Report to the bureau 2020
Committee on Chemistry Education
Jan Apotheker
April 6 2019

1. Highlights and Executive Summary

Priorities for CCE in the biennium 2020/2021
The CCE priorities for 2020/2021 biennium are the same as those for the previous biennium:

- To develop relationships for working collaboratively with groups both inside and outside of IUPAC;
- To emphasize the importance of high-quality student-centered learning practices as well as identifying and discussing learning outcomes in chemistry education;
- To emphasize the importance of using evidence-based practice and reflective approaches in teaching and learning of chemistry;
- To encourage enthusiasm for teaching in the areas of chemistry and the use of technology in chemistry education;
- To continue supporting initiatives that raise awareness, social responsibility, and understanding the nature of science as well as of environmental and ethical issues that are related to chemistry;
- To initiate programs on promoting chemistry education and public understanding of chemistry for developing countries;
- To create resources to support high quality research and practice, and to disseminate the outcomes of research in chemistry education.
- Creating professional learning communities (PLCs) of chemistry teachers, via websites, skype conversations, and other electronic means.

CCE is involved in a number of projects linked to these goals.

Projects
CCE is involved in a number of projects. Sometimes as participants, in other cases CCE is involved in the leadership.
Projects that were completed in the 2018/2019 biennium are:

	Project Numbers and chair	Total Project Budget	Status
1	2013-022-2-050 Chiu	$5,800.00	Completed, final report to be submitted
2	2015-054-1-050 Boniface	$6,000.00	Postponed until later date
3	2016-002-4-050 Apotheker	$3,000.00	Completed,
4	2017-010-1-050 Mahaffy	$7,500.00	Completed, final report pending
5	2017-031-1-050 Apotheker	$15,000.00	Completed by Feb 1 2020
6	2018-041-2-050 duToit	$3,500.00	Completed
7	2018-015-2-050 Kamata	$ 5.000	Completed
8	2018-040-3-050 Ochirkhuayg	$4,500.00	completed
9	2019-035-1-050 Chan	$3,000.00	September 2020

10	2020-004-1-050 Apotheker	$1,800.00	January 2021

1. The project about gender gap has been finished, and may continue, a new project proposal is pending.
2. The Pacific Ocean FCEP has been suspended until a later date.
3. The first issue of CTI was published, the money paid to de Gruyter
4. The Systems thinking in chemistry education has been successful, a special issue of the Journal of Chemistry Education with some of the achievements was published October 2019
5. This the project concerning the Periodic Table challenge. This was concluded February 1, but will continue on the IUPAC website. A more complete report will be published in CI.
6. The conference in South Africa was held, and several people were able to participate thanks to this contribution.
7. The YAC in Mongolia was held in September 2019. A more complete report is added as annex 1.
8. The FCEP program in Mongolia was held in September 2019, together with the YAC. A more complete report is added as annex 2.
9. This project is focused to publish a special issue of CTI, about the educational workshops held by Division IV
10. This project aims to continue the Periodic Table Challenge in a slightly different format from the IUPAC website.

Chemistry Teacher International

In April 2019 the first issue of 'the Chemistry Teacher International' was published. In this project the CCE cooperates with 'de Gruyter' and the division of Chemistry Education of EuChemS. The second issue was published in September 2019. The journal is focused on publishing good practices in chemistry education. Its main target group is chemistry teachers. Articles are still being submitted regularly. The focus in the near future will be to see to a timed publication of the journal.
The first volume of CTI is complete by now.
For volume two four issues are expected:
Vol2. Is 1.: 02-02-2020
Vol 2. Is 2. 10-10-2020
Vol 2. Spec. Iss 1. Special issue with Division 4: 09-09-2020
Vol 2. Spec Iss 2. ICCE Capetown: 12-12-2010.
These issues are all more or less financed by the start up project of CTI and by a special project, that has been approved within IUPAC. We have about 32 articles in hand that have been approved for publication. These are enough for publication in Volume 2. We are receiving a steady flow of articles, About 30 are under review at the moment.
We may need to decide to increase the number of issues. In order to be able to stimulate and attract authors a publication fund is needed in order to help authors with limited financial support to publish their articles. The fund can also be used to help establish special issues with articles from conferences like NICE, ACRICE as well as ECRICE. In the transition period between closed articles and total open access of articles a publication fund gives some leeway to help and aid authors with limited funding. The publication fund can be a major catalyst for draw articles towards the journal. The fund can be open for donations of third parties. The fund shall be established within the publishing organization.

A project proposal for volume 3 and 4 will be submitted later this year.

2. Plans and priorities for this biennium and beyond. /
3. An overall report on activities and achievements during the 2018/2019 biennium

Conferences
For the next biennium CCE will continue to work on its priorities by organizing conferences on Chemistry Education. The 26th ICCE will be held in Capetown. Because of the corona virus this conference was postponed until January 2021. It will be held from January 26 till January 30 2021.
The 2022 conference will be held in Ezruum Turkey. In 2024 the ICCE is planned in Bangkok, Thailand. In 2026 we have plans for Kiel Germany.

Other conferences.
We will support the conferences to be held in Africa, Asia and Europe. The European Conference of Research in Chemistry Education will be postponed to July 2021. The Asian conference NICE is still planned for later this year. We will need to find an organizer for the fifth African Conference of Research In Chemistry Education.

FCEP and YAC
The Flying Chemist and Educator Project was held in Mongolia in September 2019. The report is added as an annex. The project was carried out with the help of the Interdivisional Committee on Green Chemistry and Sustainable Development. The project had as a goal to introduce Green Chemistry at the University level as a Bachelor course. A total of about 80 people attended the FCEP, from different institutions. We worked for three days and were able to start up the work for a Green Chemistry Course in three institutions, including the University of Mongolia in Ulang Bataar. There was a group of about 20 secondary school teachers. With them we worked on educational material for secondary education focused on Green Chemistry. Finally, a group of six young researchers started up work for a proposal to start up research in Green Chemistry. Specifically focused on critical liquids.
Following the FCEP a Young Ambassadors for Chemistry 2.0 was held. Designed by professor Masahiro Kamata, the focus changed from cosmetics to polymers. In appemdix 1 a more complete overview and report is given.

Future
A YAC is planned in conjunction with the 26th ICCE in Capetown. Since that conference has been postponed plans will change slightly.
We are planning a YAC for the WCC in Montreal as well.
The FCEP takes more organizing. We are in contact with Nepal and discussions are in progress about the introduction of microscale chemistry in Nepal.

Projects

Systems Thinking in Chemistry Education(STICE)
The special issue of the Journal of Chemical Education – *"Reimagining Chemistry Education: Systems Thinking and Green & Sustainable Chemistry"* - published by ACS (JCE, December 10, 2019 Volume 96, Issue 12 Pages 2679-3044) most of the accomplishments of this project were published. Reports about the project have been given and will be given at several conferences, like Eurovariety, NARST, ESERA, ECRICE and ICCE.
Future
A new project about STICE is being discussed at the moment and will be submitted later in the year. It will be linked to the International Year of Basic Sciences.

The Periodic Table Challenge
The challenge ran for a year and reached over 10000 people in over 130 countries. The Nobelium round had over 100 entries. Quarterly a selection was made and prizes were awarded. The winners received a periodic table signed by a Nobel laureate. A more complete report will be published in the next issue of Chemistry International

Future
The periodic Table Challenge will be moved from the IUPAC/100 website. But will remain available from the regular IUPAC website. We will only offer the first round of the competition, where people choose an avatar and answer 15 questions. When more than 60% is answered correctly they will receive a certificate in the form of a pdf -file.

OPCW
Several attempts were made to contact the Advisory Board on Outreach and Education. So far that has not led to any concrete result. We have not received any answer from the board, apart from a request for review of video's, which was dealt with in early 2019.
Through the president IUPAC we received a request for possible participants in a new temporary advisory board focusing on on-line presentations.

4. Tabular material

IUPAC Strategic Plan	CCE activity	Completion in:
IUPAC is an indispensable worldwide resource for chemistry	Cooperated in project the Periodic Table Challenge	2020
The International Union of Pure and Applied Chemistry is the global organization that provides objective scientific expertise and develops the essential tools for the application and communication of chemical knowledge for the benefit of humankind and the world.	Several attempts were made to contact the ABEO of OPCW, without success	2019 2020
Brand IUPAC in the minds of stakeholders	Support of ACRICE	2019
Improve quality and frequency of communication with stakeholders	First and second issue of CTI	2019
	Organization of ICCE	2021/2022/2024
Enhance interdivisional interaction and collaboration	Cooperation in projects	
Emphasize multidisciplinary projects addressing critical global issues	Project on systems thinking in chemistry education	2019/ 2020
Support chemistry education, particularly in developing countries	Support of ACRICE, ECRICE and NICE	ongoing

Annex 1.

Young Ambassadors for Chemistry (YAC) achievements in Mongolia

Masahiro Kamata, Mei-Hung Chiu and Jan Apotheker

YAC is a project that trains teachers around the world to communicate the benefits of chemistry to the general public with the help of their students as young ambassadors. A typical YAC event encompasses two to three days of teacher work-shops, followed by a one-day, public event where students—the Young Ambassadors for Chemistry—share their enthusiasm and interest with the public at large, either in a public square or as part of a science festival. That last day of the YAC event is usually a festive time and fun for everyone involved. Lida Schoen and Mei-Hung Chiu organized 41 events until 2016, both small and large, in 29 different countries.

YAC in Mongolia.

In September 2019, another YAC was held in Mongolia as an IUPAC Committee on Chemistry Education (CCE) project (2018-015-2-050) following FCEP (Flying Chemistry Education Program). YAC in Mongolia was made possible by National University of Mongolia, especially vice president Ochirkhuyag Bayanjargal, two professors D. Khasbaatar and C. Nyamgerel), Ministry of Education and Green Chemistry LLC. The YAC was three day long, and workshops for school teachers were held in the library of NUM on Day 1 and DAY 2. On Day 3, we had an open event for the public with students in Bluemon Center (restaurant mall) near the university in Ulaanbaatar. Until the previous YAC, cosmetic chemistry had been used as main materials to illustrate how useful and important chemistry is in our daily lives. This time, we chose functional polymer instead because there are many kinds of functional polymers available around us which are safe and inexpensive, and some of them can be used in regular chemistry classes in high school. In addition, some polymers play important roles in the field of green chemistry, and we are expecting young students to be more interested in them.

Workshop for School Teachers (Day1, Day2)

The workshop for school teachers were composed of two parts.

The first part was lectures presented by project members of IUPAC and a polymer expert coming from Mongolian University of Life Sciences. In the beginning of Day 1, Jan Apotheker explained about IUPAC and Mei-Hung Chiu talked about the roles of YAC and how previous YACs have been carried out in many countries. After that, Masahiro Kamata made a lecture on how to relate school chemistry with our daily lives using simple examples in our daily lives, and a polymer expert, Galaaraidi Otgondemberel, explained about the basics of polymer and how they are used in our lives.

In the second part of the workshop, we introduced three experiments as follow to the school teachers; 1) making slime using PVA solution sold as laundry starch, 2) evaluating water absorption ability of the polymer taken out from a pampers, 3) science craft using UV resin. Although we did not use functional polymer in the first experiment, it is effective to make students recognize the phenomena of polymerization. Then, the teachers were asked to design and prepare the open event by arranging the experiments that had been introduced to them as mentioned above. The teachers were divided into four groups and each group was assigned to one experiment. The teachers discussed how to use what they had learned so far. They also prepared chemicals and apparatuses for the experiments as well as paper materials such as worksheet for the students.


Young
Ambassadors
for Chemistry
MINISTRY OF EDUCATION, CULTURE, SCIENCE AND SPORTS
IUPAC

Open Event (Day 3)

Although we had planned to use a large shopping mall as a venue for the open event, the permission for the usage was suddenly canceled a few weeks before the event. Thanks to the big efforts of Mongolian members, YAC open event was allowed to be held in the gallery space next to the entrance of Bluemon Center (restaurant mall). We set tables and chairs as shown in photo so that over forty participants can be seated.

The event started at 10AM. In the morning, after the opening speech by D. Dorj (former rector of NUM), fifty seven high school students experienced three experiments using PVA, water absorption polymer and UV resin guided by teachers (The detail of each experiment is explained in the latter part of this report). After they got a picture on what functional polymer was, the students discussed about their dream of future polymer in each group. (What kind of polymer do they want? How and where do they want to use their dream polymer?). Then the students made their poster presentations in front of the judges.

When the students finished their presentations, the students invite the public to their tables and let them do the experiments together. Before ending the morning session, awards for good presentations were given to three groups with some gifts from IUPAC.

In the afternoon session, elementary school students were invited and experienced polymer experiments guided by high school students. This design was to allow the high school students to practice, demonstrate, and reflect upon their understanding of polymer experiments from the morning session and then act them out along with the younger students.

After the experiments, every kid was asked to write the impression on the event (How they liked this event) on a piece of post-it and orally presented it in front of all. Then the public (mainly the parents of the kids) were invited to the tables and enjoyed the experiments with high school students.

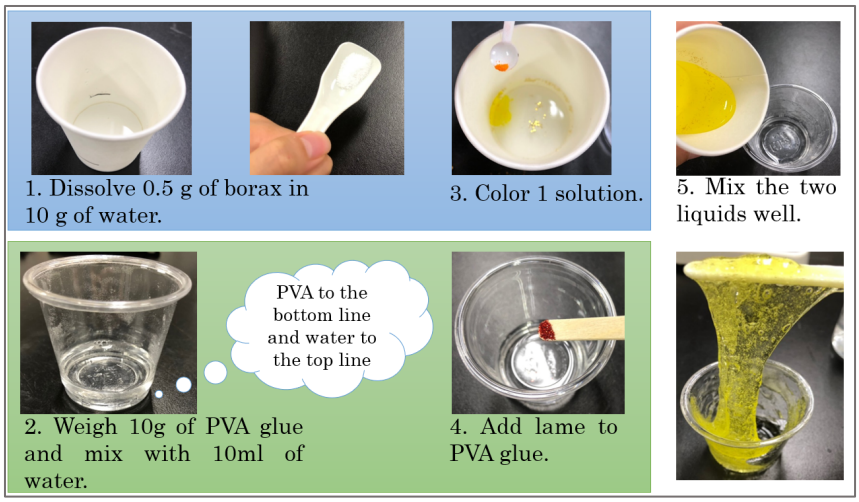
In the closing ceremony, a certificate of attendance was sent to all high school students and elementary school students with small gifts sent from IUPAC. The event ended around 15PM with a group photo of all participants.

Polymer experiments for the open event,

The materials used in open event must be safe and inexpensive in addition to being explicit about the relation between chemistry and our daily lives. From such a viewpoint, we chose functional polymer as a topic and following three experiments using it;

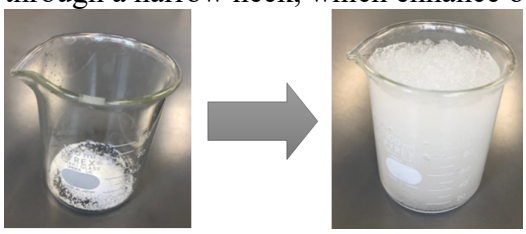
Polymerization of PVA

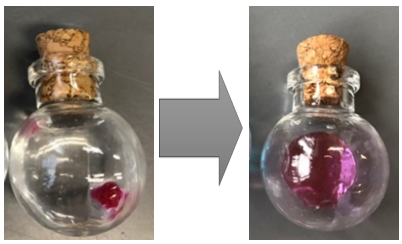
As a first step toward following experiments, polymerization of PVA is considered to be very useful. When borax is added to aqueous solution of PVA, molecules of PVA are bridged by borate ions and viscosity of PVA solution changed drastically. Therefore, this experiment is a good example for high school students to understand how cross-linking reaction works on the property of the material. In addition, students can easily recognize large amount of water can be trapped in a cage of polymer, which is closely related to water absorption polymer. As for elementary school kids, although they cannot accept explanations using molecules, they can enjoy the property (viscosity) change by adding some chemical. Something elusive is unusual for kids and most of them like to handle it with their bare hands.



Water absorption Polymer (SAP)

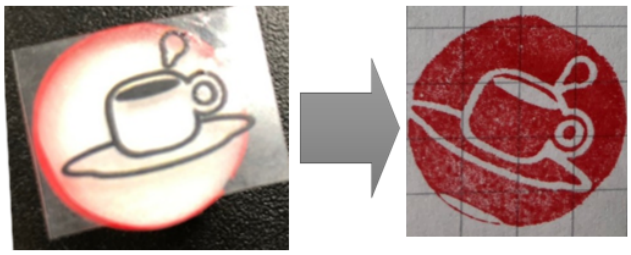
Water absorption polymer is one of the functional polymers that are used most widely in our daily lives as pampers. The materials itself is safe, inexpensive and easy to obtain almost everywhere (you can take it out from Water absorption polymer is one of the functional polymers that are used most widely in our daily lives as pampers. The materials itself is safe, inexpensive and easy to obtain almost everywhere (you can take it out from pampers if necessary). We planned to demonstrate 1) large amount of water can be absorbed in small amount of SAP and 2) absorbed water cannot be released easily. In addition to simple experiment using measuring cups to demonstrate 1), a tiny glass bottle with a narrow neck and a color SAP ball were prepared to show how much water a very small SAP ball (~1mm in diameter) can absorb. The SAP ball gets so large as 10mm in diameter as it absorbs water. Therefore, those who have not seen the initial state cannot imagine how the ball got in a bottle through a narrow neck, which enhance observers' interest in the function of SAP.





UV resin

UV resin is also one of the functional polymers that are used for many purposes; such as dental treatment, nail art and so on. In the event, students made rubber stamp by placing a printed mask over the resin and irradiating it with UV. Through this experiment, they can easily recognize only the part of the resin that are irradiated by UV is solidified. As for elementary school kids, much more simple activity to make a "YAC badge" was devised by Mongolian school teachers.

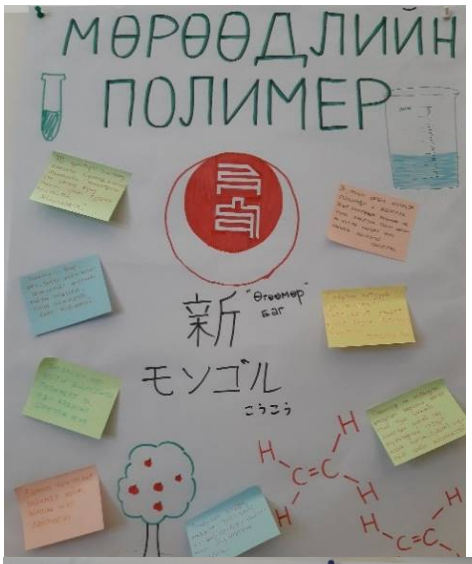


Communication to the public

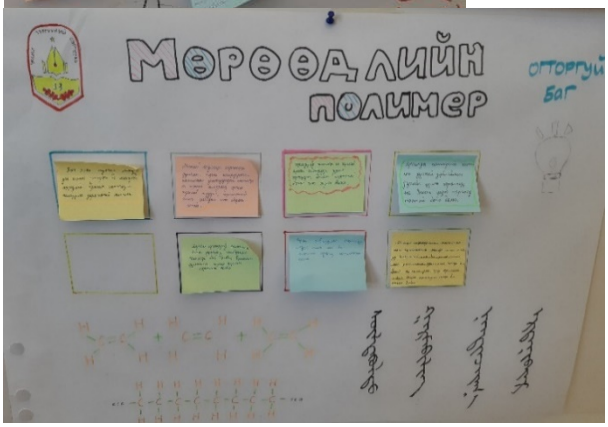
During the open event on Day 3, there was a chance for ordinary people to enjoy the experiment with high school students both in the morning and afternoon sessions. Since this hour was less than 15 minutes and the number of the people who can participate it was limited. Therefore, we prepared a leaflet which illustrate our activities and distributed them with questionnaire paper to the people who visited the venue. In the leaflet, we made a brief explanation about polymer chemistry and polymers experiments we used in open event. And we also explained what IUPAC and YAC are.

During the open event, we also got interviewed for internet TV in Ulaanbaatar, and our activities were introduced via facebook and twitter by tovch.mn social media agency.

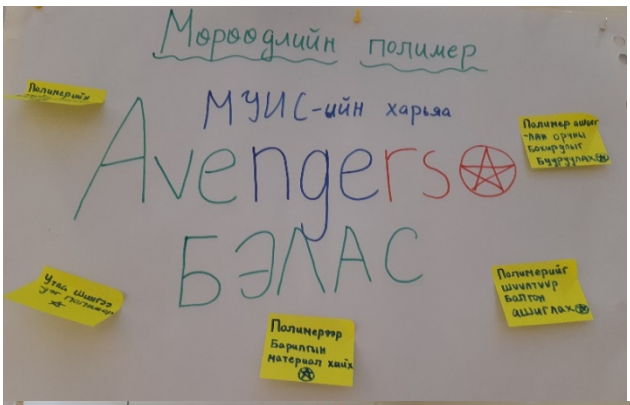
Dream polymers presented by high school students
A lot of unique and creative ideas were presented by high school students. Some of them are listed below:



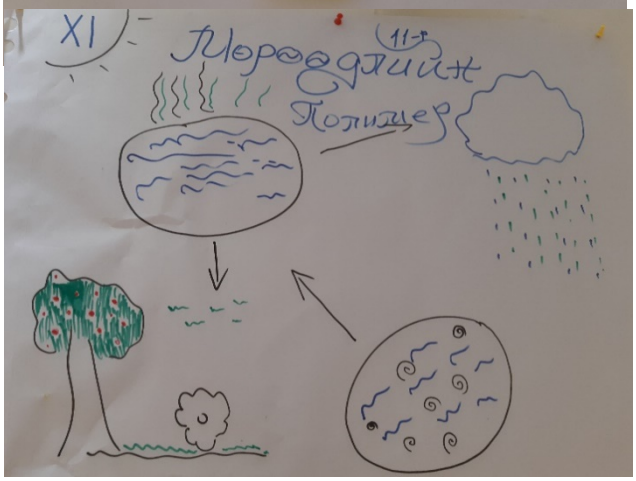
Shine Mongol school
Ideas written on the poster: Using polymer in a 3D printer to make a miniature model of a building or machine. Polymer can be combined with inert gas and made light.
The polymer can be used as vegetable soils by absorbing water and minerals. Water absorption polymer can be used to remove rainwater, and to prevent flooding by making a dam. Polymers that are easily hardened can be used for plaster and bandage at the hospital. Polymers are easy to change, so they can be used as a tool (robot) to reach a place where the person cannot reach.



School No 33
Ideas written on the poster: Polymers that emit heat, light and transmit electricity are the solution to energy issues and greenhouse gases in human life. If in the future combustion and heat resistant polymers are available, they may be used for building insulation and fuel. In the future, If there are light-transmitting polymer compounds, they may be used instead of glass. My dream polymers are very light and as hard as metal. I believe it will be widely used in road and bridge construction.



Baigal Ekh affiliated school of NUM
Ideas written on the poster: Smoke absorbing polymer, make building material by polymer, to reduce pollution using polymer, increase polymer household use, such as the use of polymer filters.



School No 11
Ideas written on the poster:
We want to have a super absorbent polymer. Absorbing the environmental pollution and releasing only the water will make ecologically clean water cycle. However, the polymer that absorbed the other contaminants can be processed into fertilizers.

Feedback from the participants.
Three kinds of questionnaire papers were prepared for teachers, high school students and ordinary people, respectively. The number of the high school students was 57 and most of them answered “After this activity, I acquired more about the application of chemistry in our daily life.” and “After this activity, my image of chemistry gets positive”. They also showed strong interest in the experiment and most of them answered that they would you like to participate again if similar activities are organized. The number of school teachers was 13 and most of them answered “I think I learned much from this activity” and “I am satisfied with the content of teaching materials of this activity”. All of them answered that they would like to participate again if similar activities are organized. As for the ordinary public, 18 results were collected. Although eight of them provided rather negative answer regarding the question “How much do you think you know about chemistry?”, twelve of them answered they had positive impression after the event. Most of 18 persons answered that they liked what the students are doing.
Twenty elementary school kids (most of them are in 5th grade) participated the event and we asked them to write down their impressions as mentioned above. All of their answers were positive and some of them are listed below;

- I liked it very much. We have done many beautiful experiments and we made stamp. Thank you for making these beautiful experiments.
- My school did not do such experiments. I am very excited today.

- I understand what chemistry is from this experiment. I did not know what chemistry was first. I knew that we use chemistry every day.

The impact on the high school students and the school teachers was much larger than expected. In addition, we got positive feedback from university professors and chemistry company who were involved in this event. Therefore, it is highly expected that the benefits of chemistry will be informed to the public in the future via students (young ambassadors) and teachers, and that this kind of activity will be continued in Mongolia.

Acknowledgement
We would like to take this opportunity to thank IUPAC CCE for providing the grant for the YAC event to be held in Mongolia. We would also like to express our sincere thankfulness to National University of Mongolia for their full support in many ways to make the event possible, in particular, special thanks to vice president Ochirkhuyag Bayanjargal, Professors D. Khasbaatar and C. Nyamgerel, Ministry of Education and Green Chemistry LLC for their kind support. At last, two graduate students, (Mina Tsuchiya, Taiga Inamura) were very helpful to conduct the experiments and to facilitate teachers' and students' activities.

Annex 2
'Flying Chemistry Educator Program' in Ulang Bataar, Mongolia, 17-22 September 2019.
Jan Apotheker, Anna Marakova, Aurelia Visa

Masahiro Kamata, a long time Titular Member of the Committee on Chemistry Education (CCE), visited Mongolia regularly since 2006, to advice school teachers. He used his contacts to initiate the negotiations to organize both a 'Young Ambassadors for Chemistry' as well as a 'Flying Chemistry Educator Program' at the University of Mongolia in Ulang Bataar. Ochirhuyay Bayanjargal, vice president of the University, worked together with CCE to organize the FCEP. 28 lecturers from the University, 27 secondary school teachers and 17 researchers from different institutions participated in the event. For IUPAC, two members from the Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD), Anna Marakova and Aurelia Visa, supported the CCE, represented by Jan Apotheker, Mei-Hung Chiu and Masahiro Kamata. The project was financed jointly by ICGCSD and CCE.

The focus of the three-day program of the FCEP was development of 'Green Chemistry' in Mongolia. The university wanted to start up a course in Green Chemistry, the secondary school teachers wanted to start up a module about Green Chemistry, the researchers were interested in starting up research in Green Chemistry. It was an ambitious program for a three-day session.

After the introductions and welcome by Ochirkhuyak Bayanjargal of the National University of Mongolia, Jan Apotheker introduced IUPAC, as well as the International Year of the Periodic Table.

Figure 1. Jan Apotheker introducing IUPAC

Anna Makarova presented a short presentation on the topic "What is Green Chemistry?". As part of this presentation, participants were given a definition of Green Chemistry and 12 basic Green Chemistry principles. Descussion the role Green Chemistry in implementation UN Sustainable Development Goals (2015) and its role in observing planetary boundaries. UN Environment (Global Chemicals Outlook II[1]) data were presented for the market size of the global green chemistry industry (2015-2020) and the global green chemicals market by region (2011-2020) which Asia-Pasific region have more them 30%.

[1] https://wedocs.unep.org/handle/20.500.11822/27651?show=full

After presentation Anna Makarova organized a discussion. In frame of this discussion the advantages that are possible from the introduction of Green Chemistry as well as a possible strategy (main activities) of the development of Green Chemistry in Mongolia was considered. The VISIS method and technology "Pyramid" wich developed by Atkisson and others was used[2]
for clarity and visualization of the discussion. VISIS method took its name from the first letters of the following four stages:
V - vision and goals. In this case, the main goals of the object of research were the creation of courses and training modules as well as the organization of research projects in the field of green chemistry.
I - Indicators. This stage includes analysis of available data on the effects of the object of research on environmental, economic, societal and individual well-being dimensions, and identifying current trends.
S - Systems. This stage consists of system model construction and identification of critical cause-effect relationships within the system, with a subsequent search for leverage points (system components where the introduction of any changes and / or innovations can be the most effective).
I - Innovation. This stage includes selection and evaluation of stability-improving innovations that can contribute to sustainable development.
S - Strategy. This stage includes building a common strategy for the implementation of selected innovations.

Figure 2. The pyramid activity (maybe a photo with more post-its on them)

During this workshop, since there were three groups (lecturers from the University, secondary school teachers and researchers) with different precisely defined visions and goals, three Pyramids were created. The pyramid activity activated the participants. After an intensive discussion, it appeared they had major concerns about the air pollution in Ulan Bataar, water pollution occurring in the streams of Mongolia, as well as the management of chemical waste,

[2] AtKisson A. The Sustainability Transformation. How to Accelerate Positive Change in Challenging Times. Published November 19th 2010 by Earthscan Publications. P. 323. ISBN 1849712441

which is missing in Mongolia. The creation of courses and training programs was considered by the participants as one of the main elements of the strategy for solving these problems.
In the afternoon session Aurelia Visa gave an introduction about 'Green Chemistry' research-challenges and opportunities.

- This introduction outlines the directions of research in the field of ecological chemistry and its benefits for the environment, as well as in areas such as human health, society, economics, sustainability and last but not least science. The need to use biomass and obtain energy from it has been detailed. The main argument for this initiative is that the vegetal material is produced as a result of the photosynthesis process, whereby, due to solar energy, simple molecules are transformed into complex organic molecules. Vegetal materials absorb carbon dioxide from the atmosphere during its growth and return it to the atmosphere during combustion. Therefore, the CO_2 balance of described processes is zero, so it does not contribute to the greenhouse outcome. Several biomass conversion pathways have been described during the lecture.
- Starting from the twelve principles of green chemistry, the topic of alternative solvents was analyzed in the sense of increasing interest both in the research community and in the chemical industry. The impact of solvents on pollution, energy consumption and contributions to air quality and climate change must be taken into account. Solvent losses are a major part of organic contamination, and solvent elimination accounts for a large proportion of the energy consumption in the process[3] (3.Prat D., Hayler J., Wells A., *Green Chem.*, 2014, 16(10) 4546-4551).
- Another interesting topic discussed was the use of alternative energy such as microwaves and ultrasounds to accelerate chemical reactions and improve synthesis results.
- Also, the importance of chemistry behind chlorine was taken into consideration. Chlorine compounds are used in the manufacture of a number of significant commercial products that may or may not contain chlorine in the final molecular structure. For these compounds, synthetic alternative pathways that adopt a holistic and proactive approach and do not use any chlorine derivative cannot offer new products and processes. Therefore, major chemical industries are already conducting research focused on addressing syntheses and processes in which chlorine or chlorine compounds are not involved.
- These studies are not yet widely known because they are protected by confidentiality. Relevant examples for replacements to chlorine in industry and in academic syntheses will be useful to facilitate the development of significant and industrially implementable advanced technologies. Chemists deserve to be perceived as creative people who make a high contribution to the prosperity of mankind and are capable of leading and engaging in dialogue with economists, politicians, entrepreneurs and philosophers about sustainable development, rather than polluting the planet[4].(4.Tundo P., Pure Appl Chem, 2012, 83(3), 411-423)
- An important aspect for evaluating chemical remedies is the use of formulas for measuring reactions efficiency through conversion, yield and selectivity. As these values do not account for pollution, the use of solvents and the resulting wastes have been reviewed in other values for measuring the green degree of the reaction. Thus, various metrics such as atom economy, e-factor, atom efficiency, effective mass yields, process mass intensity, carbon economy, SWOT analysis and life cycle assessment were introduced.
- Many of the principles of Green Chemistry can be applied in everyday life, such as waste prevention or more energy efficient industrial processes on a large scale to minimize waste and reduce environmental impact. Everyone is paying attention to pollution and how to reduce the impact of human activities on climate change.

-

At the end of the first day the participants visited the laboratories of the University.
Sarangarel Davaasambuu, dean of the faculty, discussing chemistry related industries in Mongolia, started of the second day. These are mostly related to mining 30% of the GDP of Mongolia is related to mining, at the moment mainly coal and copper. There are other deposits of metals, among which uranium and gold. These are mostly exported as fairly raw material to China. The other main source of income is agriculture. Mongolia has a vast area of steppe on which cattle, cow, horse and sheep are held.

Meat is exported. A specific local product, which needs an acquired taste is ayrak, a fermented horse milk.

Figure 3. a glass of ayrak.

One of the major problems she reported was the lack of adequate management of chemical waste, resulting in pollution both of water and the environment.
In a short presentation about a number of chemical disasters, Aurelia Visa demonstrated the need for 'Green Chemistry'. She also introduced some of the areas of research in 'Green Chemistry', focusing on reduction of waste and raising atom efficiency, as well as the use of solvents that are not detrimental for the environment. Finding different pathways for reactions, the use of catalysts optimizing atomic efficiency were some of the aspects discussed. Finding alternatives for solvents in the form of super critical liquids was another issue presented.
Before lunch Jan Apotheker gave an introduction about education. Starting with the introduction of the ideas of Piaget and Vygotsky, the framework for the design of a course was presented, based on the model of educational reconstruction(Duit, Gropengießer, Kattmann, Komorek, & Parchmann, 2012).

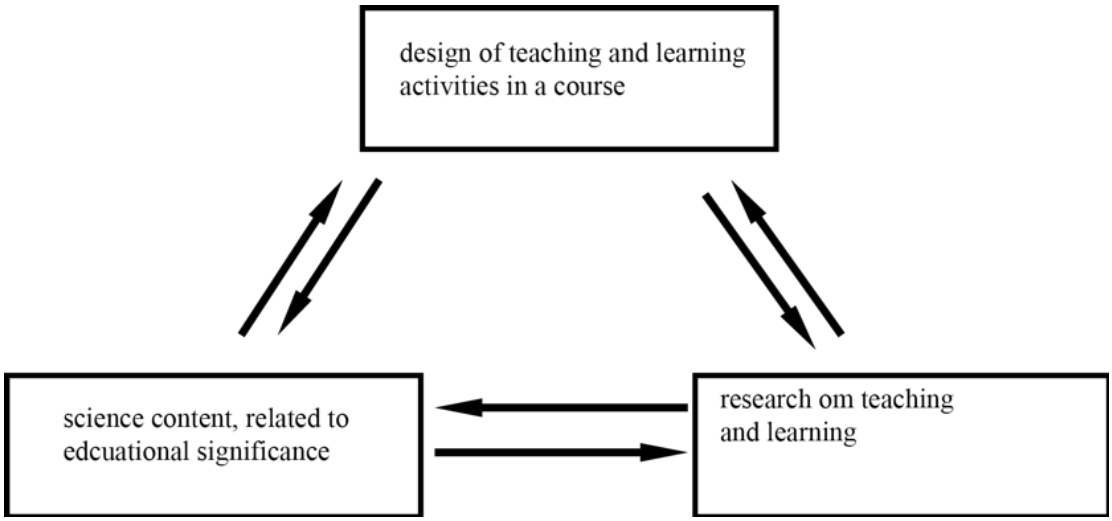


Figure 4. Model of educational reconstruction

The idea is that scientific content is related to research on teaching and learning, for the design of the teaching and learning activities in a course.

For the design of the course the framework of constructive alignment (Biggs, 1996) was used. Based on the learning goals learning and teaching activities are developed for the course. Based on these same learning goals assessment is designed, directly linked to the teaching and learning activities.

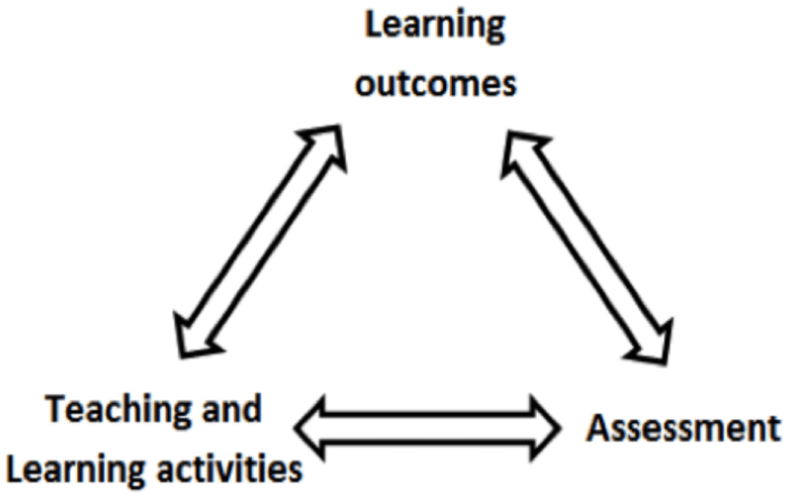


Figure 5. Model of constructive alignment

The group was first asked to formulate a more general learning goal for the course. It should express in one sentence the goal of the course. Subsequently the learning goals should be formulated in a more detailed way. These goals should be formulated SMART (Apotheker, 2018):

Specific
Measurable
Attainable
Relevant
Timely

In figure 6 one of the results is shown.

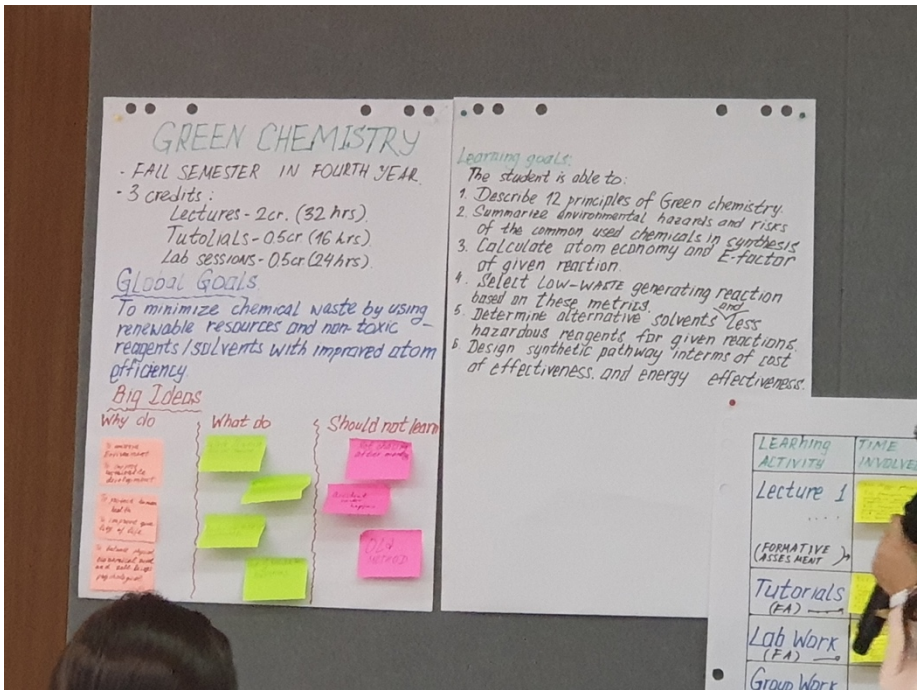


Figure 6. Results from one group design of a course

Higher education group

Two groups of about 8 members of university faculty worked on the design of a course, which were partly overlapping. They intend the course to be placed in the end of the third year. Interesting was that in one of the groups a lab session was envisioned, in which students are asked to design alternative pathways for a synthesis, which are as green as possible. In the subsequent steps they will be asked to design a waste management for the waste produced during the reaction, so that the waste can be reused.

As can be seen in figure 6 they started on the design of the lectures. They were specifically asked to introduce formative assessment in the lecture design.

At the end of the three day session they are in a position to merge the two proposals into one. It should be possible to introduce the new course in the next academic year.

Secondary education group

Ultimately two groups worked on a module for secondary education. One was planned for grade 10, the other for group 9.

The first group (9th grade) took drinking water as a subject. Using the 5E framework(Bybee et al., 2006) in which the educational activities are sequenced in 5 steps:

Engage, Explore, Explain, Elaborate, and Evaluate. A sixth E was introduced between Elaborate and Evaluate: Exchange, making it a 6E model.

The Exchange part lets the students share their results with others, either their peers or their parents, We suggested that the students should make an exhibit that can be exposed in the science centre the University is planning to construct in one of their buildings.

The water demonstrates one of the features of Green Chemistry a cycle.

After purification the water is used in the household, and is returned via a waste water plant to the surface water, which is used as a source for the drinking water.

The other module for 10th grade has batteries as a subject and looks into the differences between alkaline batteries and lithium batteries. Again here, a feature of Green Chemistry is introduced, the difference between a cradle to grave design for the alkaline batteries and a cradle to cradle design for the lithium batteries.

Both designs still need some work before they can be tried out in the classroom. We have asked the University to invite the group of teachers back to the university so they can keep on working together on the design of the module.

Research group
Anna Marakova and Aurelia Visa coached the research group. They started out with formulating ideas, performing a SWOT-analysis on the suggestions, and came up with a time line for research project. This project should over a period of three years lead to the construction of a reactor in which reactions in super critical water can be carried out. Ultimately they want to use this to introduce the use of super critical water into industry.
The research group with participants from different institutions, will continue to work on the proposal, which will be sent in to the Mongolian Science Foundation for financial support.

Figure 7. Group photo of the participants to the FCEP

The participants felt they had achieved first steps towards their objectives and will continue to work on their projects.
Over time we will contact the university to find out how things have progressed.

Mongolian Chemical Society
During the three days we had a lunch with the chair of the Mongolian Chemical Society, Avid Budeebazar. He expressed an interest in joining IUPAC as an NAO.

Acknowledgments
The FCEP was made possible by the financial support of 'Green Chemistry LLC' and the National University of Mongolia, as well as ICGCSD and CCE from IUPAC. During the week we had (work) lunches and dinners with several representatives from companies and institutions in Ulang Bataar, like the New Mongol Institute of Technology, The German Mongolian Institute for Resources and Technology, Synaps and Green Chemistry LLC. The last two are both companies trading in laboratory glass ware and chemicals.

As a delegation we were fortunate to be able to meet Chingis Kahn

Figure 8. Stainless steel statue of Chingis Kahn

Aurelia Visa is senior researcher at “Coriolan Drăgulescu” Institute of Chemistry, Timișoara, Romania.