the experimental groups already contained the main principles and ideas of designing experiments, related to the concrete tasks. For instance, how the 'fair testing' had been applied was explained to the students of one of the experimental groups after they carried out the 'step-by-step' experiments. Meanwhile, the students of the other experimental group were given clues how to apply the 'fair testing' before they had to design the very same experiments. (The control group always gets detailed 'step-by-step' instructions for doing the same experiments.)

The post-test in the end of the second school year showed that the students of both experimental groups could design experiments more successfully than the students of the control group. The lecture provides the main results of the first three years of the research and how they have been used in our chemistry teacher education.

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O1 Teaching assistant's' PCK for first year organic chemistry: Opportunities for intervention

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Many tertiary institutions employ graduate teaching assistants (TAs) to support teaching and learning at undergraduate level. Graduate TAs are content specialists, however usually with limited teacher training and experience. Current research on the relationship between content knowledge, CK, and Pedagogical Content Knowledge, PCK, confirms that while CK is a necessary requirement for the development of PCK, good CK does not necessarily translate into high levels of PCK. The training of graduate TAs for their teaching task can be improved if informed by a good understanding of deficiencies in their Topic Specific PCK, TSPCK.

This paper will report on the validation of an instrument designed to probe CK and PCK in basic concepts of organic chemistry using the Rasch measurement model, and its application to measure the performance of TAs and high school teachers, where the cohort of teachers served as reference. The Rasch analysis provided empirical evidence for validity, reliability and unidimensionality of the instrument. As expected, the TAs' performance on items probing two TSPCK components, Students' Prior Knowledge and Conceptual Teaching Strategies, was mainly at the limited or basic level while scores for an item probing Representations, were mainly at the exemplary level. However, their ability to choose the Big Ideas in chemistry and to sequence them for teaching was unexpected. Evidence suggests that several of the TAs had developed a deep conceptual understanding of the knowledge structure of organic chemistry, which will serve them well in their teaching role. However, training programmes should focus on students' prior knowledge, an appreciation of the importance of content topics for subsequent themes, and conceptual teaching strategies that are suitable to promote mastery in organic chemistry.

O2 First year undergraduate student expectations of chemistry degree programmes in the UK

Dylan Williams, University of Leicester, UK

Shane Lo Fan Hin, University of Sussex, UK

Erlina, Tanjungpura University, Indonesia

Recent work on student perceptions of skills development and engagement with different teaching and learning approaches have provided useful evidence bases for practitioners aiming to enhance the student learning experience. Although there has been some useful research on student expectations in non-STEM (Science, Technology, Engineering and Mathematics) disciplines, there remains an opportunity to measure and analyse the expectations of students in STEM disciplines, particularly chemistry. The aim of this study was to measure the expectations that first year undergraduate chemists have of the types of learning experiences that will be included in their degree programmes, the amount of time per week that they will devote to different aspects of study and the types of learning behaviours they will adopt. Data was collected using questionnaires deployed at the Universities of Leicester and Sussex in the 2017/18 academic year. The study has showed that many students overestimate the amount of lecture based (59%) and small group based (57%) contact time they expect to have. Students appear to place a high value on the importance of feedback in the learning process but the proportion of students who agree they will read and act on feedback decreases over the course of the academic year. A number of factors feed into student reflections on the difference between expectation and reality including the quality of student life (e.g. quality of accommodation and social activities), value-for-money concerns (e.g. the amount of contact time and the quality of teaching) and matters related to workload and learning support. This presentation will provide an overview of these findings along with a discussion of how the lessons learnt from this study has shaped new student support mechanisms and curriculum innovations.

O3 Were students better in the old days? Rasch analysis of three first approaches to university chemistry and a model for benchmarking between universities

Danny Bedgood, Charles Sturt University, Australia

Yann Guisard, Charles Sturt University, Australia

Damien.Laird, Murdoch University, Australia

Celia Barril, Charles Sturt University, Australia

Julia Howitt, Charles Sturt University, Australia

Paul Prenzler, Charles Sturt University, Australia

Danielle Ryan, Charles Sturt University, Australia

Lachlan Schwarz, Charles Sturt University, Australia

Rasch Analysis is a statistical and probabilistic analysis tool being used to examine chemistry exams across subjects, years, student courses and gender, and across universities. Rasch analysis converts the raw student performance on an exam - representing “ability” - **and** the performance of exam questions - representing “difficulty” - into a unified scale of measurement called “logit”. It therefore allows the academic to compare the performance of students versus that of the questions using a single understanding of “performance”. Rasch Analysis allows the academic to compare the student versus question performance using a single understanding of “performance” independent of cohort size. As to date there have been few applications of Rasch analysis to the examination of university chemistry assessments.

This talk will report on how this method is being used – for instance in:

- validation of exams;
- examination of topic coverage/question difficulty across and between four different first year chemistry classes;
- examination of student performance from a demographic perspective such as course and gender;
- changes in student and exam performance over time;
- comparisons of student *and* exam performance between two Australian Universities.

Such comparisons between universities could be used to benchmark exams, exam questions, subjects (and perhaps student abilities) between universities.

B1 Hands-on laboratories and online assessment

Row Lowry
University of Plymouth, UK

The virtual lab cannot completely replace the acquisition of skills provided by a real laboratory (1). Hence, the hands-on acquisition of data is an essential part of scientific training.

However, the subsequent marking and feedback can take a considerable amount of time, because the marker must check calculation steps follow from a student's data. Add to this the need to "carry forward" an error and the marker can find that the only way to provide meaningful feedback is to complete the calculations themselves for each student.

Computers would seem ideally suited to this task and there have been some attempts to use common VLE elements to do this (e.g. 2), but the variability of both the students' raw data and the misconceptions that might arise at each calculation step make this onerous.

In response to a large increase in numbers on our foundation chemistry modules, we have implemented formative and summative post-labs using "smart worksheets" developed by Learning Science Ltd. These allow students to input their raw data and the results of subsequent calculation steps. In formative mode, these are checked at each step and feedback given instantly, including the opportunity to re-calculate and re-input. In summative mode, the feedback is deferred until the deadline is passed.

This presentation will demonstrate the system and the specific feedback available. Student feedback shows that they appreciate the mix of formative and summative assessments using the same system and the speed at which feedback is given. It will also discuss the effect upon results (in terms of mark distributions and successful submissions) for the past 2 years (350+ students.) Comparisons with previous cohorts yield interesting differences, which are discussed in terms of learning outcomes and the nature of assessment.

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2. Whitworth, D.E. & Wright, K. *Brit. J. Educ. Technol.* **46**, (2015), 1201-1213

B2 Going paperless: The digital teaching laboratory

Anna Bertram
University of Nottingham, UK

The use of virtual learning environments to support teaching in universities has become common practice providing a flexible platform to deliver content. Many chemistry departments now provide a wide range of learning resources to support practical modules, including books, videos, animations, quizzes and assignments. These resources have normally been used either pre- or post- laboratory but advances in computer technology in the past few years has made the use of tablet computers in laboratories more viable, this has paved the way for a whole new approach to the integration of e-learning resources in laboratory teaching. In the STEM laboratory in the School of Chemistry, we are very fortunate to have tablet computers provided for each student to use whilst in the laboratory, something that is still quite uncommon across science schools and departments in UK universities.

This presentation will briefly outline advances made in the online provision of resources to support practical modules in chemistry made possible by the provision of tablet computers; these include the provision of interactive experimental procedures; the recording and reporting of analytical data; note taking; the laboratory-based electronic assessment and feedback of experimental data by demonstrators.

The presentation will highlight the development of an electronic laboratory notebook using Microsoft OneNote Class Notebook and a recent trial of Microsoft Teams. The ELN allows students to work collaboratively in teams, to share experimental data and notes, ELN's are common in industry so this has been an important development in preparing students for the workplace.

In summary, this presentation will describe how practical learning environments in Chemistry at Nottingham are evolving and will provide details of a framework that other schools and departments in any practical subjects may want to adopt.

B3 Reinvigorating first year laboratories at Australia's oldest university

Stephen George-Williams, Reyne Pullen and Siegbert Schmid
University of Sydney, Australia

It is becoming a well-known fact that undergraduate teaching laboratories around the world are often expository or recipe-based. These laboratories have been noted to result in disengaged students who simply perform the laboratory tasks with little to no critical thought. In response to this, there has been a dramatic increase in the use of context/inquiry-based activities which seek to situate the tasks in real world activities and to allow students to undertake investigations rather than following a series of steps.

The physical environments within which these laboratories occur are an oft neglected area in these investigations. Psychology research shows strong effects on learning outcomes when the architecture of a given physical space is designed to better allow for modern teaching and learning pedagogies/practices, such as the use of circular tables to encourage social interactions between students. To date, little to no literature covers the effect of the physical laboratory space on student learning before and after a given intervention.

This talk will cover the set-up of a two-stage intervention at the University of Sydney on the first-year chemistry laboratories. First, an overhaul of the 60-year-old physical laboratory environment to include the use of hexagonal laboratory benches to encourage student discourse. Second, a significant redesign of the laboratory activities with the primary goal of increasing student engagement through context/inquiry-based experiences. Overall, these changes are intended to result in higher student retention into later chemistry courses.

This intervention will be monitored using surveys of approximately 2000 students and 60-70 teaching staff. Student and teaching staff perceptions towards the physical laboratory environment will be monitored using the Chemistry Laboratory Environment Inventory (CLEI). Student attitudes towards chemistry will also be monitored using the Questionnaire on Chemistry-Related Attitudes (QOCRA) whilst their perceptions of the individual laboratories will be investigated using a survey refined at Monash University.

B4 Teaching HPLC method development through inquiry learning: Construction of a virtual lab

Laurence Orlando, Stefan Huth and Carson Yuan, Monash University, Australia

Robert Hubal and Jason Whitley, University of North Carolina, USA

Gareth Williams and Satinder Sembi, University College London, UK

HPLC is one of the most used analytical separation methods. Despite its significance in the workplace, HPLC is typically taught only at a surface level at university; vital aspects, such as the systematic development of HPLC methods, are generally not addressed.

In a collaboration under the PharmAlliance umbrella (including Monash University, The University of North Carolina and University College London), a sophisticated online platform has been developed to help students acquire HPLC technical and method development skills through an inquiry approach. This tool guides students on how to make sound scientific decisions when undertaking authentic HPLC method development, thereby effectively preparing them for the workforce.

The interactive, dynamic online HPLC simulation platform consists of three components:

- 1) 3D virtual HPLC laboratory: Students visualize the complex mechanisms of the HPLC components (pumps, injectors, detector) and follow realistic procedures to set up different HPLC instruments for sample analysis.
- 2) Data acquisition simulator: For a set of seven model compounds, students choose the level of any parameter that can be controlled and receive the corresponding chromatogram output with all the HPLC response values.
- 3) Education module: In four cycles of activities (Retention factor, Selectivity, Efficiency, Gradient) students systematically develop a HPLC method. The activities include dynamic quizzes designed to address common misconceptions via a Socratic questioning approach, in which students progress through the quiz on customised pathways dependent on their responses. Other activities scaffold the process of data evaluation, analysis and interpretation and the generalization of rules that determine HPLC performance, leading to a deep understanding of the phenomena underlying analytical separation. All activities are auto-assessed and provide automated feedback.

The first version of the platform is currently undergoing testing with students at Monash University. Evaluation of the tool will focus on the development of students' analytical reasoning skills.

B5 Resitting the exam! Learning retention in a first year chemistry course

Barbara Macfarlan and Antonio Patti²
Monash University, Australia

The use of exams to test knowledge and understanding on completion of a chemistry course is universal practice and generally the exam is undertaken not long after the course activities have been completed. Students will traditionally “cram” for the exam relying on the shorter term retention of facts and the ability to apply these facts in problem solving and demonstrating understanding. How much of this learning is retained in the short term or even the longer term?

In this study, two groups of volunteers who had undertaken Monash’s second semester first year chemistry course, CHM1022, in 2018. The two groups were given the task of resitting the exam they had previously undertaken approximately six months before, under the same exam conditions. The study groups were divided into two categories; one group consisted of 15 students who were continuing with further studies in chemistry in 2019 and the other group consisted of 15 students who were no longer taking any further studies in chemistry. The volunteers were not provided with any information regarding the task that they would be undertaking so that there was no opportunity to prepare for the exam again. They were simply told that the activity involved an evaluation of chemistry courses and were to be paid for the three hours of time required for the activity.

The “repeated exam” was marked by the same people who marked the first sitting of the paper and the results obtained by each individual was compared with their performance in the first sitting. A debriefing session after the activity was conducted to gauge the participant views of the activity and assure them that this activity had no impact on their previous result and their second results would be shared for interest only. The outcome of this study will be presented.

B6 Chemistry education of the elementary pre-service teachers

Dragica Trivic and Vesna Milanovic, University of Belgrade, Serbia

During the past fifteen years, students of the University of Belgrade - Faculty of Teacher Education learned chemistry within the course Introduction to Natural Sciences. In the realization of this course, teachers from three faculties of the University of Belgrade (the Faculty of Biology, the Faculty of Physics and the Faculty of Chemistry) were engaged. Elementary teachers educate children ages 6 (or 7) to 10. At the beginning of work we usually faced with the situation that the elementary pre-service teachers did not like chemistry and they did not feel confident in their knowledge of chemistry. Because of that during the previous period we continually developed syllabus for chemistry teaching and learning within science education of elementary teachers and changed the activities in the classroom in order to improve their knowledge, skills and attitudes toward chemistry and to prepare them to teach chemistry contents within science effectively.

In this presentation the structure of syllabus for elementary pre-service teachers' education in chemistry, the directions of its development, the activities in the classroom, as well as the formative and summative assessment will be shown. We will also consider the problems and obstacles in the education of elementary teachers in the field of chemistry and sciences that are, despite our efforts, remain unresolved.

Acknowledgements

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O1 Making chemistry relevant for pharmacy curricula

David Manallack, Joseph Nicolazzo and Daniel T. Malone
Monash University, Australia

Globally, major curricular updates are being made to pharmacy courses driven by the need to develop graduates with advanced clinical skills and practice knowledge. As such, there has been a need to better integrate fundamental sciences into healthcare courses [1]. To avoid losing relevance, chemistry needs to demonstrate links to either a formulation or to pharmacotherapy. This project is oriented to ascertaining what chemistry is needed and devising appropriate teaching material [2].

The current study consists of two components. The first is to survey pharmacists about the role of chemistry in their clinical lives [2]. Likewise, academics involved in teaching chemistry will be probed on their perceptions of how to establish chemical principles and provide relevance to pharmacy practice. Qualitative data will initially be gathered to facilitate refinement of surveys prior to wider dissemination (c.f. [3]).

The second aspect of this study concerns the development of engaging and significant chemistry material to highlight the relevance of chemistry in the pharmacy curriculum. This will take the form of a series of chemistry stories that will be made available worldwide through PharmAcademy [<https://pharmacademy.org/>]. Students will subsequently be surveyed on their opinions about the utility and relevance of the material.

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2. Fernandes, J.P.S. The importance of medicinal chemistry knowledge in the clinical pharmacist's education. *Am. J. Pharm. Educ.*, 2018, 82, 106-14.
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O2 EuChemS course 'Good chemistry, methodological, ethical and social implications'- case study from Poland

Iwona Maciejowska
Jagiellonian University in Krakow, Poland

The EQF, including the Polish Qualifications Framework, define the expected learning outcomes in the field of knowledge, skills and social competences. In Poland the latter are described in three categories: identity, cooperation, responsibility (the so-called universal descriptors), and at the seventh level of EQF, that is master's studies, as fundamental aspects (the second stage generic descriptors): critical approach, fulfilling social obligations, action for the public interest, independence and development of professional ethos (<https://depot.ceon.pl>). Although we would all like university graduates to show such attitudes, for many reasons we rarely develop them on our own courses. On the other hand, as academic teachers, we often complain about students that they can not ask questions, plan research, that they do not pay attention to the consequences of their actions, that they are not able to work in teams efficiently, that they uncritically duplicate stereotypical opinions. Therefore, a team of people representing EuChemS (the European Chemistry Society), and in particular: chairman of Prof. David Cole-Hamilton, members of the Division of Chemical Education and Working Party on Ethics in Chemistry, proposed building an on-line course for graduate students and doctoral students who would fill this gap. This was the course of Good Chemistry - Methodological, Ethical and Social Implications. Applying the fundamentals in philosophy of science and research ethics to the particular conduct of science and its internal and external domains of responsibility is expected to sharpen and solidify the students' awareness for the theory of research practice, their knowledge of ethics and their ability to exploit ethical thinking for the application in the social sphere science and technology as a field of human activity that impacts the quality of life of people all over the planet. (<http://www.elearning-euchems.eu/>). The presentation will present the experience of piloting this course in Poland which took place in the winter semester of 2018/19.

O3 How do students become experts? Development of domain specific fluency in a course of materials chemistry

Stefanie Lenzer and Nicole Graulich
Justus-Liebig-University Giessen, Germany

The development of clean-energy storage systems, harvesting technologies, and new functional materials are only a few of many contemporary challenges in sciences. In order to address these challenges, problem solving is a central skill in the 21st century. Current research revealed, however, that experts and students differ in terms of their problem-solving skills. Experts in a domain are fluent in using different resources to solve domain-specific problems, whereas students use formulas, devices, or measurement methods algorithmically without developing an awareness of how these resources contribute to a problem solution. In most cases, the students are not aware if and why the resources are appropriate to solve the respective problem. To acquire expertise in a domain, it is necessary to develop a domain-specific fluency, i.e. an awareness of various domain-specific resources and their usage in problem solving.

As we were interested in supporting students' domain-specific fluency in a course of materials chemistry, we designed and implemented a project-based learning environment in which students worked in small groups on a domain-specific problem using typical "resources", such as the software FullProf, three-dimensional models of crystal structures, and X-ray diffraction.

The entire project work was monitored with audio diaries and interviews in order to determine if and how students achieved domain-specific fluency. The data was analyzed based on the theory of *disciplinary discernment* by Eriksson et al. (2014) that describes students' awareness of domain-specific resources at different levels, ranging from *identification* to *evaluation*. In an additional analysis, students' individual problem-solving steps within their project were characterized and combined with students' awareness level of each resource. This allowed us to describe how students' domain-specific fluency developed within the learning environment.

B1 Student understanding of graphs in chemical kinetics – mathematical narratives and the crossroad between chemistry and mathematics

Felix Ho and Maja Elmgren, Upsalla University, Sweden
Jon-Marc Rodiguex and Marcy Towns, Purdue University, USA
Kinsey Bain, Michigan State University, USA

Graphical representations are an important tool for modeling abstract processes in chemistry, with a combination of mathematical and chemical expertise being required to reason about relationships between variables and to describe the phenomena represented. In this work, we studied students' graphical reasoning in the context of chemical kinetics to understand how students use mathematics in combination with their knowledge of chemistry to interpret concentration-versus-time graphs. Student responses to short-answer assessment questions were collected for a sample of 70 first-year students in a chemistry course at a Swedish university. The assessment items emphasized conceptual understanding, requiring students to integrate chemical and mathematical knowledge in interpreting somewhat unfamiliar graphical data, including a more open-ended, "ill-defined" problem having not just one correct answer.

Student responses were coded to analyze the chemistry concepts and mathematical ideas that students attributed to the graph. Mathematical reasoning was analyzed using a framework based on symbolic forms and the shape thinking perspective of graphical reasoning, with further analyses focusing on the extent in which students integrated their understanding of chemistry and mathematics. The analyses showed the different levels and kinds of chemical and mathematical resources that were activated by various students in the task. The most successful students were able to construct productive mathematical narratives integrated with underlying and plausible chemical explanations to discuss the "story" communicated by the graph. In addition to presenting these results, the challenges associated with multiple representations in chemistry (the "chemistry triplet") in the context of mathematical modelling will be discussed. These analyses have provided insight can be translated into proposals for instructional practices that promote deeper understanding and connections between chemical processes and their mathematical models.

B2 Using infographic creation as a tool for science communication assessment and means of connecting students to local research

Richard Blackburn
University of Leicester, UK

Students were asked to each create an infographic based on one of their host department's research articles as a new exercise within the "science communication" training programme of the degree. Whilst infographics have been used as an educational tool by instructors, relatively few instructors have tasked their students with creation of one. The appeal of the infographic for the assignment was the combination of knowledge acquisition, summarization ability, scientific communication and information. It was also realized that by necessity students would have to limit the amount of text they used and would therefore have to think more carefully about the information they were reporting. To this end the task proved a useful way to distil out key information with students doing an excellent job of just selecting the key information to report. Furthermore, the activities insistence on using Leicester articles helped students relate to their department's research culture and the previously un-seen world of their lecturer's research focus. The assignment has also helped to contextualize why certain lecturers had been chosen to teach their allocated subject and helped the undergraduates recognize what research is associated to the traditional inorganic, organic and physical lecture themes.

B3 Flipped problem classes to assist case study teaching of synthesis

Richard Blackburn
University of Leicester, UK

For an advanced-level module associated with designing drug syntheses, a set of homework tasks were created to help students prepare for their retrosynthesis exam. In short, students were asked to solve the next case study as homework, effectively writing the next lecture's notes in advance of the session using requisite knowledge and moderate instructor guidance. The contact sessions were now utilised to publically discuss the student's attempts with that of the instructor. The tasks were guided to begin with, with the level of independence being increased chronologically and completed answers and notes were generated in the contact sessions. This active learning environment saw a much broader coverage of organic chemistry than the traditional format and was enjoyable for staff and student. The seminar format also provided much needed opportunity to discuss the varied synthetic routes that were possible to the same molecule and the fact that various different reagent combinations existed for the same transformation. The format was highly successful in engaging and assisting students with the challenging topic of retrosynthesis, with the students who did the homework being very complimentary of the system. The collected feedback indicates effectiveness towards synthesis education and exam preparation with an increase in confidence with synthesis and retrosynthesis problems being reported. The provision of these activities may have also contributed to the increased attainment and the benefits apparently spread into other synthesis based modules they were taking at the same time.

B4 Popular science articles as the auxiliary method for chemistry teaching for non-chemist students

Ketevan Kupatadze
Ilia State University, Georgia

The presented oral presentation reviews popular science articles (these articles are published in online magazine "The Teacher") as one of the methods of chemistry teaching for non-chemist students at the University level. It describes which didactic principles they are in line with and how this type of articles can be used in order to kindle the interest of students and generally, the readers of other specialties, in chemistry. The articles review the main topics of inorganic/organic chemistry, biochemistry. A part of the articles are about "household" chemistry. Most of them review topics from ecological chemistry in a simple and entertaining manner. It is important to provide information for the new generation in the right direction to know the essence of the problem and the risks. Correspondingly, the society will get the member, if not the future environmentalist, who will take care of the environment.

The main focus is on the language and format of popular-science articles. Chemical topics are related to poetry, literature, chemistry history or simply, to fun news.

It also reviews the students' interview results about the usage of popular science articles in chemistry teaching process for non-chemist students and for teachers in-service and pre-service.

The aforementioned pedagogical study revealed that the popular science articles contain useful information not only for the students of other specialties, but also for future biologists and ecologists (having chemistry as a mandatory subject at their universities). The articles are effectively used by teachers on chemistry lessons to kindle students' interest in this subject.

B5 Slovenian university teachers' approaches in teaching chemistry

Iztok Devetak and Janez Bogrinc
University of Ljubljana, Slovenia

Teaching chemistry at university level can be organised in different ways. Research in recent years indicates that students should engage in more active role during their attendance to organised work at the university. However, Slovenian university teachers very often use traditional tertiary pedagogy, such as lectures (frontally organised, with PowerPoint slides with students in the role of listeners), laboratory work (students work in groups, pairs or individually following written instructions for conducting experiments) and seminars (students solve tasks individually or in pairs with teachers' presenting the solving strategy writing on white boards) in average. In recent years, the meaning of more flexible teaching approaches at university level is emphasised. For these purposes, projects for teaching university teachers how to use more flexible teaching approaches are implemented. The purpose of this presentation is to present the current situation in the field of teaching approaches used by university chemistry teachers and to analyse their views about their teaching approaches. An on-line questionnaire was developed to gather data about using different teaching approaches, on teachers' self-assessing about how much they are educated to use different teaching approaches, where they gained this knowledge and which knowledge about teaching approaches they still need. The questionnaire was send as an attachment to 150 teachers and teaching assistants of chemistry courses at three public universities in Slovenia. The data was analysed to show the level of participants' flexibility of teaching approaches. Additional data were obtained also by the open ended questionnaire comprising questions about assessment approaches that university teachers use and were fulfilled by students. Based on the data we can conclude that teachers would need a special program where they would gain in-depth pedagogical knowledge about different teaching approaches – more general and also specific for chemistry teaching at university level.

B6 Challenges for scientists' career evolution

Pascal Mimero,
CPE Lyon, France

One can raise a stressing point in our high speed changing world: how to perform a successful career evolution after several years of professional scientific academic activity, moving to a private company by choice or by constraint? Looking at the recent European surveys we can target a tricky equation between employers' expectations, market needs and your skills! Employers' requirements are now seeking at complementary skills: hard skills (technical applied knowledge, expertise, ...) and soft skills (competences not really developed during your training but being more and more appreciated).

Soft skills can be addressed by involving interactive processes: interpersonal skills (behaviour, collaboration, communication, ...), methodologies (problem solving, creativity, analytic thinking, ...), associated to transversal approaches (management, project, quality, safety, environment, CSR, ...).

After a scientific Master-Engineering-Ph.D. diploma, there is a potential evolution even outside of sciences. To illustrate the case, we will enlighten the French Life Long Learning context, with training programs enabling chemists to facilitate the evolution within or outside your tracks: a) pursuing in the scientific environment, updating their knowledge, acquiring new skills, developing new activities, ...; b) giving a new impulse in their career, reaching managerial positions (Project Management, R&D Coordination, Portfolio/Program Management, Industrial Risk Assessment, Quality Management, Regulatory Affairs, etc.).

Professionally, three factors are combined: 1. Human Resources' Service, assisting the professional development of their employees; 2. Chemical Societies, Professional or Sectorial Unions, Associations, may also provide assistance and training programs; 3. "Your" strong will to develop yourself and take the risk to switch. Real professional challenges, and real success stories, to illustrate those career evolutions.

Keywords: Continuing Education, Career Evolution, Life Long Learning

Acknowledgement: CESI Engineering School, CPE Lyon Continuing Education

B7 Systemic cause-effect relation maps (SCREM) to reduce cognitive overload in analytical science

Jerome Randon
University Claude Bernard, France

Depending of the future position of chemistry students, analytical expert or occasional user, knowledge, skills and abilities in analytical techniques will differ a lot in daily work. So, pedagogical strategies can be very different and directed to one of the three extreme situations in relation to specific competencies:

- an application oriented approach, which consist to apply already defined methods
- a technological oriented approach dedicated to instrumentation maintenance
- a phenomenological oriented approach required to develop analytical methods. Of course, each scenario will never be exclusive, and curricula are built with equilibrium between these three extreme situations depending of the targeted trainees, and skills to be developed. Whatever the job position, it will always be necessary for the chemist to adjust analytical methods to obtain a better information, and in such situation, student will be facing an optimization problem.

The main issue encountered by students during the optimization process is related to the apparent multiplicity of relations/equations introduced during analytical lectures. These relations do not give clearly the casual links between operating parameters and quality parameters. If these links are necessary to efficiently optimize analytical methods, the way to build these links is a very difficult task to perform during the learning process. From 2009, we used a pedagogical approach based on "Systemic Cause-Effect Relation Maps" in order to promote the development of skills related to method optimization. This strategy will be presented for different analytical problems, demonstrating how competencies associated to optimization as well as to maintenance were dramatically enhanced.

Such method can be summarized as a paradox: "A systemic approach is required to solve an analytical problem!"

B8 A comparative analysis of chemistry curriculum – dash a possible tool for education reform

Eva Stratilova Urvalkova, University Karlova, Czech Republic

Svatava Janoušková, University Karlova, Czech Republic

Milada Teplá, University Karlova, Czech Republic

The Czech national curricula, Framework Educational Programmes, are currently under major revisions that should be finished by year 2020. There are various sources for curricula improvement, one of them represented by comparative analysis. Traditionally, the focus is aimed on high performers in international educational surveys, such as OECD's PISA. Nevertheless, for the purpose of comparative analysis, the countries with similar cultural and social background are selected. Speaking about Czech Republic, both statistically significant better in science literacy and similar background are countries Slovenia, Estonia or Poland. Moreover, the results of surveys show relatively small differences between the best and worst pupils and a good ability to solve problems.

The contribution will present the results of comparative analysis of chemistry curricula of four countries: Czech Republic, Poland, Slovenia and Estonia. The intended curriculum for lower secondary education (ISCED 2) with the focus on chemistry and all science subject was used for the analysis. The analysis is based on the principles of comparative pedagogy, aimed on subject-specific competencies, the educational content and methods and procedures used in chemistry teaching. Therefore the research questions concentrated into an analysis of instructional time (1), topic areas (2) and recommended methods (3) for chemistry education.

The results have shown that allocated time for chemistry education is almost the same in all studied curricula; the expected outcomes are also comparable, yet Czech learning outcomes are grouped into broad topic areas, with few (and not deeply specified) learning outcomes. Finally, teaching methods are most closely described in Slovenian curriculum, with didactic recommendations for individual subjects.

Under the terms of curriculum revisions, such analysis represents a base for policy makers and possible policy learning approach. The question is where are the limits of policy learning in cases of quite similar curriculum but different students' performances.

B9 Design of a three year laboratory programme for international delivery

Julie Hyde
University of Sheffield, UK

It is starting to become very popular for Chemistry departments in the UK to offer joint degrees with universities abroad. A number of joint BSc programmes exist with China where students can start their university “partner” degree in their home country for three years and complete the final year in the UK. One particular challenge for chemistry courses is to deliver the laboratory abroad away from the home institution, it is unusual for UK staff to travel to China to deliver the practical component. I devised a three year practical laboratory programme to deliver in China to enable students to be fully integrated with the UK students when they travel to the UK for the final year of their degree. I have been spending approximately 3 months each year in China delivering this programme since 2012^{1,2}

My presentation will discuss the basics of setting up a laboratory programme abroad, delivering laboratory skills together with developing students scientific language so they can be fully integrated in the laboratory with the home students when they arrive in Sheffield.

How will the experiments travel? What will the laboratories be like? Can you get the same chemicals and equipment? Will the technician be able to speak English? Will the students have any English skills? Will students have practical skills from their High School courses? All these questions were my concerns before the first year I taught in China, this presentation will answer many of these questions.

Delivering the practical component of a degree away from your home country, at your host university is still a fairly unique idea. Is this you? Don't worry, help is at hand, come along to this presentation where I will share some useful tips and advice and explain where you can find further support and guidance in the literature. **(300 words)**

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O1 'They help you realise what you're actually gaining': Displaying badges to enhance recognition of transferable skill development in undergraduate chemistry

Michelle Hill, Tina Overton, Chris Thompson, Monash University, Australia
Russ Kitson, Paolo Coppo, University of Warwick, UK

Employers are seeking a range of transferable skills from graduates in addition to discipline knowledge and skills. Global trends also indicate graduates will need many skills to adapt to the rapidly evolving factors impacting jobs and workplaces. These skills include critical thinking, problem solving, creativity, communication, teamwork, numeracy, IT, organization, commercial awareness, initiative and others. Academics are building opportunities for undergraduates to develop such skills into the curriculum. However, past studies suggest students may not recognize curriculum-embedded skill development without prompting.

Badging is an easily scalable tool that may enhance skill recognition, and, as called for in the literature, make explicit links between the curriculum and employability. Despite recent interest in badging, there is a lack of literature in this area, with research and discussion typically focused on badges as learning incentives and/or a means of recognition or communication of student competency e.g. of laboratory technical skills. It is believed that the impact of badging course materials on student awareness of curriculum-embedded transferable skill development has not been reported to date.

In this mixed methods study, eleven skills badges were developed and applied to relevant laboratory online and hard copy instructional materials of two second year chemistry units at Monash University and the first and second year chemistry laboratory modules at University of Warwick. Student surveys and focus groups discussions were carried out both before and after badging course materials and staff interviews were also conducted.

Results indicated that more than half of students found the badges helpful and student recognition of the development of some transferable skills increased. Qualitative analysis of student and staff views suggest a number of strategies for maximizing the impact of skills badging. Further research is underway to extend the badging in undergraduate chemistry contexts and explore whether additional impact can be achieved.

O2 Contextualisation strikes back!

Katherine Fernandez, Chris Thompson, Nirma Samarawickrema, Monash University, Australia
Tina Overton, Monash University, Australia and University of Leeds, UK

The ongoing debate on the relevance of foundational subjects like chemistry and biochemistry to the health sciences stems from a lack of emphasis on clinical contexts ([1](#)). This has led to a foundational-clinical gap and negative perceptions of these subjects. To bridge the gap, a CUBHS (*Context based Undergraduate Biochemistry for Health Science*) resource for pharmacy students was developed. It aimed to link (*foundational*) knowledge of intermolecular forces of attraction between protein and drug molecules and (*clinical*) drug-based treatment of epilepsy.

To develop the CUBHS resource, focus groups were conducted with students, academics and clinicians. Their input formed the basis for the resource design. The resulting CUBHS resource was piloted with a first year pharmacy cohort, in 3 stages. In stage 1, the cohort was introduced to a protein molecule through a clinical scenario. In stage 2, the link between protein's binding properties and the drug's pharmacological effect was established through collaborative learning. In stage 3, the resource was evaluated through survey and interviews.

Survey data showed that the cohort strongly agreed that CUBHS resource: linked the foundational knowledge and the clinical application, contextualized foundational knowledge through a relevant scenario and enabled them to visualize the interactions in protein and drug binding. The interviews revealed that CUHBS resource: provided diverse learning opportunities, initiated stronger willingness to learn and facilitated collaborative construction of knowledge. These are necessary ingredients for engagement and success in learning ([2](#)).

In conclusion, the CUBHS resource linked foundational knowledge and clinical application.

O3 Systems thinking in green chemistry education

Glenn Hurst, James Clark, Louise Summerton, Avtar Matharu, Jonathan Miller,
Lucy Mackenzie, and Matthew Lees University of York, UK
Michael Wentzel, Augsburg University, USA

Significant impetus for the inclusion of green and sustainable chemistry practices in educational environments across the globe has been facilitated via the creation of the United Nations (UN) Sustainable Development Goals (SDGs) in 2015.¹ These objectives seek to address global challenges relating to poverty, inequity, climate, environmental degradation, prosperity and peace and justice. Due to the interconnected nature of the SDGs, meeting such objectives in an educational context can be achieved by integration of systems thinking approaches into the curriculum.² By studying the interdependence of components in dynamic systems, students can transition from a fragmented and reductionist knowledge of subject matter to a more integrated and lateral understanding of concepts, resulting in deeper learning. As a discipline, green chemistry is well suited for instructors to adopt a systems thinking approach to education because applications of the principles of green chemistry, employment of life-cycle analysis tools and devising molecular design strategies all depend upon considering the reliance of reactions and processes on one another with local and global systems. Through this, students can be challenged to solve real-world problems in the context of green chemistry with due consideration of ethics to deliver solutions that address the SDGs.

This work shows how systems thinking has been embedded into curricula to teach green chemistry at multiple levels and environments. Specifically, three case studies will be outlined as to how interventions to facilitate systems thinking can be integrated into laboratory environments,³ as part of game-based learning resources⁴ and through partnering with industry.⁵ The efficacy of such interventions with respect to student feedback and learning gain will be outlined.

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O4 Affective chemistry education research: We do not know how to deal with affect

Aishling Flaherty, and Melanie Cooper
Michigan State University, USA

Valiant chemistry education research has sought to gain insight into student affect. The majority of this work is characterised by the reduction of affective constructs such as self-efficacy and attitude into seemingly coherent, stable constructs which can be measured following the development and validation of measurement scales.

These scales have been used to measure aspects of chemistry students' affective architecture such as their attitude, self-efficacy, self-concept, effort beliefs, achievement emotions, academic motivation, beliefs about chemistry and learning chemistry, motivational beliefs, cognitive expectations and individual interest. A great deal of effort has also been invested in using these scales to explore correlations between affective states and performance in chemistry exams.

Despite this work indicating concerning affective states, such as low self-efficacy and low self-concept, as well as a seemingly influential link between affect and performance in exams, we do not know how to deal with affect. This talk will present on two prevailing themes throughout affective chemistry education research, their influences, limitations and implications to what we know, and what we do not know.

O5 Behind closed doors- questions students ask about research

Odilla Finalyson and Komala Pandurangan
Dublin City University, Ireland

First year students often experience science at university in a disjoint, modular and fragmentary manner. A module has been implemented over the last number of years, taken by first year science students, which provides an opportunity for them to bring together their fragmentary knowledge into a learning framework that provides opportunities to link content knowledge from within and across different science disciplines and to develop key skills and competencies. The module consists of a series of problems that are based on science content in first year physics, chemistry, biology and mathematics modules; that enables students to gain an appreciation of the diversity of opinion and develop a better understanding of ethical issues in real-world situations; deals with applications of science relevant / interesting to students; and has 'open' and 'closed' problems.

As part of this module, we have introduced the first year students to (mainly the chemistry) research that is ongoing within the Faculty. Following a general talk about research and its role within the University, small groups of students (in groups of 8) were presented with a research paper / review article based on particular research. Students were then tasked with reading the paper/article, discussing it amongst themselves and then preparing questions on what they had read.

The students then met directly with the researcher who discussed their questions, showed them to their research labs and further elaborated on the research. Following this, the student group then prepared and gave a short presentation on the research to their peers.

In this work, the nature of the questions that were prepared by the groups are analysed and discussed. It is interesting to note the relative frequency of questions seeking clarification or meaning of particular words/facts mentioned in the paper compared to those which addressed the overall application of the research topic.

O1 'What does the term critical thinking mean to you?' A qualitative analysis of chemistry undergraduate, teaching staff and employers views of critical

Stephen Danczak, Christopher Thompson, Monash University, Australia
Tina Overton, Monash University, Australia and University of Leeds, UK

Good critical thinking is important to the development of students and a valued skill in commercial markets and wider society. There has been much discussion regarding the definition of critical thinking and how it is best taught in higher education. This discussion has generally occurred between philosophers, cognitive psychologists and education researchers. This study examined the perceptions around critical thinking of 470 undergraduate chemistry students from an Australian University, 106 chemistry educators and 43 employers of chemistry graduates. An open-ended questionnaire was administered to these groups, qualitatively analysed and subsequently quantified. When asked to define critical thinking respondents identified themes such as 'analysis', 'critique', 'objectivity', 'problem solving', 'evaluate' and 'identification of opportunities and problems'. Student respondents described the smallest number of themes whereas employers described the largest number of themes. When asked where critical thinking was developed during the study of chemistry students overwhelmingly described practical environments and themes around inquiry-based learning. When educators were asked this question they commonly identified critiques, research, projects and practical environments to some extent. This research highlights that there is only limited shared understanding of the definition of critical thinking and where it is developed in the study of chemistry. The findings within this study would be of interest to higher education teaching practitioners of science and chemistry, those interested in development of graduate attributes and higher order cognitive skills (HOCS) and those interested in the student and employer perspectives.

O2 Evaluation of an online course to enhance teaching practice in university science laboratory courses

Claire McDonnell, Technological University of Dublin, Ireland
Natasa Brouwer, University of Amsterdam, Netherlands
Gunther Fleerackers, University College Leuven-Limburg, Belgium
Iwona Maciejowska, Jagiellonian University, Poland
Mauro Mocerino, Curtin University, Australia

Laboratory classes are an essential component of undergraduate chemistry courses and have the potential to achieve a number of practical and theoretical objectives. Students must not only learn manipulative techniques, but also link theory to practice, solve different kinds of problems, interpret data, interact with staff and other students, and successfully navigate the laboratory itself. Learning in this situation can be greatly assisted by an educator who is able to guide students through this complex process. However, the effectiveness of this support can vary significantly. To improve this situation, the European Chemical Thematic Network (ECTN) working group on Lecturing Qualifications and Innovative Teaching Methods developed an online course entitled 'Teaching in University Science Laboratories (Developing Best Practice)'.

The six week course is targeted at relatively inexperienced university teachers. A Small Private Online Course (SPOC) has been implemented in December 2017 (60 participants) and November 2018 (144 participants). Evaluation of the second iteration of the course is underway and, once this is complete and modifications required are made, open access will be provided so that it can evolve into a Massive Open Online Course (MOOC). The evaluation of the two pilot online courses will be discussed, as will lessons learned and plans for the launch of the MOOC. Participants completed pre and post 'Teaching Beliefs and Intentions' surveys as well as a post-course evaluation survey. We were also able to obtain some informal face-to-face feedback provided to one of the course designers from students in her institution who were participating in the online course. This range of data sources has enabled us to gain a depth and breadth of information that has been very useful in shaping the next phase of implementation, the open course, and to establish whether the course had an effect on the teaching approaches of the participants.

O3 Undergraduate research experiences: Insights from weekly reflections

Dorian Canelas, Elizabeth Hunsaker
Duke University, USA

Professionals with science, technology, engineering, or math (STEM) degrees often point to their experiences in formal education as important in developing technical knowledge and individual problem solving skills. However, many members of the STEM workforce wish they had had more opportunities to practice and develop soft or transferable professional skills during their undergraduate education experiences. Two types of curricular experiences provide opportunities for development of these skills in formal settings: the classroom and the laboratory. We have previously compared learner development and use of transferable professional skills in an undergraduate organic chemistry classroom environment. Our latest work in this area focuses on the experiences of undergraduates, graduate students, and post docs in curiosity driven laboratory research settings. In this study, undergraduates were engaged in laboratory-intensive academic research experiences through independent study, volunteering, or work study employment. They were interviewed in several focus groups at the conclusion of the academic year. Some of the topics probed included the lab affiliation process, student motivations, authority versus approachability of their mentors, communication skills, and time management. In-lab mentors, the graduate students or postdoctoral researchers who work most closely with undergraduates on research projects, were also interviewed in separate focus groups. A subset of the graduate students and postdoctoral researchers then used a reflection guide to record weekly audio logs about their experiences working with the undergraduates over the course of the following fall semester. Themes that emerged from the qualitative analysis of 130 of these logs will be reported. This is new, on-going, unpublished research.

P1 Developing high quality online course for chemistry educators without a budget

Natasa Brouwer, University of Amsterdam, The Netherlands
Gunther Fleerackers, University College Leuven-Limburg, Belgium
Iwona Maciejowska, Jagiellonian University, Poland
Claire McDonnell, Technological University Dublin, Ireland
Mauro Mocerino, Curtin University, Australia

Designing and teaching of laboratory classes are two essential competences of most STEM lecturers. However, the effectiveness of laboratory classes is often not achieved to their full potential. To improve teaching in laboratory classes, the European Chemistry Thematic Network (ECTN) Working group on Lecturing Qualifications and Innovative Teaching Methods has developed an online course entitled Teaching in University Science Laboratories (Developing Best Practice). To date, a Small Private Online Course (SPOC) has been launched twice, with optimisation after the first trial. In the second edition of the SPOC with 144 participants from 22 countries, the completion rate was 60% which is high in comparison to average completion rates of MOOCs (massive open online courses) (about 15%). The participants evaluated the online course very positively. In September 2019, this course will evolve into a MOOC on Coursera.

MOOCs reach millions of learners all over the world and are very important in bringing knowledge to life long learners. Big universities have huge MOOC production departments. It is also known that development of a MOOC is very expensive, costing from 30,000 up to 300,000 euro per course (Hollands, 2014). The instructional design model has an important influence on the development costs. A widespread and efficient development approach is the ADDIE model (Peterson 2003).

Our ECTN Working group took a challenge to develop a MOOC without any special budget apart from the time and own effort which was provided on a voluntary basis. According to the evaluation results, the student-centred active learning design was crucial for the pedagogical quality of the online course, and for its high retention and completion rate. In this poster presentation, we will discuss this in relation to our instructional design model, an adapted ADDIE design approach, that was used for the development of this online course.

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P2 Pre-service and in-service chemistry teachers education for sustainable development

Vesna Milanovic, Marinko Zubic, Dragica Trivic, University of Belgrade, Serbia
Marina Stojanovska, Cyril & Methodius University, Republic of North Macedonia

If we want to develop behaviour of youth according to the goals of sustainable development we should educate teachers according to these goals. With this view we prepared and performed the workshop for the pre-service chemistry teachers. Also, we conducted the same workshop with the in-service chemistry teachers in two countries, Serbia and North Macedonia.

In the framework of the workshop we explored knowledge of the pre-service and in-service chemistry teachers about the definition and goals of sustainable development and engaged the participants with activities throughout they had opportunity to consider issues from the perspective of sustainable development. The workshop contains several parts and its realisation encompasses two classroom periods (90 minutes). *Socrative* teacher app was used for gathering data during the workshop. In the beginning the participants filled the questionnaire. Some questions from the questionnaire were chosen for a further discussion and different texts or video materials were provided to participants in order to support their reconsideration of previously stated answers. This step was performed several times during the workshop. In the end of the workshop the participants filled the questionnaire again. According to the obtained results, this workshop could be used for improvement of the pre-service and in-service chemistry teachers further work associated with the goals of sustainable development.

Acknowledgements

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P3 Rasch analysis of examination results provides information about student performance and exam validity

Danny Bedgood and Yann Guisard,
Charles Sturt University, Australia

Rasch Analysis is being used to examine chemistry exams across subjects and years. Rasch analysis uses a statistical and probabilistic method that converts the raw student performance on an exam - representing "ability" - and the performance of exam questions - representing "difficulty" - into a common scale of measurement called "logit". Rasch Analysis allows the academic to compare the student versus question performance using a single measure of "performance".

The Rasch method differs strongly from other statistical approaches since Rasch analysis is suitable to measure a single "construct" or constructs that are likely to be correlated. Unlike its counterparts, Rasch analysis is insensitive to class size once validated.

This talk will briefly explain how Rasch analysis assesses data and the information that it provides. This will provide the background to the second talk which will present results of analysis of chemistry examination results.

P4 Community engaged learning and research initiative in chemistry at Technological University Dublin

Claire McDonnell, Vanessa Murphy, Patrice Behan Cora O'Donnell and Sarah Rawe,
Technological University of Dublin, Ireland

Since 2007, undergraduate chemistry students at Technological University Dublin – City Campus (known as Dublin Institute of Technology prior to 2019) have had the opportunity to participate in community engaged learning activities. Community engaged learning involves students undertaking a real world project in partnership with a community group to address a need that the community have identified. Students gain academic credit for the learning outcomes achieved, which include reflection on their experiences.¹ Participation in these activities has been shown to assist in the development of our students' problem solving, teamwork, organisation, digital literacy and communication skills.² In tandem, some final year undergraduate students have also been able to participate in community engaged research projects.

We will present an overview of the chemistry community engaged research and learning (CERL) projects that are currently implemented in our institution which includes two that were initiated in 2018-9, We will also provide further information for those who would like to find out more about implementing this approach themselves.

Four projects will be summarised. Two of these are community engaged learning activities. One is a Junior Scientist badge initiative for young people aged 10-12 implemented in partnership with a local youth service and the other is a collaboration with an open prison in which our students prepare information factsheets on the side effects of several drugs that are often misused. There are also two community engaged research projects. One is a very recent development and is a collaboration with the Distributed Pharmaceutical Analysis Lab project run by the University of Notre Dame to perform chemical analysis of pharmaceutical samples from partners in the developing world.³ The other is an ongoing project to check levels of heavy metals in soil samples from urban community gardens.

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2. C. McDonnell, P. Ennis & L. Shoemaker (2011) "Now for the science bit: implementing community-based learning in chemistry", Education + Training, 53(2/3), 218-36; available at <http://arrow.dit.ie/scschcpsart/28/>

3. Distributed Pharmaceutical Analysis Lab website; shortened link, <https://ntrda.me/2U8t2Tb>

P5 The influence of Corinth application on students' motivation and their level of knowledge of natural sciences

Milada Teplá, Martin Šrámek, David Šarboch
Charles University, Czech Republic

This article introduces the results of a research focused on the influence of Corinth application on the results of the education of natural sciences.

The purpose of this application is to support the usage of digital support in education at elementary schools as well as high schools. Nowadays, the application contains more than 1 400 different materials for teaching Humans and Nature including 3D models, animations, depth zooms and videos. The purpose of using this app is to help students to understand abstract topics and complicated tasks better.

The research has been realized at 8th and 9th grade of elementary schools in Biology and Chemistry. There have been four parallel studies – the influence of the application on the students of 8th grade in Biology, the influence of the application on the students of 8th grade in Chemistry, the influence of the application on the students of 9th grade in Biology, the influence of the application on the students of 9th grade in Chemistry.

Our research has focused the influence on students' motivation as well as on the influence of students' level of knowledge. The data were collected using standardized questionnaires Intrinsic Motivation Inventory (IMI) a Motivated Strategies for Learning Questionnaire (MSLQ) and four tests measuring the level of students' skills and knowledge in the area. The collected data have been statistically processed and then interpreted.

Silvija Markic, Lilith Rüschenpöhler, Marina Hönig, Julian Küsel,
Ludwigsburg University of Education, Germany

Women and some minorities tend to be underrepresented in science (OECD, 2009). The present research provides insights into the preferences regarding vocational orientation in science of young people with different gender and cultural backgrounds. It shows that secondary school students in Germany (N=450) do not differ significantly in their science aspirations when gender and cultural background are taken into consideration. However, they do differ in their preferences in vocational orientation regarding science. The girls with migration background tend to rely on more institutionalised, professional sources. They wish for more contacts with universities and teacher feedback. In contrast, the boys without migration background prefer more informal sources such as YouTube videos in vocational orientation. More professional, individual feedback was wished for in a retrospective view of university students (N=342). The research provides the ground for the design of target group specific measures in vocational orientation in science.

OECD. (2009). Chart A4.6 Tertiary graduates in science-related fields among 25-34 year-olds in employment, by gender (2009). <https://doi.org/10.1787/888932460192>

P7 Collaboration ability assessment of Chinese STEM undergraduates studying abroad

Zhou Wei, Chris Thompson and Tina Overton, Monash University, Australia
Julie Hyde, The University of Sheffield, UK

China is the largest exporter of international tertiary students, and the noticeable lag in the collaboration skills of Chinese secondary students compared with their peers in western developed countries (PISA, 2015) has elicited concerns for Chinese international undergraduates. We have focused on Chinese students studying in the United States, Australia and the United Kingdom, completing majors in Chemistry, Computer Science, Engineering, and Mathematics. A preliminary open-ended questionnaire indicates that communication skills are the main academic weakness and create the biggest barrier to navigating group activities. Subsequently, a “Collaboration Self-Assessment” tool was designed for self-assessing the attitude, performance, benefit and leadership of Chinese undergraduates engaged in group activities. The initial results show that there is a positive relationship between the studying attitude and collaborative performance, and an interesting skewness towards optimistic self-assessment was found. In order to explain the skewed self-assessment results, an interview among Chinese participants and a parallel peer-assessment in non-Chinese undergraduates was implemented respectively.

P8 University students' experiences of organic chemistry laboratory studies

Tanja Lahtinen, Piia Valto and Piia Nuora
University of Jyväskylä, Finland

The present study focuses on university students' experiences of organic chemistry laboratory course in Department of Chemistry at the University of Jyväskylä. This bachelor level laboratory course includes: lectures (Introduction to Organic Chemistry laboratory work), passed exam and laboratory training. The lectures will give information how to work safely in laboratory of organic chemistry. This course utilizes problem-based learning, close interaction between students and teachers and integrated theory and practice. In the practical laboratory training, the student will learn how to use basic methods and instruments of the organic chemistry.

Research questions were formulated as: (a) Did the organic chemistry laboratory experiments respond to university students' expectations? and (b) What were the university students' experiences of organic chemistry laboratory experiments? Survey data (response rate 80 %) has been collected from students ($n = 97$) in the middle of the laboratory course (years 2016–2018). Content analysis was used to examine the answers to the open questions from the questionnaire.

The participants were chemistry majors (73 %) and chemistry minors (27 %). The results of this study show that the organic chemistry laboratory experiments corresponded to students' expectations (77 %). Only few students answered that the experiments were different than they thought and 22 % of students felt that laboratory experiments only partly met their expectations. Students ($n = 92$) felt that it was nice to work at their own schedule without predetermined group times and they ($n = 91$) saw that doing independent work was meaningful. Although, students ($n = 78$) reported that taking responsibility for their own work did not cause any problems, they ($n = 52$) answered that doing independent work teased them. Only 22 students felt that doing independent work was challenging to them.

P9 An effective introductory limiting reagent lab

William G van der Sluys
Pennsylvania State University at Altoona, USA

We have investigated the use of a homogeneous precipitation of calcium oxalate from acidic aqueous solutions of a mixture of calcium chloride and potassium oxalate, in which urea is used to slowly raise the pH, resulting in the formation of easily filtered crystals of $\text{CaC}_2\text{O}_4 \cdot n\text{H}_2\text{O}$, where n is both 1 and 2. We find that the initial precipitate is a mixture of the hydrates, and since the composition at this stage is somewhat uncertain, we have decided to dry the samples at a temperature that removes, not only adsorbed water, but also the waters of hydration, at temperatures greater than 140°C . This precludes the use of cellulose-based filter paper, and we have found that the use of medium porosity fiberglass filter discs eliminates the problem of weight loss due to charring of the cellulose. The anhydrous CaC_2O_4 must be cooled in a desiccator to prevent re-adsorption of atmospheric water, giving percent yields of $98 \pm 3\%$ when carried out by experienced faculty members. Student produced results can significantly deviate from these results, due to experimental errors associated with incomplete washing to remove potassium chloride, incomplete drying, and/or product loss due to poor experimental technique. Students are required to write a short formal lab report and do an error analysis based on their results, compared with class data. We have found that this experiment can provide excellent results and an opportunity to quantitatively evaluate experimental technique, regardless of the limiting reagent. Both faculty and student produced results will be presented, along with the results of scanning electron micrographic (SEM) analysis of the precipitates.

Jan Apotheke
University of Groningen, The Netherlands

When designing a course in higher education a number of steps need to be taken. One of the first steps needed is the formulation of the goals in a SMART (Specific, Measurable, Attainable, Realistic, Timely). A useful tool in doing that is the framework of educational reconstruction (Duit, Gropengießer, Kattmann, Komorek, & Parchmann, 2012).

Building on the scientific ideas, combining these with knowledge about education the relevant goals can be derived and formulated. In an example of designing a course for green chemistry these scientific goals can first be explored and identified, followed by decisions about the way they can be formulated as learning goals and learning objectives.

In the second step external parameters like the amount of study time allocated to the course are related to the design of the course. This study time can, for example, be based on the European Credit Transfer System, in which one credit is related to 28 hours of study time. This study time includes time for lecture, self-study, as well as exam time. Based on the number of credits the number of lectures, seminars, lab time can be decided upon.

Learning activities are chosen that fit the learning goals best, and that can be fitted within the time frame of the course.

Both formative and summative assessment activities are needed to determine the success rate of the learning process of the students (Kansanen & Merk, 1999), and the effectiveness of the learning activities.

An evaluation scheme for the course as well as an analysis of the final exam needs to be part of the course design as well.

After that scientific ideas, which form the basis of the course to be designed, will be reformulated as the learning goals for a course in a 'SMART' way. If there is time some discussion about learning activities that fit the learning goals best will be held.

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P11 Utilising social media for engagement with and contextualisation of chemistry

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Snapchat is a social media platform with the ability to share media and network with others. The platform has been applied with lower division undergraduate students studying chemistry, biochemistry and natural sciences. Approximately 140 students followed a 'class' account where both images and videos were shared with the aim of allowing them to contextualize subject knowledge in the real world, demonstrate practical setups in the laboratory, provide an insight into research environments and life as an academic in chemistry. Upon surveying the students, with a 43% response rate, students overwhelmingly agreed that they feel more engaged with chemistry through using Snapchat in this manner (4.32/5.00) and together with it being a useful tool to contextualize their knowledge in chemistry in the real world and their degree program (4.32/5.00).¹ As such, instructors using Snapchat in this way could enhance student engagement with chemistry together with facilitating the ability of students to understand how chemistry can be applied to affect their daily lives.

This work has been part of the basis of a shortlisting for a Times Higher Education award for 'Most Innovative Teacher of the Year' together with a 'Jisc Higher Education Social Media Superstar' award.

1. Hurst, G. A. Utilizing Snapchat to facilitate engagement with and contextualisation of undergraduate chemistry. *J. Chem. Educ.* **2018**, *95*, 1875-1880.

P12 Development of fundamental analytical skills using a Arduino based projects: from signal to measurement accuracy

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Most of the analytical measurements are nowadays performed using instruments based on physical properties of matter. In order to enhance student's knowledge on instrumentation, project activities using microcontrollers have been recently introduced. Students are invited to build their own instrument, and if they are really involved in the selection of the electronic parts, the instrument design, the signal acquisition, and the signal treatment, we expect that they will be able to more easily understand other instruments. This became possible in the last five years because microcontrollers such as Arduino have been produced in an open access model, at very low price and with a human-machine interface easily accessible for any scientist.

One of the most often used project is the design of a simple colorimeter starting from only four parts: a LED, a cell, a photodiode and a microcontroller. For less than 15 euros, such instrument can be very helpful to address many fundamental concepts: choice of the colored LED as a function of color solution, sensor response, interferences and noise, data treatment (mean, transformation to absorbance), model $\text{absorbance} = f(\text{concentration})$, and finally concentration accuracy of an unknown sample. This last item is very often dramatically neglected in most chemistry curricula. Very often the coefficient of determination is reported but this parameter is not relevant to estimate accuracy (trueness and precision). Accuracy estimation is fundamental for any chemist and an it can be addressed at a first stage through the estimation of bias and its distribution from repeated measurements of calibration solutions.

Accuracy comparison has been performed by students using both Arduino based and commercial devices and has dramatically improved their knowledge on this fundamental concept.

P13 From research to the teaching labs: crafting research inspired laboratory projects for general chemistry with students as active participants. Design and optimization of an electrochemistry water remediation projects

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Northeastern University, USA

In this presentation we will outline the design of an electrochemistry project based on research conducted at our university using a solar powered electrolytic water remediation system to introduce electrochemistry, green chemistry and principles of water remediation in a second semester general chemistry laboratory sequence. The project was designed to be a part of a project based cooperative green chemistry curriculum for our freshman chemistry laboratories.

The development team incorporates young undergraduate students who completed the first semester of the pilot laboratory implementation of the new lab curriculum as students and showed interest in being involved in the project as co-designers and facilitators. The approach in this project is based on research conducted at Northeastern University (PROTECT project). The team is working on coupling the electrochemistry system generating H_2O_2 to a heterogeneous polymer based system containing a nature inspired catalyst (FeTAML ref) rendering it heterogeneous and reusable with use in portable water remediation system. The team incorporates students with various majors (engineering, health science, biology, chemistry) to create interdisciplinary approach into the design of the system and in ways to use for the design of a teaching laboratory module. The facile colorimetric testing of peroxide generation and the concomitant decomposition of contaminants (modeled using dyes) renders this project suitable to introduce green chemistry, catalysis and portable water remediation system design in the laboratory curriculum typically built around kinetic measurements in freshman and inorganic labs.

We will present the broader pedagogical design of the laboratory curriculum where this electrochemistry project will be implemented, the outline of the electrochemistry project design and laboratory parameters and the design and function of the curriculum team framed within a peer mentoring model in collaboration with the faculty involved in this effort.

P14 The growing role of ethical considerations in chemistry education

Remco Vasterink

HU Utrecht University of Applied Sciences, The Netherlands

What role do chemists and chemistry teachers play during their career, aside from doing research and sharing their knowledge about the subject? I would argue that they should be aware of the ethical implications of chemistry. The importance of ethics should not be disregarded, including such questions as: is it morally acceptable to change human DNA? Do the benefits of pesticide production override the substantial detrimental effects these chemicals have on the environment? Can chemists be held accountable for the development of new, possibly deadly compounds or are those who use the compound to blame? A famous example is the Nobel laureate Fritz Haber, who won the Nobel Prize for Chemistry in 1918. Haber never showed any regret for his role in the research into chemical weapons during The First World War. So should we remember him as a hero, or a criminal?

During my own chemistry education we spent little time discussing the ethical and moral consequences of chemical research and the production of chemicals and pharmaceuticals. During my career as a chemical engineer, researcher and lecturer, I face these ethical issues on a regular basis. I would probably have been better prepared if scientific ethics had been a more prominent part of my university education.

As a chemistry teacher trainer at Utrecht University of Applied Sciences, I want to incorporate scientific ethics into the chemistry teacher training curriculum. Lately, this seems even more important since sustainability goals, global warming, CRISPR-Cas and affordable pharmaceuticals, for example, are steadily gaining attention, especially among young adults.

Socio-scientific issues could be a good way to address conflicts between scientific objectivity and ethical values, especially in STEM education. The challenge is to integrate ethics and content knowledge on all levels into the curriculum.

P15 'How have I grown? What works best for me?'- a metacognitive reflection session for 2nd year chemical engineering students

Felix M. Ho
Uppsala University, Sweden

The transition from secondary school to university is full of challenges for students, ranging through the academic, financial, personal and social. First year students often become bewildered by the changes they are confront with, and find it difficult to see in which direction they are headed with their studies, career and lives. Experience shows, however, that students undergo an enormous amount of personal and academic growth during this first year, often without consciously realizing it. This lack of awareness means that they miss out on leveraging this sense of achievement to improve their self-efficacy.

To address this issue, a “kickoff” session was implemented at the start of the second year of studies for students in the chemical engineering program at Uppsala University. The session consisted of activities aimed at getting students to engage in metacognitive reflection and discussions with each other about how they have grown as a student and as a person since starting their university studies, what personal goals and expectations they have, and what ways of learning best works for them. Course progression in the degree as well as career information were also presented to help students better understand how their earlier studies connect to the upcoming year and beyond. Student association representations and students from later years in the degree program were directly involved in the planning, design and implementation of the session. This gave invaluable student perspectives and enhanced the perceived legitimacy and acceptance of the session. After presenting the details of the design and implementation of the session, the results from the student evaluation immediate after the session as well as several months later will be presented and discussed. Dissemination to other engineering as well as pharmacy programs will also be outlined.

P16 Formative assessment in a primary school chemistry education in the topic 'mixtures'

Mária Babinčáková, Pavol Jozef Šafárik University in Košice, Slovakia and
Charles University in Prague, Czech Republic

Mária Ganajová and Ivana Sotáková, Pavol Jozef Šafárik University in Košice, Slovakia

This contribution reports on the research on the effectiveness and of the implementation of formative assessment tools in primary school chemistry classes (12-14 years old students). We designed ten lessons with formative assessment tools such as a predictive card, Frayer model, self-assessment card, concept map, and exit card in the topic "Mixtures". Fourteen participating classes were randomly assigned either to a control group or an experimental group. Teachers in the experimental groups implemented formative assessment tools into their lessons, while teachers in the control group taught in a usual way. Most important results show that statistically significant improvements in learning achievements - conceptual understanding - were observed in the experimental group in comparison with the control group.

Keywords: formative assessment, chemistry, education, mixtures

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P17 'How do take that theory and put it into practice?' – the usefulness of chemistry in everyday life at different stages of education

Ludwika Kolec – Janiak, Martyna Baranowska, Robert Zakrzewski and Anna Wypych -Stasiewicz,
University of Lodz, Poland

Teaching young people at different stages of education is a great challenge for the teacher. We know how difficult it is to explain to every student what an important priority in life is to acquire wisdom from an early age. Teachers do everything they can to make students like this subject. It turns out that our students are unaware of the use of chemistry in everyday life. When we show them that all that surrounds us is matter, that is to say a topic related to chemistry, they have a different perspective on this activity. The main aim of our research was to apply chemical knowledge in practice. The students were subjected to research that was based on several meetings and was carried out in the form of presentations and interviews.

We obtained a lot of interesting information, which we, academic teachers and teachers in schools, wouldn't have come up with by ourselves.

The research surprised us very positively in terms of knowledge and creativity of such young, future scientists. We are glad that the results of our analyses can be shared with you in our research.

P18 Analysis of task content based on a variety of tearing forms – matriculation examination

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Ewa Stożek, Regional Examination Commission in Lodz, Praussa 4, Lodz, Poland

On the basis of the analysis of the tasks of external exams, the following tasks were distinguished: highly differentiating tasks. Differentiation of results at the secondary school leaving exam (matriculation exams) is influenced by a number of factors such as factors that cause the distributions to be flattened and/or multimodal. Such the factors are e.g. the type of school or the declared level of passing the subject (weaker students declare only a basic level and better students continue to pass at an extended level). Distributions of results show "Breaking" by these factors. All presented distributions the results correspond to enrolment data in schools in the area covered by the measure Regional Examination Commission in Lodz.

However, the reason for "disruption" may also be single tasks, which we will call the tearing tasks. In order to show this, we will limit our reflections to Sheet II and graduates of general secondary schools (about 6,000 students), thus precipitating the influence of other (perhaps not all) factors differentiating the population.

The purpose of our research is to find out which exam tasks we can call and describe as "breaking". We focus on matriculation sheets and other exam results.

So far, we have been able to define tasks as tearing tasks - which are tasks of organic chemistry and in full form. Tasks that were tasks in the form of a test response are not part of this type of structure.

P19 Teaching 21st century science with 21st century skills

Peter E. Childs
University of Limerick, Ireland

In many ways the teaching of science at school and university has not changed much over the years and much of the same core content and practical skills are still taught. However, there have been repeated calls from government and industry and other bodies in many countries for students to be proficient also in '21st century skills', as well as in the traditional technical skills associated with science education.

"We live in a fast-changing world, and producing more of the same knowledge and skills will not suffice to address the challenges of the future. A generation ago, teachers could expect that what they taught would last their students a lifetime. Today, because of rapid economic and social change, schools have to prepare students for jobs that have not yet been created, technologies that have not yet been invented and problems that we don't yet know will arise."

(Schleicher, (2010))

These 21st century skills are also referred to as soft skills or transferable skills, and are not specific to science. They include such skills as creativity, critical thinking, problem-solving and teamwork. I want to ask in this article: "Can these skills be taught effectively alongside the traditional content of science courses?" I will argue that they can and that science is an ideal vehicle for developing many of these skills, alongside knowledge of science, scientific literacy and laboratory skills. Such an approach needs to start in secondary school, and is relevant for those students who continue to study science and those who do not. However, it is also vital that the emphasis on 21st century skills continues in university science courses, thus fitting science graduates for the modern work environment. Student teachers also need to be trained to include such 21st century skills in their own science teaching, otherwise they will not become embedded in the educational system. The inclusion of soft skills alongside traditional skills represents a major change in science education and will need a change in mindset of teachers and students, and in pedagogy, in order to equip students for the future workplace.

P20 Using NUMBAS for e-assessment of undergraduate chemistry students

Oscar Siles Brügge
University of Nottingham, UK

Mathematics is an integral part of any chemistry degree, and it is therefore important that first year students from various diverse backgrounds are all brought up to the same level of understanding. In our courses, this is usually done through a set of lectures and workshops and problems classes. We are now working towards creating responsive resources for our students to benefit from, and encouraging them to become more “active learners” as described by Biggs.

Numbas is a free and open-source web-based tool for creating online tests developed by Newcastle University, offering much more versatility than similar options included in many VLEs such as Moodle or Blackboard. We have started to use Numbas in our first year undergraduate mathematics module in the form of formative as well as summative assessments. This allows students to be given unique question sets, and be presented with personalized feedback instantaneously. In particular, summative coursework, which has previously been done via paper submissions, is now delivered and assessed completely digitally.

In this presentation, I will discuss how we have incorporated these formative and summative e-assessments into our first year mathematics module, and how we aim to continue enhancing students' learning by introducing greater elements of blended learning in the future.

P21 Digitising chemistry teaching

Magdalena Wajrak
Edith Cowan University, Australia

The aim of this workshop is to introduce a number of novel digital resources for teaching and enhancing the learning of chemistry and to share experiences of the logistics of implementation of such resources in the University environment.

There is an increasing push by Universities to develop more fully online units. This trend towards online or eLearning is creating a dilemma for academics who teach science subjects, such as chemistry, where hands-on laboratory skills form an essential part of the learning process. However, we do recognize that “as students increasingly need to juggle the competing demands of work, family and study, the ways in which they engage with Higher Education institutions is changing.” [1] Also, with the financial stresses of the Universities, there is a need for Universities to become more adaptable/flexible in terms of the delivery of the teaching, but at the same time make sure that, in particular science students, still have the necessary practical skills. This is where “the use of technology is playing a key role.....” [1]

There is now a vast number of digital chemistry resources, which can be utilized to provide a more flexible learning environment for students, who are working and/or have family commitments, enhance their understanding of abstract chemical concepts and increase their engagement. Resources such as Labskills, smart worksheets, electronic lab books and online tutorials (OWL), can be implemented to allow for more flexible learning, without actually replacing the lab component of the unit.

This workshop will discuss the experiences from implementation of these resources in first year chemistry units at Edith Cowan University. In particular the focus will be on how these resources were utilized to increase flexibility of student's learning, how they were blended into the practical classes and how they assisted students with their learning process of chemistry concepts.

[1] Blended synchronous learning: a handbook for educators 2014

P22 Popularising chemistry in Hong Kong

K. K. Jason Chan

The Hong Kong University of Science and Technology, Hong Kong

Chemists and chemistry students stem from children who grew up with a passion for Chemistry. Their enthusiasm and curiosity in Chemistry are usually developed early during their school education. We have undertaken fruitful collaboration with public media to make Chemistry present and appealing to the Hong Kong public and made substantial efforts to engage our undergraduates in a diverse range of outreach activities aimed at popularising Chemistry among students in Hong Kong.

P23 Online support service, what role do they have in forensic chemistry?

Anna Kirkham
University of Central Lancashire, UK

As the technology dependence of students increases and the first choice is to swipe right to look for a reference or additional support is online, it leads me to consider, what role do online learning resources have in formal teaching? Can they be included successfully in lectures, tutorials or practicals or can they be used as a prelab or prelecture activities or are they just a place where students can be referred to gain additional support out of contact time.

The resources used in this study include Bestchoice, Mentimeter, Padlet, Peerwise, Blackboard, Khan Academy, Learning Science and iMotion. Here I describe the inclusion of a range of online resources into my first year semester two forensic chemistry module, for first year forensic science students. I will outline which resources my students engaged with, which they found most useful and why and which they found least useful and why. How my students interacted with prelab and prelecture resources

P24 Interactive adobe flash animation- digestion in the human body

David Šarboch
Charles University, Czech Republic

This contribution is dedicated to creation and use of the education animations made in Adobe Flash Professional CS6 program. The animation program was created in order to make the education process more effective and to help teachers to tackle the topics that are demanding to understand and imagine. The animations concern the topic of digestion in human body and the whole concept is presented in an interactive form strengthening the interdisciplinary relations between chemistry and biology. The program consists of 26 subanimations and describes all organs of the digestive system and their processes. The interactivity is strengthened by action bars (f. e. “play, pause, go forward”) and there is also a possibility to hide and reveal the accompanying text. While working with the program an easy change of the subanimations (concerning the different organs) is promoted thanks to an interactive figure of the human body. The animations are destined to the secondary school students and teachers.