Società Chimica Italiana
Divisione di Didattica Chimica

Società Chimica Italiana SCI2021

XXVII CONGRESSO NAZIONALE SCI
PROGRAMMA della DIVISIONE DI DIDATTICA

Mercoledì 15 settembre 15.00 – 18.45

15.00 – 16.00 PL001 **Jan Apotheker** (Chair of the Committee on Chemistry Education of IUPAC):
Developments in chemistry education

The recent pandemic has caused a changeover from face-to-face teaching to using on-line methodology in teaching. Responsibility for the learning process is shifting from teacher to student. This changeover is simply an acceleration of a process that has started up in (chemistry) education over the past 25 years. Recent research in chemistry education, based on research on teaching and learning from the beginning of the twentieth century, indicates the need for a more individual approach of the learning process. Both Maria Montessori and Lev Vygotsky demonstrated the need for such an approach.
This changeover in chemistry education from teacher centered education to student centered education is also illustrated in the changeover in content of the chemistry curriculum. In order to solve societal problems like climate change, the energy transition, and more recently health issues connected to the covid-19 pandemic, society needs scientists and specifically chemists. Chemists are the experts in molecular processes, that are able to connect with biology as well as physics. One of the major challenges of teaching chemistry in secondary schools is catching the interest of enough students in science and chemistry in particular. The ultimate goal will be that more students will become interested enough to take up a study in chemistry. To demonstrate the fascinating world of molecules to students, the curriculum needed to change. Two things were needed in this change over. The first was demonstrating the role of chemistry and chemical research in society. The other thing needed was linking school chemistry with chemical research. The content of the curriculum in secondary schools had no relation with the chemistry at the universities. This needed to change and has been changed over the past twenty years.

16.00 – 16.30 IL001 **Mariano Venanzi** (Università di Roma Tor Vergata):
Chimica sostenibile per una didattica universitaria sostenibile

L'introduzione di argomenti della Chimica sostenibile può diventare un mezzo per rivedere in maniera innovativa i curricula dei corsi universitari, modernizzandone i contenuti. Questo permetterebbe di sostituire un approccio spesso troppo focalizzato sugli aspetti teorici disciplinari, con una didattica legata maggiormente alle applicazioni e ai problemi che la Chimica si trova ad affrontare in una società complessa, proponendo soluzioni tecnologicamente avanzate.

Comunicazioni brevi (OR001 – OR009)

16.30 – 16.45 **Federica Branchini**: *Teaching the notion of chemical bonding: a didactic challenge* (OR001)

16.45 – 17.00 **Maria Antonietta Carpentieri**: *A new didactic pathway to introduce Spectroscopy by historical-epistemiological/STEM laboratorial/distance learning blended approach* (OR002)

17.00 – 17.15 **Maria Costa**: *Virtual Reality visualizations of complex molecular structures in chemistry education. The β-CD-ASA example* (OR003)

17.15 – 17.30 **Sandro Jurinovich**: *A didactic sequence for teaching chromatography: observation, model and practical applications* (OR004)

17.30 – 17.45 **Dora Stella Lombardi**: *'Light and Molecules' - an experimental approach to the understanding of basic concepts of Quantum Mechanics* (OR005)

17.45 – 18.00 **Alma Moretta**: *Additional Learning Requirements (OFA) in Math for Environmental Science degree course: a review for a better understanding of the difficulties of students entering university* (OR006)

18.00 – 18.15 **Davide Peddis**: *From the astro to the nano scale: a learning by doing teaching pathway* (OR007)

18.15 – 18.30 **Antonio Testoni**: *Chemistry, history and complexity* (OR008)

18.30 – 18.45 **Sergio Palazzi**: *A colorful new morning - teaching applied chemistry in pandemic times* (OR009)

Giovedì 16 settembre 13.00 – 14.45

Assemblea della Divisione

Ordine del giorno dell'Assemblea:

1) Comunicazioni del Presidente
2) Attività della Divisione svolte nel 2020-2021
3) Attività della Divisione previste per il 2021-2022 (Scuola Segre e Scuola Del Re)
4) Relazione del Segretario Tesoriere
5) Rinnovo Consiglio Direttivo
6) Varie ed eventuali

Venerdì 17 settembre 15.00 – 18.30

15.00 – 15.30 **Carlo Fiorentini** (Centro di Iniziativa Democratica degli Insegnanti, Firenze):
IL002 ***L'insegnamento della chimica nella prospettiva della cittadinanza***

La scuola può contribuire in modo significativo a sviluppare una cittadinanza consapevole e complessa, a patto che non sia soltanto un luogo di preparazione alla vita adulta, ma innanzitutto un luogo vitale di crescita socio-culturale. Ciò implica che in ogni ambito disciplinare l'acquisizione di nuove conoscenze avvenga sulla base del principio dell'adeguatezza motivazionale e cognitiva, che consente a tutti gli studenti di essere attivi, in una dimensione sociale, nella costruzione della conoscenza e di sviluppare le loro strutture cognitive e il loro pensiero. L'adeguatezza cognitiva delle conoscenze e un approccio metodologico-relazionale problematico, costruttivo possono effettivamente contribuire allo sviluppo delle competenze di cittadinanza. Entrambi permettono di vivere

costantemente e in profondità alcuni aspetti essenziali per la formazione democratica, quali, innanzitutto, il riconoscimento della pari dignità di ciascun studente nel processo di costruzione della conoscenza, a cui in modo più analitico seguono: l'apertura mentale, il coinvolgimento emotivo, il valore del confronto e del dialogo, l'attribuzione di importanza alle ipotesi provvisorie, l'assunzione di atteggiamenti non dogmatici e rigidi, l'imparare a cooperare nella costruzione della conoscenza, la capacità di valutare il grado di certezza che si può attribuire alle affermazioni fatte, lo sviluppo dell'autodisciplina.
In tale contesto verranno sviluppate delle riflessioni relative all'importante contributo che potrà essere fornito dall'insegnamento della chimica nel biennio della scuola secondaria superiore.

Comunicazioni brevi (OR010 – OR013)

15.30 – 15.45 **Teresa Cecchi**: *Chemistry - a Precious Discovery in the Dantesque World* (OR010)

15.45 – 16.00 **Maria Irene Donnoli**: *A Carbon atom journey* (OR011)

16.00 – 16.15 **Elena Lenci**: *Peer review of scientific articles: a teaching experience* (OR012)

16.15 – 16.30 **Silvia Prati**: *Increasing the engagement of non-chemistry major students: examples of didactic strategic* (OR013)

16.30 – 18.30 **Silvia Bencivelli** coordina la **Tavola Rotonda *"Chimica: come, dove, quando e perché"***

Società Chimica Italiana
Gruppo Interdivisionale
Diffusione Cultura Chimica

Società Chimica Italiana
Gruppo Giovani

La Chimica è guardata con grande sospetto e diffidenza dal cittadino ed è sicuramente poco amata dagli studenti; si tratta invece di una disciplina importante, utile e bella; importante perché ci spiega come è fatto e come funziona il mondo, compreso l'uomo; utile perché con i prodotti creati dai chimici permea ogni aspetto della nostra vita rendendola più facile e piacevole; bella perché ci permette di entrare nel meraviglioso mondo dell'infinitamente piccolo facendo da tramite a tutte le altre discipline scientifiche. Come insegnare la Chimica, come farla amare a scuola, come poter eliminare discriminazioni di genere, come contrastare la diffusione di "fake new" e come far apprezzare questa disciplina anche al pubblico dei non addetti ai lavori sono gli aspetti che verranno affrontati durante la Tavola Rotonda.

Relatori:

Pellegrino Conte (Università di Palermo)
Valentina Domenici (Università di Pisa)
Paola Govoni (Università di Bologna)
Piersandro Pallavicini (Università di Pavia)

Martedì 21 settembre 15.00 – 18.00

15.00 – 15.30 **Eleonora Aquilini** (Divisione di Didattica della SCI):
IL003 ***La cura di se stessi, degli altri e dell'ambiente nella scuola primaria***

L'educazione ambientale ha lo scopo di mettere in relazione ognuno di noi con la Terra, con gli altri esseri umani, con tutti gli esseri viventi in una prospettiva di solidarietà e partecipazione responsabile che porti al riconoscimento e al rispetto di tutte le differenze. L'ambiente non deve essere percepito quindi come altro da sé ma come parte di un "noi" e questo rapporto deve essere costruito anche a scuola, a partire almeno dalla scuola Primaria. In questo senso le varie discipline dovrebbero tutte contribuire a questo senso dell'unità uomo-ambiente. Nel caso delle scienze i collegamenti con l'educazione ambientale sembrano essere più evidenti. È importante che l'educazione ambientale faccia parte del

curricolo di scuola e che venga vista come parte integrante delle conoscenze, metodi, valori comportamentali che costituiscono il focus della formazione.

Presentazione del bando di concorso per le scuole

Comunicazioni brevi (OR014 – OR015)

15.30 – 15.45 **Sergio Palazzi**: *Towards a material archive of dyestuffs from the XX century* (OR014)

15.45 – 16.00 **Ugo Cosentino**: *The School-University joint interventions provided in the National Recovery and Resilience Plan* (OR015)

16.00 – 18.00 **Riccardo Iacona** coordina la **Tavola Rotonda "*Sostenibilità a 360 gradi"***

La sostenibilità è legata ad una nuova idea di benessere per attuare la quale è necessario rivedere il concetto di sviluppo che non deve guardare solo ai bisogni della generazione presente, che deve abbattere le barriere sociali e che deve salvaguardare il nostro pianeta. Lo sviluppo, per essere sostenibile, deve pertanto coniugare e interconnettere tre ambiti: quello ambientale (uso responsabile delle risorse), quello economico (lavoro dignitoso a tutti) e quello sociale (giustizia ed uguaglianza). Tutto ciò significa che parallelamente è necessario compiere tre transizioni, a loro volta interdipendenti: dai combustibili fossili alle energie rinnovabili; dall'economia lineare all'economia circolare; dal consumismo alla sobrietà. In definitiva, si tratta di effettuare un grande salto culturale che non è più procrastinabile, data l'attuale crisi che stiamo vivendo, e che vede la chimica e la scuola impegnate in prima linea. Questi aspetti, ed altri ancora, verranno dibattuti nell'ambito della Tavola Rotonda.

Relatori:

Vincenzo Balzani (Università di Bologna)
Giovanni De Feo (Università di Salerno)
Vittorio Maglia (Federchimica)
Andrea Segrè (Università di Bologna)

Le relazioni, a parte quella di Jan Apotheker, saranno tenute in italiano

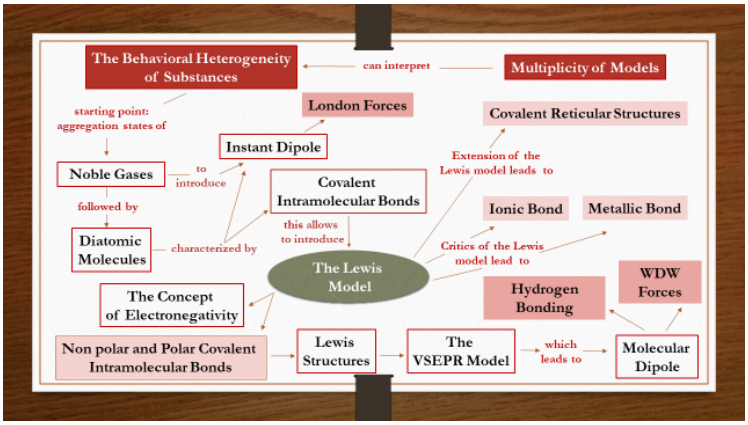
Di seguito sono riportati i riassunti delle comunicazioni brevi OR001 – OR015

Teaching the notion of chemical bonding: a didactic challenge

Branchini Federica,[a]* *Ghirardi Marco,*[b,c] *Regis Alberto,*[c] *Ghibaudi Elena* [a,c]

[a]*Department of Chemistry, University of Torino, Via Giuria 7, I-10125 Torino (Italy);* [b]*Istituto di Istruzione Superiore "Q. Sella" Biella (Italy);* [c]*SENDS – Gruppo di Storia ed epistemologia per una nuova didattica delle scienze, Torino (Italy)* www.sends.unito.it
email: federica.branchini@edu.unito.it

Teaching chemical bonding effectively is a challenge, as this notion raises numbers of didactic and conceptual problems, that are well highlighted in the literature [1]. Students are reported to misapprehend the nature of intra- and inter-molecular bonds, to overlook their involvement in physical and chemical transformations, to neglect energetic aspects, to misunderstand the relationship between the macroscopic properties and the microscopic structure of substances, etc. As a reaction to these conceptual and didactic problems, we designed a teaching sequence on chemical bonding whose conceptual structure is reported in the figure: the sequence is preferentially addressed to students of the first two years of secondary school. A main feature of this teaching sequence is the alternation between intra- and inter-molecular bonding models, aimed at emphasizing their common nature of electrical interaction and their position along the energy scale [2-3]. The issue of the stability of the resulting systems justifies the formation of all kinds of bonds and serves as logical common thread throughout the sequence. Other pivotal steps aspects are:



- The choice of discussing weak intermolecular forces (London forces) in monoatomic substances (noble gases) and to construct the notion of instant dipole, first.
- The emphasis on the non-directional character of ionic bond as a consequence of its very nature of Coulombian interaction between point electric charges, which is the key to understanding the reticular nature of ionic substances.
- The choice of introducing the ionic and metallic bonding models as critics of the covalent bond model. This is aimed at stressing both the modelling nature of bond descriptions and the limits of each bonding model. In fact, different bonding models are gradually introduced throughout the sequence, every time that previous models do not fit the explanatory needs raised by new phenomena [4].

Parts of this teaching sequence have been tested in a second-year classroom of a technical institute between January and May 2021. The results of this experience will be discussed.

[1] G. Tsaparlis, E. Pappa, B. Byers, *Chem. Educ. Res. Pract.* **2018**, *19*, 1253
[2] J. Joki, M. Aksela, *Chem. Educ. Res. Pract.* **2018**, *19*, 932
[3] A. Bergqvist, M. Drechsler, S.-N. Chang Rundgren, *Int. J. Sci. Educ.* **2016,** *3,* 298
[4] E. Roletto, "La scuola dell'apprendimento. Didattiche disciplinari, modelli e applicazioni operative" Erickson **2005**

A new didactic pathway to introduce Spectroscopy by historical-epistemiological/STEM laboratorial/distance learning blended approach

Gioia Fano,[a] Maria Antonietta Carpentieri,[a] Sandro Jurinovich,[b] Valentina Domenici[a]

[a] Dipartimento di Chimica e Chimica Industriale, Università di Pisa, via Moruzzi 13, 56124 Pisa (Italy); [b] Istituto Tecnico "C. Cattaneo", Via Catena, 3, 56028 San Miniato Pisa (Italy)

Spectroscopy is undoubtedly a powerful instrument for investigating the Structure of Matter. Among Italian High Schools, Spectroscopy is systematically studied in Chemical Technical Institutes, while it rarely appears in Scientific and Applied Sciences High School called *Licei*. In the last ten years, one of the authors has proposed and experimented interactive laboratories to introduce Spectroscopy to high school students, mainly during special programs (i.e. "Alternanza Scuola Lavoro"), called "*Fare Chimica con la luce*" [1,2]. In the present work, we are reporting a new didactic pathway to introduce UV-Visible Spectroscopy in Italian High Schools. During a first step of the work [3], a didactic pathway concerning optical phenomena was developed and tested in two classes at 'Cattaneo Technical Institute' of San Miniato (Pisa) by applying two main teaching methodologies: (i) experimental demonstrations designed *ad hoc* supported by short videos, (ii) laboratorial experiments based on the *Inquiry-Based Learning* method, followed by a collective discussion. All the experiments were collected as audio-video materials with explanatory pictures and they were made available for distance learning, too. These digital materials were also collected and presented during the Researcher's Night (Bright) organized by the Department of Chemistry and Industrial Chemistry of the University of Pisa, which was an on-line event due to the Covid-19 pandemic [4]. During second step of the work, a website was created [5] implemented with additional resources, such as instructional materials in order to help students build home-made spectroscopes; presentations and interactive materials to better understand the instrumental design and functionality of UV-Vis Spectrophotmeters; description of historical instruments with relevant educational values. The web-site (#DADSpectroscopy) was presented in the first part of the Chemical Educational National School "Giuseppe Del Re", organized by Chemical Educational Division of Italian Chemical Society (2020 edition). One of the innovative aspects of this work is related to its modular form and to the amount of original materials, which was available to teachers of any kind of High Schools. During the teacher training school, the teachers could use the available resources or select just few parts of the proposed pathway, and test them in face-to-face or distance modality teaching with their students. Reports and feedbacks from the school teachers were discussed and analyzed in the second part of the School and this was very important to implement this new didactic approach to Spectroscopy. The ongoing step of this work involving further testing in classroom and implementation will be presented during the Congress.

[1] V. Domenici, Fare Chimica con la Luce: la Spettroscopia, in «Atti di Pianeta Galileo», **2012**, vol. 1, pp. 57-62.
[2] V. Domenici, L. Sentieri, G. Silvi, A. Lenzi, "Fare Chimica con la Luce": attività didattiche di introduzione alla spettroscopia, in La Chimica nella Scuola, **2018**, vol. 3, 53-71.
[3] G. Fano, Tesi magistrale e di scienze applicate in Chimica, Università di Pisa, Pisa: **2021**.
[4] Website of the Bright 2020 (online event): https://bright.dcci.unipi.it/bright-2020/chimica-luce/chimica-luce-introduzione.html
[5] DADSpectroscopy website: https://sites.google.com/cattaneodigitale.it/spettroscopia/home-page

Virtual Reality visualizations of complex molecular structures in chemistry education. The β-CD-ASA example

Maria Costa and Michele A. Floriano.
(maria.costa01@unipa.it; michele.floriano@unipa.it

Dipartimento di Scienze e Tecnologie Biologiche Chimiche e Farmaceutiche, Università degli Studi di Palermo, Viale delle Scienze ed. 17, 90128, Palermo

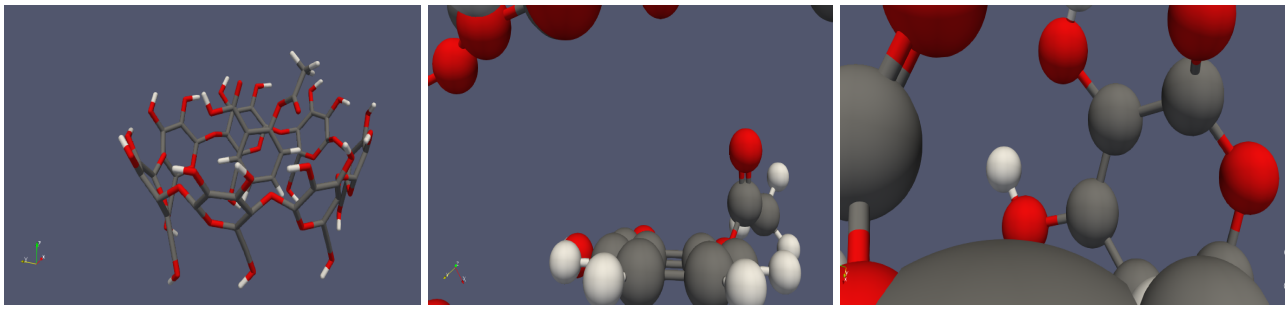
Chemistry can be a very difficult topic to understand for students, because it requires to think in abstract way both about the existence of atoms, molecules, and ions, and about their structural and dynamic behaviors and interaction. In this context, realistic multimedia visualization tools (visual, audio and interactive learning) are very helpful. Virtual Reality (VR) molecular scenarios have been recently developed in order to enhance 3D molecular structure visualizations.

Virtual reality implies designing and immersive reality in which simulated real objects, such as a virtual laboratory, and/or molecules can be explored and/or manipulated. In this way complex molecular structures can be elucidated more readily and making it is possible to focus on specific portions.

In order to demonstrate the advantage of using VR visualizations, in this work we report an example of host-guest interactions in the β-cyclodextrin (β-CD) - acetylsalicylic acid (ASA) complex whose pharmacological properties and structure have been reported. [1][2] In this study, the preferential orientation of ASA in β-CD has been suggested and we have adopted it for our visualization.

In the above figure different views of the β-CD-ASA complex are shown. Different types of atoms are indicated by different colors: H, C, O.

In the left figure, an overall view of the complex is displayed; it can be seen that the ASA molecule is arranged so the carboxylic and acetylic groups stick out the secondary β-CD ring thus optimizing different kinds of H- bond intermolecular interactions. [1][2] This situation can be further explored in VR. For example, if we imagine to over tune the complex on its side and virtually enter through the β-CD's primary ring (middle figure), it is possible to observe more closely the arrangement and the relative positions of the substituents on the ASA benzene ring. At this point (right figure) the VR environment makes it possible to turn around and observe the ASA's surroundings. In this way, along with other panoramic views, a more realistic and detailed views of the complex can be obtained with important advantages in chemistry education.



[1] T. Loftsson, M. E. Brewster, *Journal of Pharmaceutical Sciences,* **1996**, Vol 85, 1017.
[2] B. Bezzina, R. Djémil, D. E. Khatmi, S. Humbel, Y. Carissan, *Journal of Inclusion Phenomena and Macrocyclic Chemistry,* **2018**, 92 (1-2):115-127.

A didactic sequence for teaching chromatography: observation, model and practical applications

Sandro Jurinovich[a]

[a] *Istituto Tecnico "C. Cattaneo", Via Catena, 3, 56028 San Miniato Pisa (Italy)*

Chromatography is a fundamental separation and analytical technique in chemistry. The principles of chromatography and the application of this tool in the laboratory practices are core knowledges of the Italian national curriculum of chemistry technical high schools. Moreover, the use of chromatography in many different fields makes this topic suitable for students of general science courses in scientific high school curricula.

In the last two years the author has experimented didactic activities involving chromatography in the framework of the analytical chemistry courses of *Istituto Tecnico "C. Cattaneo"* in San Miniato (Pisa). The activities have been conducted using both face-to-face and on-line learning, as required during the Covid-19 pandemic. In this work, the past experiences have been arranged into a complete didactic sequence made of three main modules. The didactic approach includes theoretical lessons, in-class discussions and laboratory experiences; these strategies are inserted in a general *inquiry-based* learning framework. Furthermore, the didactic sequence involves the construction of models and theoretical simulations that develop mathematical and computational skills in students, and it encourages abstract and symbolic thinking.

The didactic sequence starts from the macroscopic observations of a simple column chromatography separation process of a blue food colorant and the collection of different fractions. In this first step, the main goals are building the first chromatogram and understanding the concepts of chromatographic run and of chromatographic band, as well as introducing the basic terminology.

In the second step, a separation model based on the distribution equilibrium is elaborated with the students by means of in-class discussion and brain storming. The proposed separation model is based on the classic plates' theory by Martin and Synge [1]. From an historical point of view, such theory has played a significant role as the first model to understand the chromatographic process.

Our simplified model can be used to simulate a chromatographic run with a single component or with a mixture, by using a spreadsheet that has been compiled following a tutorial approach with videos and slides. The result of the virtual experiment is a chromatogram that can be analyzed in the same way as a real one. The simulation is important for understanding the dependence of the chromatogram (retention time and peak broadening) from the input parameters (distribution constant, phase factor, number of plates ecc…). The self-reflection and the reworking of basic chromatographic concepts are promoted by structured worksheets that can be solved by using the students' simulation program.

The last part of the didactic sequence is constituted by laboratory practical activities in which students face to a real problem: the separation and the identification of leaves pigment extract by using both the thin layer chromatography (TLC) e the column chromatography.

The *inquiry-based* approach and the different didactic tool and methodologies allow a successful student engagement in the learning process and an overall satisfying result. The connection between observation, model and simulations and practical activities is the strength of this didactic sequence. All the educational materials (video-tutorial, presentation, notebooks, and worksheets) are free available from the website "*Percorsi di chimica*" edited by the author [2]. The materials facilitate other teachers in replicating the sequence in their classes.

[1] A. J. P. Martin, R. L. M. Synge, *Biochemical Journal.* **1941**, 35, 12.
[2] https://sites.google.com/cattaneodigitale.it/percorsidichimica

‘Light and Molecules’: an experimental approach to the understanding of basic concepts of Quantum Mechanics

Dora Stella Lombardi,[a,b] Rita Cimino,[b] Gabriele Rossi,[b] Mariano Venanzi[b]

[a] I.I.S. Liceo L. A. Seneca, Roma; [b] Dip. Scienze e Tecnologie Chimiche, Università di Roma “Tor Vergata”, Roma

Physics Curricula for the fifth year of Liceo Scientifico are expected to introduce basic concepts of Quantum Mechanics (QM). There is an evident conceptual gap with respect to the teaching of Chemistry, that since the first years is bound to introduce some issues the physical basis of which lies on QM (electronic configuration of atoms and molecules, physical basis of Periodic Table, nature of chemical bond, atomic and molecular orbitals).
Unfortunately, QM is generally introduced in a rather formal way, that requires mathematical tools to be managed (at the very end, the Schroedinger equation is a second order differential equation, and such equations are not part of the background of a secondary school student). However, we firmly believe that some very basic ideas of QM can be introduced via an experimental approach, minimizing the formal apparatus of presentation. Among the others: the quantum nature of energy exchange, the wave property of matter, the probabilistic nature of the QM laws.
In this regard, optical spectroscopy seems to us the most suitable instrument to pursue an experimental approach for the understanding of the QM foundations of molecular properties. It should be noted that from an historical point of view, spectroscopic experiments represented the most evident proof of the failures of classical physics (black body spectrum, Rydberg spectral series).
With this aim, a joint activity, connected to the Piano Lauree Scientifiche/PCTO, was established between the Department of Chemical Science and Technologies of the University of Rome Tor Vergata (UTOV) and the I.I.S. Liceo Scientifico Lucio Anneo Seneca (LS Seneca) of Rome. The laboratory, denoted as ‘Light and Molecules’, was dedicated to the study of the interaction between the electromagnetic radiation (the electric field component) and some simple molecular systems [Carbon Monoxide (IR), $CHCl_3$/$CDCl_3$ (IR) acetone (UV), cyanines (Vis)].
Four teams of students (5R class - LS Seneca) participated to the PLS/PCTO Lab, working on general aspects of the radiation-matter interaction and on two case studies:
1. General Theory: *Radiation-Matter Interaction*. Team: Lorenzo Rocca, Emanuele Soave, Gianluca Stati, Alessandro Tripodi.
2. Case study: *Vibrorotational spectrum of Carbon Monoxide*. Team: Alessio Chelli, Emilio Di Salvo, Arabella Lacap, Lia Pagotto, Aurora Seri.
3. Case study: *Solvatochromism of the UV spectrum of Acetone. Determination of the energy of Hydrogen Bonding*. Team 1: Denise Albertin, Giovanni Cianciusi, Valeria Cianciusi, Enrico Roncucci; Team 2: Sara Brunetti, Flavia Del Monaco, Giulia Forgione, Simone Mastrogiacomo, Luca Sbriccoli.
Due to COVID-19 emergence, the students analysed the spectra measured in the spectroscopy laboratory at UTOV (Rita Cimino, Gabriele Rossi) under the supervision of Prof. Dora Stella Lombardi (LS Seneca) and Mariano Venanzi (UTOV). All the activities were carried out applying group learning and peer training methods.

Additional Learning Requirements (OFA) in Math for Environmental Science degree course: a review for a better understanding of the difficulties of students entering university

Alma Moretta, Giacomo Battipaglia, Antonio Proto, Vincenzo Venditto*

Department of Chemistry and Biology "A. Zambelli", and INSTM Research Unit, University of Salerno, Via Giovanni Paolo II, 132, 84084 Fisciano, SA, Italy

Enrolled freshmen in Environmental Science Bachelor's degree course at University of Salerno must certify the minimum required skills in math and logics by obtaining at least 15 points (out of 30) in the compulsory national CISIA TOLC-S entry test (sections Basic math and Logics/Problems). If not, students can apply to the degree course but they are assigned Additional Learning Requirements (OFA) and must attend a preliminary remedial math/logics course in order to be admitted to the Math exam of the degree course. From a review of the last three academic years data it has been observed that only a tiny percentage of students fit the entry test requirement: 7.6% in 2018/19; 2.2% in 2019/20; 6.1% in 2020/21; consequently, high numbers of students must attend remedial courses every year and many of them fail to pass the relevant exam, sometimes after several attempts. Therefore, in order to get better understanding of the reasons of students' difficulties, a critical review has been performed of the whole process, from the entry competence requirements to the OFA rationales and outcomes.

In detail, the seven OFA exam sessions held in the last two years have been considered, involving 150 students. The percentages of students passing the test at first attempt constantly stand between 40% and 60%. The test questions have been grouped in topic categories and for each of them the results have been analyzed, as percentage of correct, incorrect and not given answers. The category representing the major challenge for students, with percentages of correct answers always well below 50%, is relevant to "*Problems*", intended as application of basic math notions to solve simple reasoning problems. All the 150 students, including the ones who had precociously left the degree course for another course or another university or have just abandoned studies, have been asked to answer a survey questionnaire for acquiring information regarding: school background (i.e. type of high school attended, favorite subjects, attitude to apply problem solving in the different subjects, etc.), motivations and expectations regarding the degree course, difficulties encountered in the OFA courses and exams, perception of the OFA impact on development of students' academic career. Among the aspects that emerged it is worth highlighting one as surprising as it is worrying, which concerns the apparent disconnection, at high school, between the Basic Science studies (Biology, Chemistry, Earth Science) and Math studies. Despite the good attitude and preference of these students towards Science (which positively influenced their choice of pursuing a study career in the environmental sciences) mathematical tools and approaches are poorly regarded as the basis of science, which suggests there is a widespread belief that mathematical skills are not fundamental to scientific studies.

Moreover, a further important finding of the survey is the marginal role of high school teachers in advising students in choosing Environmental Science degree program.

Finally, the results of this study indicate that further insights into the difficulties encountered by incoming students are needed, but at the same time careful reflection to define, as a matter of urgency, more effective orientation strategies, possibly cooperative between universities and high schools, to increase awareness and motivation towards choice of university course is certainly necessary.

From the astro to the nano scale: a learning by doing teaching pathway

M. Salvador [a,b], D. Lago-Cachón [e], P. Calandra [f] , A. Malito [b,c] and D. Peddis [b,c,d]

[a]Universidad de Gijón, Department of Physics, Campus de Viesques. 33204 Gijón, Spain; [b] National Research Council (CNR) Institute of Structure of Matter mVia Salaria, Km 29,300, 00015 Monterotondo Scalo (RM), Italy; [c] Science is Cool (SCOOL) Cultural Association Via Monte Cervialto, 130 00139 Roma (Italy); [d] Università degli Studi di Genova Dipartimento di Chimica e Chimica Industriale Via Dodecaneso 31, Genova, 16146, Italy; [e] King Abdullah University of Science and Technology Computer Electrical and Mathematical Science and Engineering Thuwal, 23955-6900, Saudi Arabia; [f] CNR-ISMN, National Research Council Institute for the Study of Nanostructured Materials Via Salaria, Km 29,300, 00015 Monterotondo Scalo (RM), Italy

From the nano-world to solar systems length-scales span over several orders of magnitude. In young student it is therefore hard to fully understand the relative proportions among different objects even belonging to the same level of complexity. Resizing to human related distances is an effective way to understand the relative distances in astronomic scales or the amount of information contained in a single cell. In general, the use of imagination is essential in educational research as well as the use of different skills in interdisciplinary works. Some appealing examples will be given and the result of a pilot learning by doing teaching pathway involving hundreds of young students will be presented. Clues will give indications for future directions in educational research.

[1] M. Salvador, D. Lago-Cachón, P. Calandra , A. Malito And D. Peddis, Atti Accad. Pelorit. Pericol. Cl. Sci. Fis. Mat. Nat., **2021** In press

Chemistry, history and complexity

Antonio Testoni

Divisione di Didattica della Società Chimica Italiana

The issue of sustainability is inextricably linked to the issue of complexity. Chemistry, and more generally science, is something more than a "corpus" of knowledge: it is a way of thinking, it is a way of operating, it is a particular way of relating to the world and understanding its complexity. Therefore, in the teaching / learning of a scientific discipline, such as chemistry, not only specific disciplinary knowledge / skills must be considered, but also the knowledge of the processes and strategies used for the construction of knowledge. Knowledge and processes are inseparable as they are two sides of the same coin, which is that of culture. For this reason we believe that it is important, from the didactic point of view, to put in place a narrative that takes into due consideration the evolutionary process of growth and innovation of knowledge. Therefore, we cannot decontextualize knowledge, divide it from its origin and from the network of problems that generated it. Without the didactic reconstruction of this problematic context (theoretical and experimental), concepts and theories are meaningless for the student, they remain mere verbal definitions, lifeless and do not affect pre-existing conceptual schemes, that is, they do not become a "way of thinking disciplinary". We will exemplify these considerations by taking into consideration some aspects of “Lavoisier's Chemistry”, in particular the issue of the quantification of chemical phenomena.

A colorful new morning - teaching applied chemistry in pandemic times

Sergio Palazzi

ISIS di Setificio "Paolo Carcano", Como

Colour is one of the most effective stimuli to capture the attention and elicit the fantasy of learners, and this is especially true for those who are not primarily interested in "hard sciences".
The world of textile chemistry offers a lot of didactic chances that could be helpful even for those not directly involved in that sector of applied chemistry [1].

We are teaching at a historic *Istituto Tecnico* devoted to the study of textile production (weaving, finishing, printing…). During the pandemic periods, laboratory practice had several limits and normal lessons were often given via web, so it was hard to keep the concentration on experimental observations and on the subsequent theoretical interpretations.

The occasional aim of this job was already introduced elsewhere [2]; here we would like to stress the scientific and operational part of the job as a didactic approach for future works.

This presentation will discuss how we organized our lab practice dividing the tasks among different classes, where the younger students (3rd class, 16-17 y) were "leading" and the older ones (4th-5th classes) were more or less acting as consultants to better explain several points.
We also decided to collect our materials in a bound catalogue to be kept at our school museum, to remember this terrible period.

Both in research and in daily life, one of the most relevant differences between fibres of different chemical nature or different structure is the ability to be dyed by substances grouped in the traditional *dye classes,* and within each of them by the structural peculiarities of related molecules. Dyeing conditions (e.g. temperature, time, pH, salinity…) can differentiate those behaviours.

In order to save time, we simply used two not-so-different dyes, a blue and a magenta from the *direct* and *acid* classes, to simultaneously dye fibres like viscose, silk, nylon and wool; dyes where then partly stripped by washing. The only instrument used to study their behaviour was the reflection spectrophotometer. From the graphs in the "old" chromaticity diagram and in k/s vs. λ it is possible to argue the different ideas of equilibrium; numbers do not require physical presence.

A study of the chemical composition of the dyes and of the auxiliaries introduced to the topics of ecotoxicological evaluations and sustainability issues, relevant not only in textile production. Students also realized that the distinction between "natural" and "man made" fibres is an artefact of our traditional prejudices, whereas the understanding of chemical properties and microstructural features is quite more relevant also to design new and more acceptable technological processes.

[1] S. Palazzi, *CnS – La chimica nella scuola*, **2012**, XXXIV-3, 284-289
[2] S. Palazzi, *A Campione*, AICTC, **2021**, *58*, 1/21, 12-13

Chemistry: a Precious Discovery in the Dantesque World

Teresa Cecchi, Arianna Giuliani

ITT Montani, Via Montani 7, 63900 Fermo

This didactic path celebrates the 700th anniversary of Dante Alighieri's death with a STEAM approach through a chemical reading of the Divine Comedy. The outcome of our journey to Hell, Purgatory, and Paradise is both a theater performance which will be held in Torino and Fermo, (next Fall), and 15 video pitches in English available on YouTube (next July) which can also be shown during the Congress.

Chemistry interprets various specific cultural aspects relating to the souls placed by Dante in otherworldly places with surprising and never explored scenic effects. Chemical reactivity underpinning the show is both theoretically and practically studied. It is demonstrated that an aesthetically fascinating scientific experiment promotes learning thanks to the emotions related to it [1]. In the realization of the show important relational aspects come into play that are crucial in cooperative learning: self-confidence and trust in the group of peers are needed to face the stage. Deep and significant understanding of the chemical reactivity is needed to explain it on the stage.

In common parlance, art and technique belong to different categories, usually antithetical. Our didactic path aims to recompose this dichotomy. In Greek “tecnè” means “art”! The Latins indicated the science of matter as "Ars Chimica" and this is another motivation for bringing the most spectacular chemical technique to the stage.

The show is a significant stimulus for the spread of chemical culture even in humanistic environments normally impenetrable to it: the proper chemical actions are not only clearly explained but also accompanied by readings of appropriate extracts from the Divine Comedy, philosophical reflection and music that cause pleasant synaesthesias.

The didactic strategy and the continuous evaluation of learning try to develop in the students not only LOTS but also HOTS through brainstorming, Inquiry based learning, and rationalization of every chemical aspect connected to every cultural feature dealt with.

In the following we detail 5 excerpts from the theater performance (corresponding to 5 YouTube video pitches)

1-In Hell, the avarice is represented by marvelous oscillating reactions whose electric potential is transformed into a sound with a fluctuating pitch.

2-In Hell, in the circle of the lustful the wind of passion, made of oxygen (developed from the reaction of potassium permanganate with hydrogen peroxide) and of liquid nitrogen, safely overwhelms Paolo and Francesca and the audience.

3-The alchemist wizards in Malebolge will show us the wonderful alchemy of breathtaking reactions, accompanied by the notes of Paul Dukas's Apprentice Sorcerer. The 9th circle of Lucifer is displayed with the chemistry of sulfur, the demonic element par excellence, whose spectacular reactions are accompanied by Paul Bonneau's Dance of the Demons.

4-The ascent to Purgatory is mimicked by ascending chromatography, the purification chemical technique par excellence, on paper folded in the shape of a cone, with a breathtaking scenic effect

5-The ascent to Paradise passes through the 7 heavens of the Ptolemaic Aristotelian universe, each associated with a metal, whose spectacular reactivity is the "chemical track" of the brief reading that exemplifies the cultural aspect linked to the specific sky. The journey through Dante's skies is accompanied by the musical scales written by Kepler in his book “Harmonices Mundi” for the celestial bodies. The theology of light (Love that moves the sun and other stars) to represent the divine is interpreted with the lighting of the magnesium circles, as per the exact Dantesque description.

[1] C. Milne, T. Otieno, *Sci. Educ*., **2007**, *91*, 523.

A Carbon atom journey

Valentina Cantarelli, Maria Irene Donnoli

IPASR "Giustino Fortunato" Potenza – sede di Lagopesole

This is the synopsis about the teaching experience of first class students of the IPASR "Giustino Fortunato" high school of Lagopesole (Potenza, Italy). This activity was inspired by the "Carbon" story of the book "The periodic system" written by Primo Levi. There, the author claimed a final end of the book reporting the story of a carbon atom.
The atom, after being stored for millions of years in the form of $CaCO_3$ in a limestone rock, is brought to the Earth's surface by a miner, and then becomes CO_2 freed by the action of a furnace. The journey continues, time after time, as in an eternal present: always equal to itself, and yet in completely different forms. In fact, it becomes glucose with the process of chlorophyll photosynthesis, and thus migrate to humans, plants and animals. Finally, tied in a long chain, it is ingested, assimilated, and finally transported by the blood until it reaches a nerve cell, the same one that is responsible for Levi's writing who concludes the book in this way.
The carbon cycle is the biogeochemical cycle through which carbon is exchanged between the geosphere (among which sediments and fossil fuels are considered), the hydrosphere (rivers and oceans), the biosphere (including fresh waters), and the Earth's atmosphere. In order to provide a full understanding of this process, the school teachers of the "Giustino Fortunato" high school were inspired by the author's suggestions. Together with the student, they carried out basic chemical reactions in the laboratory involving carbon compounds ($CaCO_3$, CO_2, $C_{12}H_{22}O_{11}$) that manifest macroscopic variations (precipitate formations, color variations, gas production), which represent experimental evidence of chemical transformations.

[1] Primo Levi, *Il Sistema Periodico,* **1975**.

Peer review of scientific articles: a teaching experience

Elena Lenci

Dipartimento di Chimica "Ugo Schiff", Università degli Studi di Firenze, Via della Lastruccia 13, 50019, Sesto Fiorentino (FI), Italia
e mail: elena.lenci@unifi.it

Frontiers for Young Minds is an open access, non-profit scientific journal for which young people are both the target audience and critical participants in the review process [1]. An innovative and engaging peer review process allowed researchers to confront with young minds, with positive results for both sides. From one side, kids are encouraged in asking questions, they can learn how to distinguish between true science facts and "fake news" and they have the chance to interact for the first time with the "modus operandi" of the research world and of the publishing process. From the other side, researchers, with the aim of describing their work in a more comprehensible fashion, are stimulated in looking at their data from a broader perspective, gaining inspirational and motivational glimpse from students' comments. In this process, Science Mentors play a key role. The Science Mentors guide the Young Reviewers through the review process, serving as a direct connection to the scientific community. They assist them in navigating through a cutting-edge science manuscript, and empower them as young experts to provide feedback to authors about communicating science to their peers. Finally, as the entire process is carried out in English, this teaching experience represents an interesting opportunity for the application of the CLIL (Content and Language Integrated Learning) methodology [2].

[1] https://kids.frontiersin.org/.
[2] P. Mehisto, D. Marsh, M. J. Frigols, Uncovering CLIL, Content and Language Integrated Learning in Bilingual and Multilingual Education, Macmillan, Oxford, **2008**, 13.

Increasing the engagement of non-chemistry major students: examples of didactic strategic

Silvia Prati

Department of Chemistry G. Ciamician, University of Bologna, Ravenna Campus

In recent years, many educational institutions have focused the attention to the evaluation of the students' engagement.
The engagement is a measure of the level of attention, and interest that a student develops for a subject [1] and can be considered as a benchmark of the quality of the teaching activities [2]. Moreover, several studies have shown that there is a strict connection between student engagement and student performance [3].
Increasing the students' engagement towards a subject which is not related to their major may be a challenge [4]. Referring to chemistry, some aspects may be particularly critical such as the varying degrees of chemistry backgrounds and the different perception of self-efficacy [4].

This contribution is aimed at presenting the experimentation performed in the frame of a course on chemistry applied to cultural heritage held for students at the second year of a five year degree programme in restoration.
To increase the students' engagement and their self-efficacy 's perception, different didactic strategies have been applied considering that students learn using different cognitive styles. Pro-active learning has been promoted proposing activities which allowed students to make connections between theory and practise, both in classroom and in laboratory and using interactive quiz to allow the students to gain awareness of their comprehension level and to acquire metacognitive skills about their own learning process.

[1] D. Hymers, G. Newton, *Can. J. Schol. Teach. Learn.* **2019,** 10(1).
[2] E.T. Pascarella, T.A Seifert, C. Blaich, *Mag. Higher Learn.* **2010**, 42(1), 16-22
[3] R.M. Carini, G.D. Kuh, S.P. Klein, *Res. High. Ed.* **2006**, 47, 1-32.
[4] V.R. Vishnumolakala, D.C. Southam, D.T Treagust, M. Mocerinoa, S. Qureshic, *Chem. Educ. Res. Pract.* **2017**, 18, 340

Towards a material archive of dyestuffs from the XX century

Paolo Aquilini, [a] *Sergio Palazzi* [b]

[a] *Museo didattico della Seta, Como,* [b] *ISIS di Setificio "Paolo Carcano", Como*

The preservation of material archives of substances is a relatively recent issue, relevant in the field of cultural heritage preservation.
Although since the start of large-scale industrial chemistry (first half of XIX century) many artists experimented new pigments and ligands, along XX century the use of commercially available new materials in art production reached a general diffusion, at a level that in many cases the study and the conservation of works of art have to face many problems. Most pigments, and often the totality of other ingredients, are practically unknown and/or require expensive chemical analysis, when it is not possible to find traced samples.
Something alike happens with all the textile materials present in many kinds of collections, if we think of the mind-blowing number of synthetic dyestuffs that followed the lucky intuition by William Perking in the spring of 1859.
The availability of dye material archives could also be useful for researchers involved in other fields: the synthetic dyestuffs revolution has led to exceptional advantages to the lifestyle of all mankind, but was characterised by tragic consequences for the health and the environment, still present in many places around the world. As we know, most of the early introduced substances were of high ecotoxicological concern. Having an archive of industrial grade formulates, often rich in by-products and raw materials residuals, can give an added value also to these researches.

At international level, the publicly accessible material archives of dyes and pigments are very few. This communication outlines an early feasibility stage for the creation of a new archive, or an addition to existing collections, starting from a considerable number of dyestuff samples, in their original packaging, almost all from the second half of last century.
They were "rescued" some years ago from a clean-up of old didactic warehouses of the former Istituto Nazionale di Setificio (now, ISIS Paolo Carcano), Como. Until now they have been preserved in a confined storage. Most of them are in the range 10 – 100 g.
For many of them, there is also a documentation in a large collection of bound catalogues, mostly with original dyed fabric samples.

Possible research lines could include the complete cataloguing starting from the Colour Index tracing, the chemical characterisation of some representative formulates, but also a controlled use to prepare new textile samples as references.

Further developments could include a cooperation with other schools (analogue "relics" can be still present in the storages of many other historic Istituti Tecnici) and with a large number of firms, both chemical producers and finishing factories.

The School-University joint interventions provided in the National Recovery and Resilience Plan

Ugo Cosentino

Department of Earth and Environmental Sciences, Univerity of Milano-Bicocca, Piazza della Scienza 1, 20126 Milano
e-mail ugo.cosentino@unimib.it

The National Recovery and Resilience Plan (*Piano Nazionale di Ripresa e Resilienza*, PNRR) [1] provides for a series of interventions concerning: student orientation; initial and in-service training of teachers; strengthening of the STEM disciplines in the schools. For the realization of these actions it is necessary that the University and the School work closely together. Implementation of these measures, their monitoring and evaluation on the basis of appropriate indicators constitute a characterizing element of this Plan: it is necessary to spend well and within the established times.

The *Piano Lauree Scientifiche* (PLS), which involves all classes of scientific degrees, has been operating for 15 years on the topics previously indicated [2, 3] and in these years has created a solid network of relations between the universities and the schools. Since 2018, the University and Research Mystery (MUR) has also launched the *Piani Orientamento e Tutorato* (POT) [4] that share the same objectives of the PLS in the technological, social and humanistic disciplines. Finally, the three-year programme 2021-2023 of MUR provides for the reprocessing of national PLS and POT projects, extending the latter to all graduation classes.

The objectives set out in the PNRR can be achieved by using the network of the national PLS and POT projects and the community of colleagues that has ensured the quality of the actions and results in these projects. In addition, student orientation, in-service teacher training and strengthening of STEM disciplines are addressed in the PNRR as “separate chapters” while the experience gained in the PLS has shown that these elements are closely interconnected with each other and play a significant role in reducing drop-out and improving the careers of university students. Experience shows that these issues can and should be addressed within a common reference framework.

[1] Piano Nazionale di Ripresa e Resilienza, https://www.governo.it/it/articolo/piano-nazionale-di-ripresa-e-resilienza/16782
[2] Linee Guida Piano Nazionale Lauree Scientifiche 2017 – 2018, https://www.pianolaureescientifiche.it/le-quattro-azioni-del-pls/
[3] Ugo Cosentino, Nicola Vittorio “Il Piano Lauree Scientifiche: passato, presente e futuro”, Annuario Con.Scienze 2020, pp. 31-38, http://www.conscienze.it/annuario.asp