Knowledge hub
-
Collection of best practices

Summary of the best practice

1. Title of the best practice (e.g. name of policy, programme, project, etc.) *

Capacity building of teachers on chemistry teaching with hands-on small scale experiments in high schools

2. Country or countries where the practice is implemented *

Thailand, Myanma, Cambodia, Indonesia, Vietnam, The Philippines, Nepal

3. Please select the **most relevant** Action Track(s) the best practice applies to *

- [x] Action Track 1. Inclusive, equitable, safe, and healthy schools
- [ ] Action Track 2. Learning and skills for life, work, and sustainable development
- [x] Action Track 3. Teachers, teaching and the teaching profession
- [ ] Action Track 4. Digital learning and transformation
- [ ] Action Track 5. Financing of education

4. Implementation lead/partner organization(s) *

Chemical Society of Thailand, Dow Chemical Thailand Co., Ltd., Bangkok Bank Public Co., Ltd., International Union of Pure and Applied Chemistry (IUPAC)

5. Key words (5-15 words): Please add key descriptive words around aims, modalities, target groups etc. *

Key words;
small scale chemistry, microscale chemistry, hands-on experiments, chemical safety, green chemistry, sustainable development, capacity building of the teachers, quality education, reduced inequalities, responsible consumption and production, partnership for the goals

The objectives and Rationale;
1. To introduce and promote chemistry teaching with hands-on experiments safely, conveniently, quickly, at much lower cost and less waste by using small amount of chemicals, called small scale chemistry or microscale of chemistry.
Using this technique will automatically prevent pollution for a safer environment and lower the risk of chemical hazard while performing chemistry experiments without compromising the quality of learning. Furthermore, it will allow the students to do the experiments in concomitant with the lecture in the classroom, which will be a new approach to attract the students' interest in science.
2. To raise awareness on chemical safety, green chemistry and sustainable development goals.
Small scale chemistry experimentation can be the pathway for learning those three subjects which are correlated to one another.
3. To build a network of small scale chemistry teachers.
The extensively trained teachers, along with the networking with the teachers from other countries, are expected to act as trainers for other teachers in their respective countries.
4. To attract the students to further study in Science.
5. To strengthen the role of chemistry education towards the achievement of Agenda 2030 and SDGs.

The project is composed of 4 activities;
1. Introductory small scale chemistry workshop (in the host country)
2. Selection of the leading small scale chemistry teachers from the workshop participants
The teachers are encouraged to be creative and design their own experiments with the small scale and green chemistry principles, and safety concept. The selection of the leading teachers will be judged from their submitted VDO clips of the designed experiments.
3. Training the trainers
About 10 leading teachers from each workshop will get training to be the small scale chemistry trainers each year.
4. Networking of global small scale chemistry teachers
Each year a hundred of the small scale chemistry teachers and trainers will be invited in rotation to attend a special session in Pure and Applied Chemistry International Conference, PACCON, in Thailand, where they will learn and exchange their experiences on the implementation of small scale chemistry experiments in schools as well as the workshops conducted in their respective countries.

6. What makes it a best practice? *

The small scale chemistry workshop was firstly conducted in Thailand in 2000. However, not until 2013, the project becomes more materialized firstly in Thailand. The extension of such a project has been sponsored to launch in 5 ASEAN countries and recently approved by IUPAC to implement in Nepal.

Description of the best practice

7. Introduction (350-400 words)
   This section should ideally provide the context of, and justification for, the practice and address the following issues:
   i) Which population was affected?
   ii) What was the problem that needed to be addressed?
   iii) Which approach was taken and what objectives were achieved? *

The developing countries have aimed to rectify a lack of workers in the STEM field by implementing various youth science education programs in order to improve STEM education. Each of these countries struggles to distribute educational funds equally across the country and there is a large inequity of resource availability between advanced and underprivileged schools, such as lack of laboratory space, laboratory equipment, consumable supplies and sometimes even a shortage of qualified science teachers. It is generally accepted that chemistry is the central science and the practical experiments are regarded as an essential part of the chemistry learning, which always generates new perspectives and new ways of synthesizing knowledge. However, the students have actually performed chemistry at risk or otherwise have no opportunity to do, mainly due to the lack of budget and appropriate facility. Most of the chemistry experiments require use of chemicals and at the end such chemicals are discarded and are not recyclable. This has caused a number of schools either to evade teaching chemistry or to teach the theory only without any experiments. This deprives the students the benefits gained from performing experiments such as arousing interest in the subject, and connecting the sometimes abstract theory to the real world. This leads sometimes to students losing interest and eventually leaving the sciences.
In Thailand, the Chemical Society of Thailand and Dow Chemical Thailand have created a program entitled the Dow Chemistry Classroom, which trains high school teachers in small-scale chemistry techniques. Small-scale chemistry uses miniature plastic apparatuses, as opposed to full-size glassware, and uses less than 100 times the amount of chemicals compared to full-scale laboratories. The small-scale science experiments offer multiple benefits to students' education such as highly improved safety, lower overall cost, less time to prepare solutions and reduced waste. By such a technique, classrooms in developing countries are able to implement hands-on learning into their science curriculum to aid in capturing students' engagement and interest in science in providing a quality education through laboratory experiences.

8. Implementation (350-450 words)
   Please describe the implementation modalities or processes, where possible in relation to:
   i) What are the main activities carried out?
   ii) When and where the activities were carried out (including the start date and whether it is ongoing)?
   iii) Who were the key implementation actors and collaborators? (civil society organizations, private sector, foundations, coalitions, networks etc.)?
   iv) What were the resources needed (budget and sources) for the implementation?
   *

Among the 4 activities of this project, the small scale chemistry workshop is the most difficult step. Much effort to recruit the teachers from different schools across the region or the nation or region must be paid by the local coordinator (The Chemical Society, The Academy of Science, The Science Teachers Association, some governmental sectors and even NGO). Normally we expect 50-100 high school teachers attending the 2-day workshop. The preparation of the 8 experimental kits for each teacher must be planned to finish in time for the workshop, by filling up the chemicals at the host country. The criteria for the selected experiments are the topics relevant to the course syllabus and should require various types of the different apparatus, so that the teachers can try and learn how to use them correctly. These model experiments are designed and managed by the Chemical Society of Thailand. After learning and practicing from the workshop, the teachers are challenged to design their own experiments using these provided apparatus and/or any kind suitable materials and household chemicals they can find locally. Then the teachers who submitted the video clips of their designed experiments, will be qualified to be the leading teachers if their VDO clips are judged to be the first 5 or 10 best ones. These leading teachers will be invited to join the third and fourth activities in Thailand, training the trainers and networking of small scale chemistry teachers worldwide. This is a one-year project.

The Chemical Society of Thailand will seek for some budget of the project, and the project partner(s) must commit a partial budget too. Generally the host country will request from the government and some private sectors.

9. Results – outputs and outcomes (250-350 words)
   To the extent possible, please reply to the questions below:
   i) How was the practice identified as transformative? (e.g., impact on policies, impact on management processes, impact on delivery arrangements or education monitoring, impact on teachers, learners and beneficiary communities etc.);
   ii) What were the concrete results achieved with regard to outputs and outcomes?
   iii) Has an assessment of the practice been carried out? If yes, what were the results? *

A small scale chemistry laboratory enables conducting of experiments using small plastic kits and local materials that are easy to source. These techniques shorten the duration of experiments and lessen the use of chemicals, water, energy, and waste, due to chemical amounts lowered by 1,000 times from those commonly used in traditional experiments. It is safe, environmentally friendly, less expensive, easier to use, and can be reused multiple times. The experiments can be conducted anywhere without using a high-cost standard laboratory, resulting in better educational equality for Thai students nationwide. More importantly, it encourages students to acquire good attitudes towards science studies through practical, hands-on experience.

Accordingly, the teachers can teach chemistry and science experiments more conveniently and have more time for explanation and discussion with students in a teaching period, which never been like this before. The chemical management and safety in schools will become much better as well.

Many researchers indicated that students' achievements on small scale chemistry experiments were as good as those which were obtained on normal scale. However, students obtained, in general, slightly better marks when doing small scale chemistry experiments compared to their achievements in normal scale experiments.

Recently, the Office of the Basic Education Commission (OBEC) and the Chemical Society of Thailand (CST), Dow Thailand (Dow) has signed a Memorandum of Understanding (MOU) titled "Enhancing Science Teachers' Capability Using Small-Scale Chemistry Laboratory Techniques for High Schools." More than 2,000 teachers from 1,055 schools have already used small-scale kits to teach over 300,000 students. This MOU will mark an expansion of small scale chemistry laboratory techniques to OBEC-regulated schools nationwide.

10. Lessons learnt (300 words)

To the extent possible, please reply to the following questions:

i) What were the key triggers for transformation?

ii) What worked really well – what facilitated this?

iii) What did not work – why did it not work? *

The small scale chemistry workshop was firstly conducted in Thailand in 2000. It was found that the teachers still could not do much for the students at schools. In 2013 the Chemical Society of Thailand (CST) partnering with Dow Chemical Thailand (Dow) launched the project on "Capacity building of teachers on chemistry teaching with hands-on small scale experiments in high schools", or in short as "Dow Chemistry Classroom". By Dow sponsorship, the project scope has been enlarged to cover 4 activities; the workshop, monitoring and follow up the teaching at schools, award competition of the designed experiments, training the trainers and networking. Now more than 2,000 teachers have been attended the workshop and about 110 leading teachers are trained to be the trainers. Through words of mouth and the networking, this project has become well known in Thailand. The first year of the project, about 60 teachers attended the workshop. The number of teachers participating in the workshop has gradually increased each year, and the workshop has now accommodate for 200 teachers since 2020. Due to the safety with small scale chemistry technic, the workshop has been offered online during the COVID-19 pandemic in Thailand. Recently, the Ministry of Education

However, not all experiments in chemistry manuals were able to be justified in to small scale experiments, due to the limitation of plastic apparatus. Particularly for organic reactions, another kind of small scale apparatus must be applied. For example, the Small-Lab Kit has been designed and manufactured in Thailand since 2009 and promoted by UNESCO, available at website ; https://documents.pub/document/small-scale-laboratory-organic-chemistry-at-university-level.html?page=5

11. Conclusions (250 words)
    Please describe why may this intervention be considered a “best practice”. What recommendations can be made for those intending to adopt the documented “best practice” or how can it help people working on the same issue(s)? *

After assessment of the DOW small-scale chemistry experiments, we concluded that small-scale chemistry experiments can benefit all schools regardless of their funding or lab quality. Schools that without laboratories that teach mostly from theory would benefit the most from small-scale experiments; exposure to hands-on learning, as opposed to lecture-style learning, has been shown to increase student interest and engagement. Due to the lower price, small-scale materials would be easier to acquire than full-scale glassware, providing more opportunities for hands-on experience. Additionally, schools with larger budgets and full-scale laboratories could also benefit from small-scale chemistry since they can be completed more frequently due to less set up and clean up time.
Although we can conclude that small-scale is more feasible to implement nationwide, we cannot conclude that small-scale is better than full-scale considering the inequity of funding and resource availability throughout Thailand. Many teachers claimed it was essential to teach students full-scale in addition to small-scale, so that students can learn how to handle full-scale laboratory equipment that would be utilized in university and the workforce.
According to the correlation between laboratory quality and student career plans in our data, implementing small-scale chemistry and increasing the amount of hands-on learning throughout Thai high schools could lead to an increase in students pursuing careers in science. This could result in great benefits for the Thai economy as students could hopefully fill the open positions in the STEM field.

It is not just the design of small scale chemistry experiments that lead to the success of this project. It is required a strong partnership with private sectors and government to fulfil the project.

12. Further reading
    Please provide a list and URLs of key reference documents for additional information on the “best practice” for those who may be interested in knowing how the results benefited the beneficiary group/s. *

https://bsac.chemcu.org/wp-content/uploads/2021/02/PROMOTING-SCIENCE-EDUCATION-IN-THAILAND-WITH-SMALL-SCALE-CHEMISTRY-EXPERIMENTS.pdf
file:///C:/Users/Admin/Desktop/Bob%20Worley%202022/Issue53_Microchemistry.pdf
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