

To summarize, first, Chile, Japan and Turkey emphasized more on the linkage between phenomena at macroscopic level and structures of matters at microscopic level. Second, Japan and Malaysia focused more on the linkage between phenomena at macroscopic level and symbolic representations of matters and compounds, while there were three countries integrating macroscopic, microscopic, and symbols in their curriculum standards to present a relatively holistic framework for chemistry learning (Figure 1, bottom).

Conclusions

With well-designed curriculum standards, teachers can develop appropriate learning materials and strategies to cultivate students' understanding of chemistry and then apply their knowledge of chemistry in problem solving and authentic situations. The analyses of this study might provide an avenue for designing chemistry curriculum standards and further for chemistry education reforms.

We are faced with a great challenge in teaching chemistry, but it is also a great opportunity for us, as chemistry education researchers, to reflect on why we do the work we do and where our research could lead us to the next stage for future generations. While learning chemistry is a challenge for most students, research has shown that certain approaches can effectively promote learning through the use of sense-making materials and strategies (such as modeling-based text, conceptual conflict scenario, systems thinking, and innovative technology). Yet, more evidence-based research is needed to guide us on improving the quality of chemistry education both locally and globally. This goal cannot be easily achieved without researchers' and policymakers' persistence and passion for chemistry education.

Note:

Research findings were presented at various international conferences, such as the 23rd International Conference on Chemistry Education in Toronto, Canada, 2014; International Conference on Network for Inter-Asian Chemistry Educators (NICE) in 2015, and 24th International Conference on Chemistry Education 2016. Some of the participating countries might launch new curriculum standards ever since. Further analysis might be needed to investigate the progressive development on curriculum standards in chemistry across countries.

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Capacity Building of Teachers on Chemistry Hands-on Small-scale Experiments in High School in Asia: Nepal

by Supawan Tantayanon, Jyoti Giri, Rajesh Pandit, Rameshwar Adhikari, Supakorn Boonyuen and Zuriati Zakaria

Capacity Building of Teachers on Chemistry Hands-on Small-scale Chemistry [Kathmandu, 19-20 October 2022]: The capacity building of high school government science teachers were envisioned by the IUPAC Committee on Chemistry Education by introducing



Photographs of Dignitaries at Opening ceremony and participants in working in technical session

chemistry practical education at the high school level on a small scale. In the same connection, the IUPAC Project 2022-004-1-050 was planned in such a way that it could be sustainable for the future as well, therefore it was planned in four different segments:

- Phase 1: workshop in Nepal, 19-20 October, 2022, NAST
- Phase 2: video competition to select 10 best teachers who participate in PACCON 2023, 15 November 2022, Online
- Phase 3a: Networking & workshop in PACCON 2023, 21 January 2023, MaeFah Laung University
- Phase 3b: Training for trainers, 22 January 2023, Sann Hotel

As per project theme, the two-day workshop was conducted at the Nepal Academy of Science and Technology (NAST), Saatdobato, Lalitpur, Nepal for 100 government high school science teachers selected from 7 different provinces of Nepal. The workshop was organized by the Chemical Society of Thailand (CST), Bangkok Bank with financial collaboration and local organizing partner Nepal Polymer Institute (NPI). Locally the program was hosted by NAST and teachers out-reach partner Science Teachers Association, Nepal (STAN).

The workshop was the lightning bolt to all the participants; chemistry and science teachers who are responsible for teaching chemistry for high school students in theoretical and practical aspects inside the classroom. 100 permanent teachers from government high school were selected using a google form for application and selection was done on the basis of their answers to the questions and gender equity. Out of total 147 applicants 100 were selected: 22 participants from Province 1, 8 participants from Madhesh Province, 20 participants from Bagmati Province, 19 participants from Gandaki Province, 14 participants from Lumbini Province, 8 participants from Karnali Province, and 9

participants from Far Western Province. Of the 100 participants, only 3 were female teachers.

The workshop was conducted by 11 dedicated trainers came from Thailand

1. Supawan Tantayanon, *Chulalongkorn University*
2. Vudhichai Parasuk, *Chulalongkorn University*
3. Noppavan Chanunpanich, *King Mongkut's University of Technology North Bangkok*
4. Supakorn Boonyuen, *Thammasart University*
5. Boonnak Sukhummek, *King Mongkut's University of Technology Thonburi*
6. Thitinat Sukonket, *Suan Dusit University*
7. Sudkanueng Singto, *National Nanotechnology Center*
8. Chayawin Chomngam, *Prachinratsadornamroong School*
9. Jiraphan Charoensinvorakul, *Doing Sciences Co., Ltd.*

Chotima Noopruck, *Office of the Basic Education, Ministry of Education* Zuriati Zakaria, Institute Kimia Malaysia, was also involved in training the teachers during the workshop.

The local organizing members were Rameshwar Adhikari, Jyoti Giri, Rajesh Pandit from NPI, Rabindra Dhakal from NAST and Devendra Karn from STAN facilitated the complete local arrangements.

The trainers from Thailand and Malaysia with 100 small scale experimental kits on 17 October, 2022 were warmly welcomed by local organizers. The due preparations were with experimental kits were completed on 18 Oct with all trainers and volunteers from local organizers.

The official opening of the workshop was conducted in the presence of very inspiring dignitaries

- **Rameshwar Adhikari** (Chair of Local Organizing Committee)
- **Supawan Tantayanon** (Director, Small Scale Chemistry Center, and CCE IUPAC)

Project Place

- **Vudhichai Parasuk** (President, Chemical Society of Thailand)
- **Khil Kumar Pradhan** (President, Science Teachers Association of Nepal (STAN))
- **Chartsiri Sophonpanich** (President, Bangkok Bank Public Company Limited)-virtual
- **Indu Bikram Joshi** (Associate Secretary, Ministry of Education, Science and Technology, Nepal Government)
- **Marietjie Potgieter** (Chair, Committee on Chemistry Education, IUPAC) —virtual
- **Sunil Babu Shrestha** (Chief Guest, Vice-Chancellor, Nepal Academy of Science and Technology)
- **H.E. Vosita Vorasaph** (Special Guest, Ambassador of Thailand to Nepal)

Before entering the technical workshop, all participants gave the online pretest about their real knowledge on small scale experiments. The technical session started with brief introduction of small-scale and all nine experiments that they were going to learn in those two days by Supawan.

On the first day (19 October) 3 experiments were practiced among the participants followed with question answer session.

- Experiment 1: Interdiffusion of gases
- Experiment 2: Electrochemical separation of copper

- Experiment 3: Solubility of ammonia

All participants were enthusiastic to learn different techniques they could apply to their chemistry teaching chemistry practice. On the second day (20 October) the rest of six experiments were practiced:

- Experiment 4: Titration of a strong acid with strong base
- Experiment 5: pH indicators
- Experiment 6: Electrolysis of water
- Experiment 7: Reactions of acid and carbonates
- Experiment 8: Property of oxygen gas
- Experiment 9: The law of conservation of mass

After completing all nine experiments participants, gave the post-test which clarified the knowledge they gained in this workshop. Moreover, they were also explained about video competition process to select ten best teachers among them who could participate in training the trainers and networking on 21-22 January in Chiang Rai, Thailand.

The closing ceremony of the workshop was conducted in the presence of member secretary of NAST, Mahesh Kumar Adhikari. Trainers and Trainee both shared their experiences that they gathered in the workshop.

A post workshop meeting was also held among all organizers to make the workshop more sustainable for the future as well.

The second phase of the project was a video



All dignitaries, mentors, organizers, and volunteers pose for a picture at the closing ceremony of the two-day workshop on chemistry education. It was washeldat the Nepal Academy of Science and Technology (NAST), Saatdobato, Lalitpur, Nepal for 100 government high school science teachers selected from 7 different provinces of Nepal.



Group photograph of teachers from five countries during training the trainers

competition where teachers need to submit their innovative experiment designed video of 5 minutes for small scale chemistry practical using their local resources and submitting it to before 15 November 2022.

Among 40 videos submitted from Nepal, the best 10 videos with small-scale concept using local resources were selected by the expert team of Chemical Society Thailand as follows:

- Govind Bahadur Dhimi: *Preparation of Carbon dioxide Gas*
- Hari Ram Devkota: *A Popping Sound from Hydrogen Gas*
- Janak Raj Pant: *Study of Chemical Kinetics for the Evolution of Hydrogen Gas*
- Lokendra Subedi: *Generation of Gas from the Reaction between Acid and Metal*
- Matrika Timilsina: *Handy Preparation of Carbon dioxide Gas to Observe Fire Extinguishing Property*
- Narendra Rawat: *Sublimation Technique for Separation of Volatile and Non-Volatile Mixture*
- Prameshwor Sharma: *Distillation Flask Setup from Locally Available Materials*
- Rohini P. Lohani: *Kitchen Materials for Generation of Carbon dioxide and Study Its Properties*
- Uttam Subedi: *Convenient Electroplating of Copper on Iron Nail*

- Yubaraj Ghimire: *Low Cost Convenient Construction of Galvanic Cell*

These ten teachers were nominated to participate Phases 3a and 3b of the project on 21-22 January in Chiang Rai, Thailand.

Ten selected teachers from Nepal travelled to Thailand on 19 Jan 2023 to accomplish the third and fourth phases of the project. On 20 Jan 2023, teachers joined the banquet dinner in Mae Fah Luang University, Chiang Rai, Thailand, with all PACCON 2023 delegates. On 21 Jan 2023, the Chemistry Teachers networking session was organized at the E4 building in Mae Fah Luang University.

In the program, 63 participants actively participated in the networking session, among them 10 from Nepal, 30 from Thailand, 6 from Vietnam, 8 from Cambodia, and 9 from Indonesia. As the program was focused on building the networking between the teachers, participants, experts, and mentors from each country introduced themselves briefly. One special video lecture was displayed by Robert Worley, the high school teacher as a safety expert of CLEAPPS from United Kingdom. The lecture was mainly focused on safety and cost reduction aspects of small-scale chemistry as well as the challenges faced in the implementation of small-scale chemistry techniques in schools.

Project Place

After the lecture, all the participants were divided into two groups with blue and red circles. Each group was further divided to fill ten tables arranged to make two circles. Five tables in each circle housed five experiments which need to be completed in ~15 minutes. Participants were instructed to conduct experiments and shuffled to another table to conduct the next experiment. The shuffling of tables was carried out to ensure that every participant will meet new people each time they conduct new experiments. Participants carried out each experiment by interacting and sharing their idea with each other in the group which increased their networking capacity. The five experiments performed in networking session were given follows:

1. Indicator colors at different pH and making a universal indicator. An introduction to small-scale chemistry
2. Chemistry of Transition Metals—Iron
3. Spectator ions: Using small-scale to challenge misconceptions
4. Diffusing Precipitate Reactions
5. Solubility Rules: Using small-scale for an investigation

At the demonstration site, experimental stalls were set up by all participants to display their winning experiments. The experimental display was visited by PACCON 2023 delegates, the main attraction being the presence of Nobel Laureate David W. C. McMillan along with Vice President (President-Elect) of IUPAC, Ehud Keinan. The participants had the opportunity to interact with prominent chemists at the conference. The participants observed each other's experiments and interacted to share their knowledge and expanding their networking. The exciting part was when the organizer announced that there will be an award for one participant from each country with the highest networking.

On the second day (22 Jan 2023), the Phase 3 of the program was conducted at 9:00 am at Sann Hotel with a short introduction from Niwat Srisawasdi, Faculty of Education, Khon Khaen University, Thailand who gave lecture on "Competency-based chemistry education for new generation learners" focusing on both trainers and trainees to conceptualizing research based high impact learning and teaching strategies. Based on the lecture, nine high impact teaching strategies were practiced:

1. Supporting visual generation
2. Supporting content producer
3. Receiving immediately feedback and rewards
4. Receiving challenge to level up

5. Learning as game playing
6. Presenting isolated facts
7. Disconnecting to present daily living
8. Linkage of multiple representations
9. Disconnecting nature of the scientific inquiry

In the training the trainers workshop, the participants were separated in 9 groups for the task assignment. Each participant had selected one topic in which they wanted to be an expert from the above 9 topics. After selection of specific topic, each participant moved to each table from 1 to 9, where they could exchange and learn a certain strategy from each expert. Each expert group discussed in detail their respective topics for 20 minutes and shared the information gained from the expert in group discussion.

After discussion, they correlated the strategies which were relevant to the small scale experiments performed by them on 21 Jan. Each group prepared a PowerPoint presentation on the related strategy and small scale experiments for their proposed learning activities within the provided time frame. The technical session ended with a lecture on "Applications on low-cost simple colorimeter for education" by Supakorn Boonyuen to instruct the participants how to correlate strategy in small scale experiments.

At the end of the program, the best networking awards were announced for every country:

- Dang Thi Houng Giang, Vietnam,
- Surangkana Srisawet, Thailand,
- Neav Navy, Cambodia
- Mohammad Wahyudi, Indonesia
- Hari Ram Devkota, Nepal

The Vice President of Bangkok Bank Public Co., Ltd. distributed certificates to awardees and all participants in Singha Park. The award giving celebration was conducted with cultural program from each participating countries in group performance. Supawan Tantayanon motivated all the participants to spread the knowledge they gained among their colleagues in their country for small scale chemistry experiments and network with other teachers in Asia. The CST and Bangkok bank also gave a set of small-scale distillation set for individual participant to carry to their workplace making them more equipped.

All the participants of the small-scale workshop agreed that this was a very fruitful and sustainable program for Nepal.