REPORT OF THE ADVISORY BOARD ON EDUCATION AND OUTREACH ON THE ROLE OF EDUCATION AND OUTREACH IN PREVENTING THE RE-EMERGENCE OF CHEMICAL WEAPONS

SUPPLEMENTAL PAPER ON

CURRENT THEORY AND PRACTICE IN EDUCATION AND OUTREACH (E&O)

1. Introduction

As part of his request to the Advisory Board on Education and Outreach (ABEO), the Director General asked: "…what are current best practices as well as the latest advances in education and outreach theory or practice that are of relevance to the E&O activities of the Organisation for the Prohibition of Chemical Weapons (OPCW)?" This paper provides an expanded version of the brief primer in the ABEO's main report with additional information about the various bodies of research that inform our current understanding of the best approaches to E&O. It also provides more examples of current practice to illustrate how the concepts are applied.

Although many of the publications about modern research on E&O have emanated from North America and Western Europe, the insights and approaches are being applied globally. There is extensive practical experience from around the world to show that the methods can be used successfully in a range of different cultural settings and social contexts. This growing body of knowledge and experience provides lessons for how the OPCW can deliver E&O in ways that are appropriate for different national and regional experiences with chemical weapons (CW) and disarmament to support the prevention of their re-emergence.

The report deals with E&O separately. After a brief review of the key components of the relevant theories, the text provides examples of relevant resources and applications from the activities of the OPCW and others. One of the encouraging conclusions to emerge from this review is that many the OPCW's E&O resources and activities are already well-grounded in the best practices discussed here. The challenge, addressed in the main report, is how best to design and support ways to expand the applications and lessons being learned to all the relevant parts of the organisation.

2. Education and the Science of Learning

Continuing advances in cognitive psychology, neuroscience, and related fields are providing a fundamental scientific understanding of how people, from infants through adults, learn and what this implies for the most effective approaches to education and training.[1] A key insight is that

> Learning is not simply the accrual of information; rather, it involves a process of conceptual reorganisation. The brain is a "dynamic organ"; even a mature brain is structurally altered during learning.[2] The brain actively seeks to make sense of new knowledge by connecting it with prior knowledge and experience. Through this process, the learner "constructs" new understanding and meaning.[3]

[1] National Research Council (NRC), *How People Learn: Brain, Mind, Experience, and School (Expanded Edition)* (Washington, DC: National Academies Press, 2000) and NRC, *Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering* (Washington, DC: National Academies Press, 2015).
[2] NRC, *How People Learn*, p. 235.
[3] NRC, *Reaching Students*, 57.

One of the major implications of this research is that "active learning" methods, as opposed to traditional, lecture-based instruction in which students are passive recipients, are best suited to supporting this process of construction.[4] The results hold for factual information and for more fundamental concepts. The biggest change from traditional education and training is to put the student rather than the instructor at the centre of all activities. This student-focused approach can be applied in the classroom, the laboratory, or the field.

Active learning approaches are not new; in Western culture, the Socratic method could be considered an example, and others from India about ancient and more recent applications may be found in Box 1 below. But in recent decades a growing body of research is showing how much they and modern versions of these methods offer the potential for significantly improved learning outcomes.[5] Some of the characteristics of active learning processes include:

- Having students engage in some activity that forces them to reflect upon ideas and how they are using those ideas;
- Requiring students to regularly assess their own degree of understanding and skill at handling concepts or problems in a particular discipline (this process is also called "metacognition");[6]
- Attaining knowledge by participating or contributing; ans
- Keeping students mentally, and often physically, active in their learning through activities that involve them in gathering information, thinking, and problem solving.[7]

Much of the research on active learning comes from classroom settings from pre-school through university, but the insights from learning theory are also applicable to adults and to many forms of training. As discussed further below, there are many teaching strategies that support active learning, such as in-class problem solving, peer-to-peer instruction, case studies, role-playing and other simulations, exercises, and learning from original investigations (as, for instance, in the laboratory). The theory and practice are thus as potentially relevant to the OPCW's extensive capacity-building programmes as they are to the materials and methods for its engagement with the academic community.

BOX 1

Activity-Based and Active Learning Methods in the Indian Social Context

Active learning methods seem to have existed in ancient civilisations like India for centuries, but social referencing to the contexts in history of time has changed the tools and methodologies. Nalan Da and Taxila is said to have adopted universal models of education focused on theology and understanding nature.[1] In the pre-industrialisation era, an Indian system of education seemed to have been delivered through Pathahsala, Madarasa etc., which adopted village centric models. This has been chronicled by Dharam Pal in the form of a Book entitled "A Beautiful Tree".[2] In the British Raj, some early initiatives were made on activity-based learning systems (ABL) during World War II. Mahatma

[4] As discussed further later in this paper, lectures do no disappear as a teaching method, but they are redesigned to include systematic opportunities to engage students.

[5] NRC, *How People Learn*, and J. Handelsman, S. Miller, and C. Pfund, *Scientific Teaching* (New York: Freeman, 2007).

[6] NRC, *How People Learn*.

[7] J. Michael, "Where's the evidence that active learning works?" *Advances in Physiology Education* 30 (2006):159-167.

Gandhi promoted an educational curriculum with the name "Nai Taleem" based on the pedagogical principle that knowledge and work are not separate.[3] The three pillars of Gandhi's pedagogy were its focus on the *lifelong character* of education, its *social character* and its form as a *holistic process*. For Gandhi, education was "the moral development of the person," a process that is by definition "lifelong."[4] A British teacher David Horsburgh[5] came to India in 1944 and settled down in India. He is reported to have started to teach in the Rishi Valley School and later joined the British Council working in Chennai and Bangalore. After his voluntary retirement, Horsburgh opened a school, Neel Bagh. He introduced a diverse curriculum, which included music, carpentry, sewing, masonry, gardening, as well as the usual school subjects, English, mathematics, Sanskrit, and Telugu. This initiative later proved to be one of the milestones in ABL.[6]

Experience with the Participatory Rural Appraisal Participatory Learning method has been reported.[7] More recently, there is a helpful report in the field of anthropology.[8] ABL has gained visibility in Tamil Nadu. The exercise has gained international recognition for reforming the government school class rooms into active child centred learning environments. The unique experiment has been accomplished through a social movement of actions initiated by State's administrators. It is truly a people's movement. The initiative which commenced in 2007 under the name Sarva Sikhsa Abhiyan has transformed class rooms in 37,000 schools in Tamil Nadu. Successful experience of Tamil Nadu has led to the spread of ABL to other states in India. Under the name of Rajya Shiksha Kendra Charm, Schools in Madhya Pradesh are implementing ABL.[9] Some newer tools for spreading the ABL techniques in cloud computing and e-learning environment have been reported.[10]

1. J. Frazier, ed., *The Continuum companion to Hindu studies* (London: Continuum, 2011).
2. Dharampal, The Beautiful Tree: Indigenous Indian Education in the Eighteenth Century (Goa, India: Other India Press, 1983).
3. G. Richards, *A Source-Book on Modern Hinduism* (London: Routledge, 1996).
4. D. Dehury, "Mahatma Gandhi's Contribution to Education," https://shareslide.org/mahatma-gandhi-s-contribution-to-education-dinabandhu-dehury.
5. Actvity based learning in India, Wikipedia, https://en.wikipedia.org/wiki/Activity-based_learning_in_India.
6. *The Hindu* "Where mind is without fear," 11 January 2004.
7. J. Mascarenhas, "Participatory Rural Appraisal and Participatory Learning Methods: Recent Experience from Myrada and South India," RRA Note 1991 Issue 13, (London: International Institute for Environment and Development, 1995), 26-32,
8. T. Niesz and R Krishnamurthy, "Movement Actors in Education Bureaucracy: The Figured World of Activity based Learning in Tamil Nadu," *Anthropology and Education Quarterly,* Vol. 43 (June 2014), 148-166.
9. G Tunda and A Saly, *Education Today*,
10. T. Selvi and P. Perumal, "Blended Learning for Programming in Cloud-based Learning," International Conference in Trends in Information Technology, Chennai 19-21 April 2012, IEEE Xplore (1 June 2012).

An important finding from the learning sciences is that to be well understood, factual knowledge must be placed in a cultural framework. Using an example from science education, one can think of learning as four intertwined strands of proficiency which provide the foundation for creating teaching and learning experiences:

- Understanding scientific explanations;
- Generating scientific evidence;
- Reflecting on scientific knowledge; and
- Participating productively in science.[8]

This model emphasises the integration of learning about process and content in effective instruction. There are many opportunities for students to become engaged with conceptual

[8] NRC, *Taking Science to School* (Washington, DC: National Academies Press, 2007).

material, while being deeply involved in laboratory or similar activities. With this approach, laboratory work is one of many pathways to both factual knowledge and deeper understanding of concepts.

Ensuring time for reflection is an essential component of effective approaches to learning. It is the only practice that research has shown will produce gains in a student's understanding of the nature of science, and by extension, other fields.[9] "Reflection involves the opportunity to engage in the exploration of understandings with other students and a teacher, and in giving students opportunities to become more aware of their own levels of learning".[10] Again, there are many strategies that can provide an opportunity for such reflection. For example, the *Conflict by the Numbers* project puts secondary school students in contact with some characteristics of explosives and CW.[11]

One of the reasons this insight is important for the OPCW is that students, and particularly adults, do not come to the classroom as empty vessels into which instructors pour new knowledge and insights. They come with a range of experiences and cultural frameworks, on which new understandings are constructed. Another key insight from the science of learning is thus the importance of recognising and engaging students as they experience new material.[12] Sometimes a student's prior understandings will support further learning. In other instances, he or she may bring pre- or misconceptions that can inhibit their capacity to learn. Prior understandings also can be influenced by culture, which has implications for the development of curriculum materials for the types of international audiences that OPCW is addressing.

Addressing and perhaps changing a student's prior understandings requires time and explicit engagement. A student presented with too many ideas too quickly will find it difficult to absorb them, especially if this requires changing a previously held conception. Without assistance through education, humans struggle to make connections between disparate fields or types of knowledge.[13] Given the complexities of some of the OPCW's work, which may involve assessments drawing on observations of a specific situation as well as technical knowledge, designing training to include different types of reflection time – from deliberate breaks in lectures that provide such opportunities to exercises that structure and guide reflection – would be important.

Education increasingly seeks to help students acquire key skills, such as higher-order thinking, including critical thinking, problem solving, synthesis, and transfer, where a student is able to apply what he or she has learned to a new problem. Some educators argue that, in

[9] NRC, *America's Lab Report: Investigations in High School Science* (Washington, DC: National Academies Press, 2005) and NRC, *Ready, Set, Science*! (Washington, DC: National Academies Press, 2008).

[10] NRC, *Promising Practices in Undergraduate Science, Technology, Engineering, and Mathematics Education: Summary of Two Workshops* (Washington: National Academies Press, 2011), 38.

[11] See http://modelsofexcellence.eleducation.org/search?search_api_views_fulltext=chemical+weapons. In terms of what is appropriate, primary grades might focus on toxic chemicals (perhaps in the general context of safety, and then turn to chemical weapons and disarmament in secondary, university, and postgraduate settings.

[12] NRC, *How People Learn*.

[13] Ibid.

fields where the pace of new discoveries and advances is accelerating, these skills may be more important than content knowledge that can be expected to become outdated.[14]

Learning is enhanced when the student perceives the relevance of the material. The need for relevance underscores the importance of making materials and activities adaptable to local settings and individual circumstances, for example by providing instructors with a range of suggestions for adapting a common curriculum to their own settings, and supporting the translation of materials into local languages.

Ethics Education

Less is known about ethical development than about science learning in college-age students and other young adults. There is also less consensus on appropriate ethical models for different cultural settings, as well as in culturally diverse settings such as some of the OPCW's training courses.[15] As discussed above, prior understandings will affect how an individual interacts with course materials and activities. There is substantial agreement, however, that active learning approaches are appropriate and effective for engaging students in ethical issues in many contexts.

In the last decade there has been a substantial effort to develop common principles to guide the increasingly globalised research community.[16] There are several examples of successful approaches to education about responsible conduct of research and other ethical issues in science that have been developed, tested, and implemented in varied settings by international teams.[17] The faculty institutes on responsible science that the U.S. National Academy of Sciences has carried out in the Middle East, North Africa, and South and Southeast Asia described in Box 2 include discussion of security issues. These experiences offer lessons for developing learning outcomes for education intended to promote the norms related to "preventing the re-emergence of CW."

Box 2

NAS Institutes on Responsible Science

Life scientists, chemists, physicists, physicians, nurses, and many other collegiate-level researchers/educators take part in a programme for up to 18 months. They first attend a 5-day-long Educational Institute on responsible science, an immersive learning experience constructed to educate on three core themes: the development of professionalism in science, conducting research responsibly, and being part of the responsible scientific community. These themes are explored using the techniques and practices of active learning, which challenge the attendees to teach their fellow scientists by employing critical thinking, intellectual rigour, creativity, and the spirit of experimentation that defines modern scientific research. The Educational Institute uses a diverse collection of active learning and assessment techniques – diverse both in the goals and methods used and in the audiences the project strives to reach – to engage the attendees in learning.

Following the institute, attendees can competitively apply for modest funds to help them implement teachings of responsible science in their home institutions. Successful grantees engage in diverse

[14] For an in-depth discussion of learning needs in specific disciplines, see NRC, *Discipline-Based Education Research: Understanding and Improving Learning in Science and Engineering* (Washington, DC: National Academies Press, 2012).

[15] S. Bonde et al, "Making Choices: Ethical Decisions in a Global Context," *Sci Eng Ethics,* No.22 (2016):343–366. DOI 10.1007/s11948-015-9641-5.

[16] InterAcademy Council and IAP (The Global Network of Science Academies), *Responsible Conduct in the Global Research Enterprise: A Policy Report* (Amsterdam: IAC, 2012); *Lancet,"* Promoting research integrity: a new global effort," Editorial, Vol. 380 (October 27, 2012):1445; and N.H Steneck, "Global Research Integrity Training," *Science,* Vol. 340 (May 3, 2013):552-553.

[17] Bonde et al., "Making Choices."

educational activities exploring a variety of topics on misconduct, authorship, collaborations, biosafety and dual-use issues, and more. A reunion meeting at the end of the programme brings together the grantees to provide assessment and feedback and discuss with the programme faculty and staff their experience from implementing activities in their home institutions.

Six 18-month-long Educational Institutes have been held to date: three regional Institutes in the Middle East and North Africa; one in South and Southeast Asia; a combined programme in Egypt composed of two institutes (2 opportunities for funds and one combined reunion was led by Egyptian alumni of previous regional Middle East and North Africa (MENA) activities), and a shorter 4-day long Institute in India. Numerous workshops originate from these activities, delivering aspects of active learning and the message of responsible science in a more compressed manner.

Additional information is available on the project website at http://nas-sites.org/responsiblescience/, which includes podcasts with many examples of active learning approaches. See also NRC, *Developing Capacities for Teaching Responsible Science in the MENA Region: Refashioning Scientific Dialogue*, (Washington, DC: National Academies Press, 2013).

Design and Assessment

The research shows that active learning methods are most effective when the course or activity in which they will be used clearly identifies the goals and objectives of each component as well as those of the overall effort. After the goals and objectives are established, the assessments are designed and checked to ensure that there is alignment between the objectives and the content matter. This process is called "backward" or "reverse" design.[18] It ensures that by explicitly articulating the learning objectives, they will inform and be integrated into the design of both the instructional and assessment strategies from the beginning. In addition, making the objectives clear to students enables them to understand the purpose of the class or activity, which further enhances their understanding.

Research on learning strongly indicates that assessment should be an integral part of teaching and learning.[19] It is generally agreed in the field of education research that a programme that does not integrate assessment into the learning process will likely prove ineffective in achieving its training or educational goals. A variety of tools are also available to support assessments, but to be effective, they must be geared to the desired learning outcomes. In addition, both standard education assessment and the concepts of backward design are compatible with the Results Based Management system currently guiding the OPCW's programme development and evaluation.[20]

Good assessment practice includes two types, called "formative" and "summative." Formative assessment is used regularly throughout the learning process to provide feedback about student learning and progress to both students and faculty. It is another component of the active learning approach that engages students in understanding their own progress. Examples of formative assessment tools that can provide quick feedback are:

- "minute papers" where students write a response to an instructor's query about a confusing point or concept;
- the use of "clicker" devices so that individual responses to a problem become the collective judgement of the students and visible to both the instructor and the

[18] G. Wiggins and J. McTighe, *Understanding by Design*, Expanded 2nd ed. (Upper Saddle River, NJ: Pearson Publishing, 2005).
[19] NRC, *Reaching Students*, and Dirks et al., *Assessment in the College Classroom* (New York: Freeman, 2014).
[20] United Nations Development Programme, "Results Based Management: Concepts and Methodologies" (undated), http://web.undp.org/evaluation/documents/RBMConceptsMethodgyjuly2002.pdf.

students (even more basic approaches like the use of coloured cards can be used if clickers are not available); and
- online feedback, which is now available in many course management tools.[21]

Formative assessments can be designed so that students can make adjustments in response, in which case the iterative process can enhance their attainment of knowledge and formation of a meaningful conceptual framework. An instructor normally would not grade a formative assessment, although there might be points awarded for completing them during the instruction period.

As the name implies, summative assessment, conducted at the end of a course or activity, provides information about student learning gains and the overall success of the effort. A variety of assessment tools is available, including pre- and post-tests, and should be geared to the desired learning outcome. Both formative and summative assessments are important for the continuing development and improvement of subsequent courses and curriculum, as well as for course adaptation and evolution.

Examples of Active Learning Approaches

With active learning, lectures do not disappear as a teaching method, but they are redesigned to include systematic opportunities to engage students. For example, the instructor might give a 10 to 12-minute talk, followed by the sort of short exercise or organised discussion described above as part of formative assessment. These provide both the instructor and the students with an opportunity to assess whether the material is being understood.[22] The approaches can be applied in many settings, from small classes to large lecture halls with hundreds of students.

Two common examples of active learning are problem-based learning and case studies. Barrows identified six core characteristics of problem-based learning: (1) student-centred, (2) small-group work, (3) tutor as a guide, (4) authentic, real-world problems, (5) problems as a tool to develop problem solving skills and acquire conceptual understanding, and (6) students acquire new information through self-directed learning.[23] The approach was originally developed for medical education but has since been applied across a wide range of disciplines (including biosecurity) and age levels (see below). Gijbels' subsequent metanalysis of the literature indicated cognitive gains from problem-based learning.[24]

Connecting to real-world problems is an important feature of both case and problem-based strategies. Writing has also been shown to enhance learning. For example, students who write about how they are going to solve a physics problem (a metacognitive strategy), are more effective in mastering introductory level physics problem solving than those who start with equations.

Successfully applying these approaches requires paying attention to the social aspects of learning, such as helping students deal with differences of opinion or persuading them that it

[21] NRC, *Promising Practices*, 40.
[22] A number of examples may be found in NRC, *Reaching Students*, 96-103.
[23] H.S. Barrows, "Problem-based learning in medicine and beyond: A brief overview," in eds. L. Wilkerson and W. Gijselaers, *Bringing Problem-Based Learning to Higher Education: Theory and Practice,* New Directions for Teaching and Learning Series (San Francisco: Jossey-Bass, 1996), 3-11.
[24] D. Gijbels, F. Dochy, P. Van end Bossche, and M. Segers, "Effects of Problem-Based Learning: A Meta-Analysis From the Angle of Assessment," *Review of Educational Research*, Vol. 75, Issue 1 (2005), 27-61.

is worth investing time in the group process. One incentive for students may be that, given the increasing prevalence of team-based work environments, acquiring group work skills in problem-based learning can have significant real-world benefits.

A problem-based learning approach has been applied in materials for education about biosecurity issues. With support from the UK and Canadian governments, for example, the University of Bradford prepared an edited volume, *Preventing Biological Threats: What can you do? A guide to biological security issues and how to address them*, with articles related to a wide range of issues in biological non-proliferation and disarmament.[25] The volume includes discussions of active learning and there is an accompanying handbook with exercises based on "team-based learning", as well as additional materials for teachers available at the project website.[26]

Cases studies are often used by faculty employing a problem-based method of instruction. A review of the case study literature by Lundberg indicates that cases have particular value in helping students to gain knowledge and understanding of how global, ethical, and societal contexts influence interdisciplinary issues.[27] Cases do not teach themselves, however, and need to be carefully structured to be applied successfully. Teaching notes for instructors are valuable additions and can provide information about how the case can be adapted to different settings. Learning goals need to be clearly stated and the scale should be appropriate for the specific case. The Active Learning in International Affairs Section of the International Studies Association, an interdisciplinary society with more than 6,500 members from over 100 countries, supports the use of case studies and other interactive approaches in international relations.[28]

Cases that involve multiple participants lend themselves to role-playing, one of the oldest forms of active learning. The use of simulations is relatively common practice in teaching in a number of social science disciplines, such as political science. In international relations, simulations provide a way to encourage students to "step into the shoes" of decision makers and come to appreciate the complexity of negotiations or the pressures of an international crisis. Role-playing can range from the simple to the elaborate, from an exercise that takes a portion of a class session to a simulation of an arms control negotiation that would fill the entire course.[29] Wedig, for example, provides a review of factors for faculty in political science to consider in selecting a simulation.[30] Audiences can range from younger students through senior professionals. In January 2017 OPCW hosted a tabletop exercise, a familiar form of active learning among security professionals, for representatives from international

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[25] S. Whitby et al., *Preventing Biological Threats: What You Can Do* (Bradford, UK: Bradford Disarmament Research Center, 2016), http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issues/.

[26] T. Novossiolova, *The Biological Security Education Handbook: The Power of Team-Based Learning* (Bradford, UK: Bradford Disarmament Research Center, 2016), http://www.brad.ac.uk/social-sciences/peace-studies/research/publications-and-projects/guide-to-biological-security-issues/.

[27] M.A. Lundberg, *Case Pedagogy in Undergraduate STEM: Research We Have; Research We Need*, White Paper (Washington, DC: National Research Council, 2008), https://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072622.pdf.

[28] See http://www.isanet.org/ISA/Sections/ALIAS.

[29] A. Kelle, "Experiential learning in an arms control simulation," *PS: Political Science & Politics,* Vol. 41, No.2 (2008): 379-85.

[30] T. Wedig, "Getting the Most from Classroom Simulations: Strategies for Maximizing Learning Outcomes," *PS: Political Science & Politics*, Vol. 43, No.3 (2010), 547-555.

and regional organisations. The OPCW regularly hosts groups of students from Model United Nations programmes to carry out their simulations in a "real-world" disarmament setting.

One advantage of role-playing, particularly in discussions of ethical issues, is that individuals can adopt and argue for a position without obligation to make their own views known from the start. As discussed in the next section, advances in online education are enabling role-playing and simulations that can engage participants beyond the classroom and even national boundaries.

Technology-Enabled Learning

Online technologies make it possible to develop high-quality curriculum materials that can be shared with a broad audience, a particularly promising approach for international applications as long as attention is paid to necessary adaptations. Given the overwhelming evidence in support of the effectiveness of active learning, modules that will be technology-enabled need to be designed to be interactive. Simply reading about an issue on a web page and clicking through a quiz is unlikely to support cognitive, behavioural, and performance change.

Practical technical issues are also an essential part of designing effective online education. The availability of technology and bandwidth needs to be carefully considered, since the OPCW conducts major assistance programmes in areas that suffer from frequent power cuts or slow connection speeds.[31] In some settings cell phone access is available even if internet connectivity is limited or unreliable, and there is increasing attention to developing these options.[32]

Technology can provide the opportunity for students and instructors to collaborate on a learning activity internationally. For international relations, for example, the International Communication and Negotiation Simulations Project (ICONS) project, based at the University of Maryland in the United States, provides a catalogue of ready-to-use online simulations and will also work with instructors to create custom designs for individual or collaborative use.[33] The simulations can be managed through ICONS' online simulation platform, and have been used by academic institutions in 53 countries. ICONS simulations have also been used to train government personnel in negotiations.

Social networking tools are also being increasingly adapted and incorporated to enable varied forms of discussion and engagement. Problem-based learning has been adapted for technology-enabled learning in a variety of ways. Researchers are also currently investigating whether environments that combine and integrate online and face-to-face learning and interactions (also called "blended environments") are more effective than either approach alone.

Students' familiarity with technology can also be harnessed to engage them in disarmament relevant activities. ABEO member Benjamin Ruiz Loyola has been working with a group of students from several schools within his university who built a webpage (blog) called *ciencia para la paz* (science for peace; www.cienciaparalapaz.wixsite.com/cienciaparalapaz), on which they will post information about CW and other weapons of mass destruction (WMD). Professor Ruiz has also engaged students to use a traditional form of science communication

[31] NRC, *Challenges and Opportunities for Education about Dual Use Issues in the Life Sciences* (Washington, DC: National Academies Press, 2011), 82.
[32] D. Sagarmay, "Distance Learning in Developing Countries through Multimedia Technology Using Mobile Devices," *International Journal of Education and Learning,* Vol. 1, No. 1 (March, 2012):41-48.
[33] More information is available at https://www.icons.umd.edu/education/resources.

– the poster – to produce materials related to science for peace and CW issues. He is now exploring a new possibility: a MOOC (Massive Online Open Course).[34] This would consist of a complete course supports with videos, lectures, additional readings, specific activities for the students and different evaluations.

The UK government has commissioned the firm Biosecu.re to produce a standalone, online English-language course on biosecurity issues accessible to all via the FutureLearn MOOC platform that is due to be completed in early 2018. The project builds on the *Preventing Biological Threats* text from the University of Bradford described above, updating and amending the content in line with new developments. The MOOC will align with the requirements of the new international certification in biosecurity created by the International Association of Biosafety Associations to deliver open-access online training tools underpinned by best practices in active and blended learning.

In March 2017 the EU Non-Proliferation Consortium, an EU-wide academic and research network led by four European think tanks supporting the European Union in its non-proliferation and disarmament policies, launched an e-learning course, *EU Non-proliferation and Disarmament*.[35] The course covers all relevant aspects of the EU non-proliferation and disarmament agenda and aims to provide a comprehensive knowledge resource for practitioners and scholars interested in arms control, non-proliferation and disarmament, and EU policies in these fields. Twenty-four authors from 12 European countries and EU institutions contributed to the course, which is an open educational resource for all interested users world-wide. The course consists of 15 learning units covering both non-conventional and conventional weapons, and has an optional certificate section. The Peace Research Institute Frankfurt (PRIF) took the lead in developing the course and consulted with experts in active learning from German universities to take advantage of the latest practices for online education. The units thus have specific learning objectives and include videos with short lecture segments as well as interviews and animations. ABEO chair Jean Pascal Zanders prepared and presented the unit on CW.[36]

In the policy realm, the Friends of Europe, a Brussels-based think tank, hosts an annual online conference. According to the announcement for the 2017 conference

> Debating Security Plus is a global online brainstorm that aims to yield concrete recommendations. It builds on Friends of Europe's experience with other online debates and gathers several thousand experts around the world. The 2017 event will bring together senior international participants from the military, government and multilateral institutions along with voices from non-governmental organisations (NGOs) and civil society, business and industry, the media, think tanks and academia. …From 26-28 September the international security community will for 48 hours debate ideas relating to six different themes, each introduced by video messages from leading figures of the security and defence sector. Moderators will steer discussions towards concrete recommendations, and will also highlight disagreement as well as

[34] See https://library.educause.edu/topics/teaching-and-learning/massive-open-online-course-mooc for further information, including references to several studies of the use of MOOCs in developing countries or among several countries.
[35] See https://nonproliferation-elearning.eu/.
[36] https://nonproliferation-elearning.eu/learningunits/chemical-weapons/

consensus. In-depth "rapid-fire chats" will be hosted by partner organisations, allowing participants to zero in on highly specific topics.[37]

The conference included discussions of nuclear weapons and proliferation and cybersecurity.

Teaching the Teachers/Promoting Professional Development

Developing education materials and activities is unlikely to be effective without parallel professional development for faculty. And research shows that simply providing evidence about the effectiveness of active learning methods is not enough to persuade faculty to change how they teach.[38] Carefully designed and target efforts are necessary. Programmes that focus on graduate students and postdoctoral students early in their careers, in addition to established faculty, for example, have been shown to be a particularly effective means of encouraging change.

Professional societies in many disciplines offer workshops for new faculty, education symposia, special interest sections for members, and other venues to raise awareness about effective teaching practices and to provide recognition of individuals who engage in this work. The programmes are a subset of the more general category of "train-the-trainer" programmes in which more experienced educators seek to impart knowledge or skills in a way that can be sustained after the initial encounter. The newest programmes draw on the science of learning to inform the design of the faculty development programmes, infusing the workshops/meetings/institutes with active practices as well as principles. A report released in 2013 on *The Role of Scientific Societies in STEM Faculty Workshops*, for example, provides descriptions and initial assessments of several programmes run by major U.S. professional societies. Although the features of the programmes vary, they share several major characteristics.

- Simply stated, the goals of all the STEM [science, technology, engineering, and mathematics] faculty programmes discussed here are to develop expert competence in teaching, to enhance faculty views of teaching as a scholarly activity, and to promote the use of evidence in evaluating the effectiveness of teaching practices.
- All initiatives promote, either explicitly or implicitly, the importance of "scientific teaching."
- The meetings generally consist of a mix of plenary sessions, often carried out with interactive engagement techniques—to model what the leaders hope the participants will implement in their home institutions—and smaller breakout and discussion sessions.
- While many effective pedagogical practices cut across disciplines, their effective implementation requires broad knowledge of the discipline and its modes of discussion and argument. Hence, all programmes described here have the participants think about (and in some cases practice) effective pedagogical methods within the context of the discipline. This method builds on the content knowledge of the participants and prepares them more directly for the teaching decisions they will need to make in their own classrooms.

[37] See http://www.friendsofeurope.org/event/debating-security-plus/.

[38] C. Henderson, N. Finkelstein, and A. Beach, "Beyond dissemination in college science teaching: An introduction to four core change strategies," *Journal of College Science Teaching*, Vol. 39, No.5 (2010):18-25.

- …all programme leaders recognise that a one-time workshop is unlikely to produce the kind of expert teaching competence required of an effective instructor. The programmes use a variety of mechanisms to continue interactions among the participants (peer mentoring and coaching) and with the programme leaders. [39]

Some professional societies and their counterparts in the international disciplinary unions, including chemistry, have also promoted active learning approaches internationally. The International Union of Pure and Applied Chemistry has a Committee on Chemistry Education (CCE), of which the OPCW Science Adviser is a liaison member. CCE holds an international conference on chemistry education every two years, along with numerous regional conferences on chemistry education. Together, these and other programmes offer several models for undertaking faculty development.

The work of these professional organisations also has lessons for the effort to promote the inclusion of topics like chemical weapons and the Chemical Weapons Convention (CWC) in courses in schools at the secondary level and beyond. The role of "champions" as advocates for including these topics and the desirability of building networks of faculty who can support one another and share lessons learned and best practices are particularly important.[40] They have inspired efforts to build comparable networks to address security issues, usually within a broader framework. An example, found in Box 2 above, is a programme of the U.S. National Academy of Sciences to develop networks of faculty in a region (or country) who are knowledgeable about responsible science and who can educate others using active learning pedagogical techniques. Biosafety and biosecurity, including dual-use issues, are one component within this broader approach. Another network-building project by ABEO member Austin Ochieng, described in Box 3, employs "brain-friendly learning" techniques to conduct training in chemical safety and security in Kenya and surrounding countries.

Box 3

Chemical Safety and Security in Kenya

The Kenya Chemical Society (KCS) is spearheading chemical safety and security training in the in the East African region. To improve on the delivery of the training, KCS has collaborated with US-based Sandia National Laboratories (SNL) in a Trainer Development Programme in Curriculum Development. In February 2017, trainers from Sandia trained a number of KCS's trainers on both chemical and biological agent risk management and in the use of tabletop desk exercises. In April 2017, one of KCS' trainers participated in a week-long workshop on chemical risk mitigation with Libyan participants under Sandia's auspices at a meeting in Kuala Lumpur. The three KCS trainers have, under the guidance of SNL trainers, been reviewing previously prepared training materials/modules to reflect new pedagogy skills. These so-called "brain-friendly training**"** approaches use trainee's existing knowledge/experiences, and build on this, with facilitators guiding the learning process to a desired outcome. Learning is far more successful with this new approach than with the classical lecture where the trainer is generally the only one who talks. Future training in Kenya will encompass more interaction in the classroom, and tabletop exercises, with participants actively involved in discussions and role-play. A pilot project module is at the planning stage and awaiting funding. Plans by KCS for converting all previous chemical safety and security training material to be more interactive are also under consideration.

[39] R.C. Hilborn, ed., *The Role of Scientific Societies in STEM Faculty Workshops* (College Park, MD: American Association of Physics Teachers, 2013), 6-9, *www.aapt.org/Conferences/newfaculty/upload/STEM_REPORT-2.pdf*.
[40] These and other ideas are discussed in detail in NRC, *Challenges and Opportunities*.

Insights from Industry

One tends to think first of academia when discussing education and training, but industry carries out many activities that are potentially relevant to the OPCW and the States Parties. For chemical companies, recruiting and retaining well-educated and motivated personnel is essential to fulfil their goals of competitiveness, innovative capacity, attractiveness and reputation. Policy in this area is a matter of good governance and is generally handled at the highest level in the company. Policy implementation generally falls under the responsibility of two major functions – Human Resources for training after recruitment and communication (internal/external) – and the division of responsibility between the functions generally depends on topics, relevance, urgency, depth of information, target groups, etc. Training can be for groups (such as for topics concerning safety and compliance) or tailor-made. In the latter case, it is based on the need to broaden or deepen the competence of selected individuals who elect to acquire certain competences by themselves and/or following the recommendation of their management. Communication campaigns are generally limited in time and hit a large number of individuals with high-level standardised messages.

Chemical companies ensure that their personnel (generic or hired) are competent based on appropriate education, training or experience; they determine which training is required, and when applicable take action to acquire the necessary competence and evaluate effectiveness of actions. These requirements are implemented for all types of occupations within the company. Not all approaches are interactive, but industry's interest in the effectiveness of their training makes them a good audience for active learning methods.

The Responsible Care Initiative requires adequate training on health, safety, security and environment matters.[41] Companies shall also establish and maintain systems to facilitate the flow of hazard and safe handling information, appropriate guidance and appropriate training along the value chain to support risk evaluation and risk management of their products and for receiving such information from suppliers on goods and services used by the organisation.

During training, knowledge is delivered through in-depth specialised courses. Courses can include evaluation. They can be split into levels adapted to employees at different stages of their career, or that they can acquire in sequence. Training can take place in a company's dedicated training centres or external specialised institutes where trainees come and take courses. Communication works differently; it generally uses mass media, such as internet/intranet, social media, large-scale distribution of brochures, leaflets, posters, and /or videos. The goal is to convey massively high-level standardised messages to a large audience. The contents are adapted for the many. Internal workshops, seminars or conferences can be organised at regular intervals or on an ad-hoc basis, and can involve external experts/speakers and/or audiences.

Training courses are generally delivered by specialised trainers in dedicated company training centres or external institutes where interactions between trainers and trainees are facilitated. Training courses generally take employees away from the office for a few days

[41] First launched in Canada in the mid-1980s, Responsible Care is a global, voluntary effort by chemical companies, national chemical industry associations, and their partners to improve health, environmental performance, enhance security, and to communicate with stakeholders about products and processes. Practiced today in more than 65 countries around the globe, Responsible Care empowers companies to continue to strive for innovative ways to contribute to the vision of the World Summit on Sustainable Development that, by the year 2020, "All chemicals will be produced and used in ways that minimize risks for human health and the environment" (see https://www.icca-chem.org/responsible-care/).

(e.g., two to three or five days in a row). Companies have started to develop e-learning that is more flexible than conventional training for many topics and allows for broader audiences. E-learning can be practised with just a computer and an internet connection during shorter periods of time (less than one hour in some cases), and are more adapted to today's business life. A test immediately checks the recognition of the acquired level of information.

Insights from Other International Non-proliferation and Disarmament Organisations

The mandate given to the ABEO includes providing advice on the "development and maintenance of partnerships" with other international organisations. Education and training are considered fundamental to continuing global progress on disarmament and non-proliferation. The most authoritative statement comes from the 2002 *United Nations Study on Disarmament and Non-Proliferation Education*:

> …[t]he overall objective of disarmament and non-proliferation education and training is to impart knowledge and skills to individuals to empower them to make their contribution, as national and world citizens, to the achievement of concrete disarmament and non-proliferation measures and the ultimate goal of general and complete disarmament under effective international control."[42]

The UN continues to monitor non-proliferation and disarmament education, providing a website with a wide array of resources for different audiences, and a biannual report on the activities of different organisations.[43]

Such education has received considerable attention in recent years, reflected in activities across the spectrum of international organisations. Some of the activities are focused on encouraging a "next generation" of policy and technical experts able to carry out work directly related to reducing the risks of proliferation or supporting the implementation of treaties and agreements. Other efforts focus on engaging wider scientific and technical or policy communities to raise awareness of the existence of treaties such as the CWC and build support for their goals and effective implementation. Finally, some activities respond to the call to build a global citizenry.

OPCW Today devoted a special issue in December 2013 to E&O, including articles about the activities of other international organisations.[44] These activities offer the potential to cooperate where appropriate, for example in efforts to engage the "next generation," and to share experiences and lessons learned.

3. Outreach and the Science of Public Communication

Basic Concepts: Conceptual Maps, Cognitive Misers, Framing, and More

The fundamental concepts that underpin current outreach theory and practice are drawn from a range of social science disciplines, including psychology, sociology, political science, anthropology, communications, and linguistics. They are increasingly informed by insights from research on how the brain functions in fields such as neuroscience and cognitive psychology. In this sense, there are ties and connections to the basics concepts discussed earlier as part of the science of learning section, although here there is less consensus and

[42] United Nations, *United Nations study on disarmament and non-proliferation education*, Report of the Secretary-General, A/57/124 (New York: United Nations, 2002), http://www.un.org/ga/search/view_doc.asp?symbol=A/57/124.
[43] See https://www.un.org/disarmament/education/.
[44] See https://www.opcw.org/fileadmin/OPCW/OPCW_Today/OPCW_Today_-_Vol_2_No_5.pdf.

more field-specific terminology to describe the research results. It is less a "theory" than a set of interdisciplinary concepts that provide important insights to inform action. For example, the synthesis and application of the concepts and research is the heart of "strategic communications," the most common general term for this approach to outreach in all types of organisations from governments to corporations to NGOs and beyond, as well as fields as diverse as marketing, political campaigns, public diplomacy, crisis communications, and others.

For both outreach and learning research, a key insight is that audiences, whether students in more formal education settings or the recipients of outreach activities, are not empty vessels or blank slates. In general terms, people receive and process information and experiences by relying on "cultural models," interpretive schemata that provide an economical way to understand what is happening around them.[45] The models can be moral values, religious beliefs, cultural values or identity, level of trust in experts, or any combination of these and other factors that help people make sense of information. Whether seen as lenses or filters, these models can mean that the same information or messages will be understood differently by different people depending on their predispositions.[46]

The same basic insight is reinforced by research on voting, where political scientist Samuel Popkin coined the phrase "low-information rationality."[47] Scheufele explains it in the context of science as

> …based on the assumption that human beings are cognitive misers and minimise the economic costs of making decisions and forming attitudes. Most citizens will therefore not bother to develop an in-depth understanding of scientific issues, which would require significant time and effort. Rather, they collect only as much information as they think is necessary to make any given decision. They rely on *cognitive shortcuts or heuristics* to efficiently sift through large amounts of information and to form attitudes about issues, such as nanotechnology or agricultural biotechnology. And the less expertise citizens have on an issue initially, the more likely they will be to rely on cognitive shortcuts or heuristics.[48]

On issues that generate controversy, social psychologists also explore an aspect of this phenomenon referred to as "identity protective cognition."

> Identity protective cognition refers to the tendency of culturally diverse individuals to selectively credit and dismiss evidence in patterns that reflect the beliefs that predominate in their group. … Individuals are also more likely to accept misinformation and resist the correction of it when that misinformation is identity-affirming rather than identity-threatening.[49]

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[45] N. Quinn and D. Holland, "Culture and cognition," in eds. D. Holland and N. Quinn, *Cultural models in language and thought* (Cambridge: Cambridge University Press, 1987), 3–40.
[46] D.A. Scheufele, "Five lessons in nano outreach, *Materialstoday*, Vol. 9, No. 5 (2006):64.
[47] S.L. Popkin, *The Reasoning Voter: Communication and persuasion in presidential campaigns*. 2nd ed. (Chicago, IL: University of Chicago Press, 1994).
[48] D.A. Scheufele, "Messages and Heuristics: How audiences form attitudes about emerging technologies," in ed. J. Turney, *Engaging Science: Thoughts, Deeds, Analysis and Action* (London, UK: The Wellcome Trust, 2006):20-25.
[49] D.M. Kahan, "Misconceptions, Misinformation, and the Logic of Identity-Protective Cognition," Cultural Cognition Project Working Paper Series No. 164; Yale Law School, Public Law Research Paper No. 605; Yale Law & Economics Research Paper No. 575 (2017), 1, https://ssrn.com/abstract=2973067.

Taken together, this research suggests that knowledge plays a relatively limited role in shaping people's attitudes. Simply providing information, even in the most neutral manner possible, is thus unlikely to be the most effective path to engagement. "People" includes the public and also so-called "influencers," the elites whose engagement has the capacity to potentially affect policy choices.

The findings of this research are relevant to any complex topic, such as international disarmament and certainly CW. It is often unwelcome news to experts who understandably believe that audiences should acquire as much knowledge as possible about a topic and that this information will significantly affect their attitudes – the so-called "knowledge deficit" model. But it has important implications for the design of outreach efforts. In particular, it suggests the importance of understanding how particular audiences are likely to regard and potentially respond to an issue as an integral part of designing outreach activities or campaigns.

Much of the research cited here comes from the emerging social science subfield of the "science of science communication".[50] While there is extensive literature from many regions about how the public views science, fewer data are available for specific fields, and little data specifically on chemistry. To fill that gap, in 2014 the Royal Society of Chemistry (RSC) undertook a major project to study current public attitudes, awareness, interest and engagement towards chemistry in the United Kingdom. The project included several qualitative workshops (also called "focus groups") and a nationally representative face-to-face public survey.[51] An extended quotation from the foreword by David Phillips, former RSC president, in Box 4, provides an interesting illustration of how technical experts' beliefs about the public – such as an expectation of widespread "chemophobia" – may not necessarily reflect reality.

Box 4

What the British Public Really Thinks About Chemistry

> As professional chemists, we thought that we knew how the public feels about chemistry, but we had no hard evidence to back this up. Now we do. …
>
> For me the most interesting and surprising finding is that the public perception of chemistry and chemicals is far more positive than professional chemists believed. Having said that, this view is coloured by some confusion over what a chemist is and what a chemist does. For example, the misidentification of chemists as pharmacists, which is a peculiarly British phenomenon.
>
> While we have anticipated this result, we underestimated its scale. We will have to work hard to try to ensure that the noun "chemist" is in future used for what we understand it to mean. We can't easily change the common meaning of a word but we can be consistent with the way we use it. When we talk about ourselves and our jobs and say "I'm a chemist" (and I am always proud to say it!) we could change it to "I am a scientist working in chemistry". And if we think that framing ourselves as scientists sounds obvious, we should look at these findings because it is not obvious at all. It could be a first important step in contributing to a more understandable use of a word that defines who we are.
>
> This research shows that our views of public opinion can be too negative. Chemistry is our profession, our passion, and we care about it so much that we possibly are a little biased. Perhaps we have become

[50] See, for example, eds. K.H. Jamieson, D.M. Kahan, and D.A. Scheufele, *The Oxford Handbook of the Science of Science Communication* (New York: Oxford University Press, 2017).
[51] A number of reports from the research, and a toolkit to enable RCS members and other chemists to communicate more effectively with the public are available at http://www.rsc.org/campaigning-outreach/campaigning/public-attitudes-chemistry/.

> defensive owing to poor press over decades. But we should challenge this view and instead start thinking about public opinion in a more evidence-based way.
>
> This research shows us a better picture than anticipated but also a picture of neutrality towards chemistry. Instead of focusing on the minority of negative views we should try to address the neutrality expressed by so many people. I believe that it is with these people that we can make a difference.
>
> We shouldn't rely on content-focused traditional approaches whose motivation is to educate others. We need to embrace a more strategic and contextual approach of public communication where as much planning goes into understanding our audience and crafting an effective narrative as it does in building the content.
>
> To try to influence public attitudes towards chemistry we, as chemists, must rethink our attitudes towards the public.
>
> Source: Royal Society for Chemistry, *Public Attitudes to Chemistry*. Research report TNS BMRB. (London: Royal Society of Chemistry, 2015), 3.

Other concepts that can be important to designing outreach strategies related to CW and preventing their re-emergence include "issue salience" – how important an issue is to the audience – and "efficacy" – how much do audience members believe they can make a difference in addressing the issue. An analysis by the Frameworks Institute to guide U.S. NGOs in their communications strategy on nuclear disarmament that draws on key tenets of outreach theory argues

> The public does not consider nuclear disarmament a pressing social concern. People are alternately disinterested, scared, in denial, and fatalistic about the threats nuclear weapons pose in today's world. Proponents of nuclear disarmament must overcome these challenges if they are to raise the salience of this issue.
>
> To raise the salience of this issue, proponents of disarmament must understand the causes of public indifference. This indifference is not a matter of chance or accident, nor is it the fleeting result of capricious shifts in public opinion. Rather, it is the natural consequence of the deep assumptions and implicit understandings—what cognitive anthropologists call *cultural models*—that are embedded in American culture and that structure public thinking about nuclear issues. These cultural models shape how people think and talk about nuclear issues; they drive people's disregard for the gravity of the problem and their reluctance to work towards solutions.[52]

The Frameworks Institute analysis offered several recommendations to overcome these challenges, in particular by paying close attention to one other fundamental concept in outreach theory: "framing." Framing, cited above in the RSC report excerpt (Box 4), is the insight that, given the ways in which people process information, *how* it is communicated can be as or in some cases more important than *what* is communicated because of the ways it will interact with existing cultural models.[53] The same information, framed in different ways, will have different impacts and awareness of this issue can help inform the OPCW's selection of the key messages for its outreach efforts. "Preventing re-emergence of CW" is the primary goal for the OPCW, but it can also be considered a way to frame chemical non-proliferation

[52] M.A. Fond, et al. *An Unthinkable Problem from a Bygone Era: How to Make Nuclear Risk and Disarmament a Salient Social Issue* (Washington, DC: Frameworks Institute, 2016), 29.
[53] D.A. Scheufele and S. Iyengar, „The State of Framing Research: A Call for New Directions," in eds. K. Kenski and K.H. Jamieson, *The Oxford Handbook of Political Communication Theories* (New York: Oxford University Press, 2014).

and disarmament. And there is room for other themes/frames that support it, such as "Chemical Safety and Security," the chemical industry's "Responsible Care Initiative", and "responsible science."[54]

Framing is also relevant in efforts to promote specific policy choices. "Competing interests frame issues in ways that strategically advantage their political positions, emphasising certain aspects of an issue over other considerations, influencing estimations of the causes, consequences, and solutions to a policy problem."[55] The next section moves into this more political space for outreach.

Outreach and Public Engagement

Over the last several decades, scholars have devoted considerable attention to the ways in which governments interact with their citizens in the implementation – and sometimes development – of policy. This interaction is very much affected by the type of government institutions and processes, as well as by broader social and cultural contexts. The OPCW, States Parties, and National Authorities may benefit from considering some of the insights of this research. Scholars and practitioners usually talk about public engagement as a flow of influence and information between authorities and constituents. Very simplistically, there are three different modes of public engagement: communication, consultation, and collaboration.

- In the *communication* mode, an official or an agency conveys information to members of the public in a one-way fashion, often with the intent of educating and informing the public. Public feedback is not required and not necessarily sought.
- The *consultation* mode is an interaction in which authorities solicit opinions from the public through methods such as surveys, polls, and focus groups or during public comment periods. Again, this communication is one-way, but it is from the citizens to the authorities. The public's points of view, criticisms, and constructive advice can inform policy options, but this input is just one of many that decision makers take into consideration.
- The third mode, *collaboration*, is considered to be a two-way flow of information and influence between citizens and authorities; it is about dialogue fostering better understanding of very complex problems from all sides and perspectives. Collaboration allows an opportunity for collective learning as part of honest and respectful interaction among the authorities and diverse constituents.[56]

There is also more than one "public" that could be the target of engagement. For example, in the context of preventing the re-emergence of CW, there are three overlapping categories it may be useful to consider: the *general public*; the *affected public*, or persons or groups whose lives are altered or influenced by a policy decision; and the *partisan public*, or representatives of groups with vested interests or expertise in the policy matter. The relevance of these or similar categories will depend on the nature of specific issues.

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[54] The report of the Temporary Working Group on Education and Outreach explores a number of themes that could be used to support awareness raising and engagement with particular audiences. OPCW, *Education and Engagement: Promoting a Culture of Responsible Chemistry.* Final report of the Scientific Advisory Board's Temporary Working Group. (The Hague, 2014), https://www.opcw.org/fileadmin/OPCW/SAB/en/Education_and_Engagement-v2.pdf.

[55] M.C. Nisbet and B.V. Lewenstein, "Biotechnology and the American Media: The Policy Process and the Elite Press, 1970 to 1999," *Science Communication*, Vol. 23, No. 4 (2002), 5.

[56] See for example, M. Schoch-Spana, "Public archetypes in U.S. counter-bioterrorist policy," in eds. H. Durmaz, B. Sevinc, A.S. Yayla, and S. Ekici, eds., *Understanding and Responding to Terrorism* (Amsterdam: IOS Press, 2007):364-375.

There is no single methodology for public deliberation, but scholars have described a number of minimum standards for effective public deliberation, in particular for inclusivity and diversity, the provision of information, and value-based reasoning. Several the OPCW States Parties could have insights to offer based on their experience with the process of carrying out the destruction of their declared stockpiles. Collaboration and dialogue with stakeholders is also a feature of the chemical industry's Responsible Care Initiative.

This emphasis on collaboration and dialogue coincides with a fundamental change in the approach that experts are taking in their outreach to key stakeholders, a recognition that effective communication is not simply a one-way flow in which the expert tells an audience what he or she thinks they need to know. As a 2017 report from the U.S National Academies of Sciences, Engineering, and Medicine concluded:

> The committee believes that while scientists have a duty to speak about their work, they have an equal duty to listen to the public so as to strengthen the quality of public discourse and increase the perceived and actual relevance of science to society. … It also can clarify what information society needs and wants from scientists.[57]

Public Diplomacy as a Special Form of Outreach

The Technical Secretariat of the OPCW operates a public diplomacy strategy, which was developed and implemented before the establishment of the ABEO.[58] Its primary objective is "to increase recognition of the OPCW's achievements to engender greater confidence in multilateralism and international cooperation as means for achieving global peace and security". It has developed a three-pronged strategy to achieve this objective:

(a) developing dynamic messaging to highlight the positive achievements of the OPCW;

(b) generating increases in media coverage of the OPCW and traffic to our web and social media sites; and

(c) increasing knowledge about the Convention and OPCW among core stakeholder communities, such as the chemical industry.

In terms of adaptation to changing circumstances, the strategy document cited the shift of emphasis from "disarmament" to "the prevention of the re-emergence of CW", adaptation "to the virtual mode of information engagement and corporate employment of social media", and maintenance of "the currently high profile of chemical disarmament achievements in the wake of the Syria mission and the Nobel Peace Prize".

Public diplomacy is difficult to define as a concept. However, it is more than an instrument that the OPCW Public Diplomacy Strategy note seems to suggest. First and foremost, public diplomacy is usually viewed as "a support function, an adjunct or accessory service to major policy initiatives which have high-political, economic, and even military components".[59] More recently the understanding has widened "to capture the emerging trends in international

[57] NRC, *Communicating Science Effectively: A Research Agenda,* (Washington, DC: National Academies Press):18.
[58] OPCW, "Note by the Director–General: Public Diplomacy Strategy', S/1215/2014, (The Hague, 2014), https://www.opcw.org/fileadmin/OPCW/S_series/2014/en/s-1215-2014_e_.pdf.
[59] A.K. Henrikson, "What Can Public Diplomacy Achieve?" *Discussion Papers in Diplomacy* (The Hague: Netherlands Institute of International Relations "Clingendael," 2006):1.

relations where a range of non-state actors with some standing in world politics—supranational organisations, sub-national actors, NGOs, and (in the view of some) even private companies—communicate and engage meaningfully with foreign publics and thereby develop and promote public diplomacy policies and practices of their own".[60]

It is probably in the latter context that a public diplomacy strategy in support of a major policy initiative by the OPCW must be viewed. The development of a coherent public diplomacy policy (in addition to the communication strategy) ensures timely and regular outreach (in the sense of deepening understanding) to specific stakeholder communities. Public diplomacy highlights and updates the OPCW's goals and policies towards achieving them. In this sense, it translates "prevention of the re-emergence of CW" for broader audiences, whether specialist constituencies (e.g. industry or scientists) or the public.

In addition, it establishes an overall framework for communicating confidently each time events challenge the integrity of the CWC. For the OPCW and its Technical Secretariat public diplomacy has an anticipatory, if not pre-emptive quality. Through regular and focused interaction, the OPCW briefs specific key stakeholders on its programme of work, achievements and aspirations. In this way it establishes itself as an authoritative source of information while acquainting target audiences with the goals, intricacies and complexities of its various activities (all the while respecting any applicable confidentiality modalities).

It is also in this understanding that public diplomacy can connect with E&O strategies.

Creating Situations for Outreach

In addition to understanding how individuals process and react to information, another body of research from sociology and anthropology offers insights about the value of creating meaningful situations where E&O can take place. Anthropologists argue that the "value" is an effect of all the efforts people have made to maintain, protect, and preserve such remains to help establish better future.[61] Value is produced through the management of heritage, as the result of public history, anthropological archaeology, community archaeology, etc., to:

- identify significant sites, burdened with the shadow of the CW use, which can be properly activated for the benefit of future generations; and
- help determine and maintain their value as the warning monuments for the future.

The preservation of the sites as well as the creation of exhibits to provide the history and experience of CW to wider audiences can substantially enhance the effectiveness of outreach. Centennial commemorations of the large-scale CW attacks in World War I have offered the opportunity to use the material remains of those events, including the sites themselves, to promulgate key messages about preventing the re-emergence of CW. The commemorations on 21 April 2015 at Ieper, Belgium, in which the OPCW played a leading role, are an obvious example.[62] .[63] ABEO member Anna Zalewska led the multidisciplinary research (archival studies, excavations, etc.) and the onsite workshops where CW were used in 1915 using active learning strategies. Her exhibit was first presented at OPCW headquarters in March 2015 and then at the Biological Weapons Convention annual meeting in Geneva (December

[60] Ibid.
[61] D. Graeber, *Toward an anthropological theory of value: The false coin of our own dreams* (New York: Palgrave, 2001)..
[62] See https://www.opcw.org/special-sections/ieper-a-centenary-commemoration.
[63] See https://www.opcw.org/special-sections/ieper-a-centenary-commemoration.

2015), as well as in Poland.[64] The specific outreach activities, prepared through the initiative of the permanent representatives to the OPCW from Belgium, Poland, Latvia, Germany, and Russia, together with Director General Üzümcü, were intended to remind viewers of the origin and impact of CW on the history of mankind, and to show the historical significance of the CWC. From an outreach standpoint, the public presentations of this troubled past through the exhibition created circumstances that were especially conducive to showcasing OPCW priorities.

As with any outreach, to be effective the communication must recognise the experiences and expectations of the potential audiences. Research can unearth how national narratives are influenced by difficult pasts (ancient, modern, recent) of CW use and how civil society, politics, and the media constructed discourses, and which factors and acts – including non-actions -- informed both the construction and the evolution of such narratives on local and regional as well as global levels. A critical engagement with such negative heritage may also facilitate the construction of more value-oriented identities and deeper reflections on "preventing of the re-emergence of CW."

Existing OPCW Resources and Activities

As part of its work in preparing this report, the ABEO reviewed current OPCW activities in E&O and the resources already available to support them. Several of the Technical Secretariat's activities, such as tabletop exercises, already make use of active learning approaches. Among States Parties, interest has been growing in undertaking outreach beyond to those subject to formal implementation under the CWC. Some 30 States Parties undertook national activities as part of the 20th anniversary of the CWC's entry into force.[65] Formal engagement in education activities is less common, since it requires working with parts of the governments with which the National Authorities would not normally be engaged. A major exception is Argentina, whose significant work with its academic community as a collaboration with the Ministry of Education and several national universities is described in Box 5.

Box 5

The Argentine Project on Education and the Chemical Weapons Convention

In 2010 the Argentine National Authority initiated several national activities as part of the next stage in the implementation of the CWC in Argentina. These activities included the establishment of a Working Group to study outreach and dissemination of the obligations under the Convention and the national legislation that implements it.

A subsequent outreach campaign conducted in 2011 and 2012 identified many companies that were not registered with the National Authority. In parallel, during several inspections to declared sites, the National Authority noticed that even well-educated and trained senior facility managers had an incorrect or incomplete understanding of the technicalities of the Convention and the national implementation norms. The individuals acknowledged that they had not received adequate information during their university studies about the national legal requirements and obligations of the Convention.

This showed that the information campaign run by the National Authority for the private sector was not sufficient, and that other ways had to be devised to improve the level of technical knowledge among

[64] Professor Zalewka's work is the subject of the Fires film "Buried Memories." See also A. Zalewka, "The "Gas-scape' on the Eastern Front, Poland (1914–2014): Exploring the Material and Digital Landscapes and Remembering Those "Twice-Killed'," in eds. B. Stichelbaut and D.C. Cowley, *Conflict Landscapes and Archaeology from Above* (London and New York: Routledge, 2016).
[65] Information on these events may be found at https://20years.opcw.org/events/.

students of chemistry, chemical engineering and other related careers who would eventually manage declared chemical plants.

Significantly, the Working Group considered that the subject was too important to be circumscribed to only providing a better understanding of the obligations of the Convention to future managers of declarable facilities. As described in an Argentine national report submitted to the Eighteenth Session of the Conference of the States Parties: "The Group therefore proposed a broader scope for the project, in order to promote a culture, among all professionals in the chemical fields, of the responsible use of technical and scientific knowledge, in order to be aware of the potential danger and to prevent all misuse and abuse of chemicals."(1) It was proposed that the project should also include practising chemists, research scientists and university laboratory professionals and the group also considered that, at a second stage, the project should be targeted to secondary level students.

Given the federal nature of the Argentine university system, the Argentine National Authority, based in the Ministry of Foreign Affairs, sought the support of the Ministry of Education. Both ministries agreed to work together and signed a Memorandum of Strategic Cooperation in August 2013, which established the goals and actions to implement a "National Project on Education on the Responsible and Secure Use of the Chemical Sciences and Technologies for the Scientific, Economic and Social Development of the Argentine Republic". This partnership between the National Authority and the Ministry of Education has been key to the success of the Argentine national project.

The four main elements of the project were established at the First National Meeting on Education about the Responsible Use of Chemical Knowledge, which was held in Buenos Aires, in April 2013. Those elements consist of (2)

1. An overarching "Network of Networks" coordinated by the National Authority and the Ministry of Education which holds annual meetings;
2. A "Train-the-Trainers" Programme Coordinated by the National University of Rosario and the Southern National University (Bahía Blanca). A first workshop was held in Rosario in June 2013 (3) and a second in Bahía Blanca in November 2014. (4)
3. A Virtual Classroom coordinated by the Kennedy University with the National University of Lomas de Zamora. Approved online content will be made available to all participating universities;
4. A Travelling Class coordinated by the National University of Córdoba with the intention of conducting outreach to faculties where there are no educational tools or trained personnel yet.

In addition to the activities to implement the project nationally, the Argentine National Authority has also been keen to share the experience gained in implementing the national project with its Latin American and Caribbean counterparts, and with other interested stakeholders from further afield. In this regard, in April 2014 the Secretariat, together with the Government of Argentina, co-organised the First Regional Meeting on Education in the Responsible Application of Knowledge of Dual-Use Chemicals. The meeting was attended by representatives of 44 National Authorities and universities from 22 States Parties in the region and also by Temporary Working Group (TWG) member Alastair Hay. The results of the meeting are described in a national paper which Argentina submitted to the Executive Council at its Seventy-Sixth Session.(5) The meeting has served as a model for another such regional meeting in Asia in 2015.

Having the project in place, apart from the organisation of the Second National Meeting on Education about the Responsible Use of Chemical Knowledge in June 2016, where the actions implemented since 2013 were analysed and a new work agenda was defined, a series of complementary activities have been taking place in Argentina.

These activities include:(6)

- The commemoration of the centennial of the first large-scale use of CW through a workshop (Current Challenges after 100 Years of the Use of Modern Chemical Weapons) and a closing lecture offered by the Secretary of the Argentinean National Authority at the 30th Meeting of the Argentinean Chemical Association. Using the same trigger, outreach activities were organised at different faculties, high schools as well as an essay contest among students from early years of chemistry and related subjects.
- During 2016, postgraduate courses were given at the National University of Rio Cuarto, Córdoba, during June and December about the Responsible Use of Chemicals, Biological Agents and

Related Technologies. Moreover, a course about Dual-Use of Chemicals was imparted at the University of Exact and Natural Sciences in Buenos Aires in June.

- Another modality adopted by the faculties due to the over-packed curricula was the implementation of optional subjects, which was adopted since 2016 by the Southern National University with topics such as ethics, dual-use of chemical knowledge and chemical safety.
- In order to celebrate the 20th anniversary of the OPCW, a series of activities was held in the second half of 2017.

1. C-18/NAT.3, dated 2 December 2013, available at https://www.opcw.org/index.php?eID=dam_frontend_push&docID=16910
2. For a comprehensive description of the national project, see the presentation by the Executive Chairman of the Argentine National Authority at http://www.opcw.org/index.php?eID=dam_frontend_push&docID=17818
3. For more information on the June 2013 workshop in Rosario, see Alejandra Suárez and Rolando Spanevello, "Projects in Education and Outreach Relevant to the CWC: A Pilot Activity in Argentina", *OPCW Today*, Vol. 2, No. 5 (December 2013), pp. 27-28, available at https://www.opcw.org/fileadmin/OPCW/OPCW_Today/OPCW_Today_-_Vol_2_No_5.pdf
4. For more information on the June 2014 workshop in Bahía Blanca see the information at: https://www.opcw.org/news/browse/2/article/second-national-workshop-on-education-and-outreach-held-in-argentina/.
5. See EC-76/NAT.1, dated 5 June 2014, available at https://www.opcw.org/index.php?eID=dam_frontend_push&docID=17492.
6. For more information see the Argentine Project of Education at http://cancilleria.gov.ar/proyecto-nacional-de-educacion.

One of the encouraging conclusions to emerge from the ABEO's review is that several of the Technical Secretariat's E&O resources are already explicitly designed for, or readily adaptable to, the best practices discussed in this report. Examples of these resources are described below.

"Multiple Uses of Chemicals" website

The earliest example of a resource with the potential to be used in E&O grew out of the OPCW's relationship with International Union of Pure and Applied Chemistry (IUPAC). In 2005 the OPCW sponsored the creation of set of interactive electronic materials, *Multiple Uses of Chemicals*, explicitly based on active learning principles. The website introduces students, educators, and policymakers to the topic of multi-use chemicals, and discusses how they can be used for beneficial purposes and misused to create illegal drugs or even CW. The project was carried out by two leaders in IUPAC's chemistry education work, Peter Mahaffy from Canada and ABEO member Alastair Hay from the United Kingdom.

The term "multi-use chemicals" was chosen to emphasise the shades of grey that are present in decision-making about the responsible uses of chemicals.[66] Sometimes chemicals are used in ways that are clearly either ethical or unethical, but more often a spectrum of purposes is present, and the effect of a chemical substance or reaction depends on the context of its use and the intent of its user. For this reason, particularly in educational and outreach contexts, the materials seek to engage users with the complexity of classification of uses and the challenges in developing responsible practices to guide the choices students, educators and policy makers and the public make each day about chemicals, most of which are beneficial.

Although the website received several thousand visitors each year, the project did not have the resources to take advantage of the many advances in interactive, web-based education. As

[66] G. Pearson and P. Mahaffy. "Education, outreach, and codes of conduct to further the norms and obligations of the Chemical Weapons Convention" (IUPAC Technical Report), *Pure and Applied Chemistry*, Vol. 78, No. 11 (2006): 2169-2192.

part of the TWG activity, funds from the European Union through the OPCW and another joint OPCW-IUPAC project made it possible to update the website.[67] Following best practices in the design of electronic learning materials, an interdisciplinary team of undergraduate students and faculty members at the King's Centre for Visualization in Science in Edmonton, Canada expanded the website with interactivity in mind, implementing a variety of case studies and role-playing scenarios to communicate information effectively.

To engage a wide range of audiences while delivering content appropriate to each type of user, the resource starts with three separate portals: Brief Overview, Students, and Educators and Policymakers. The Brief Overview displays the major features of the resource, and is highly condensed for easy navigation through the site. The Students portal targets secondary and post-secondary chemistry classes, and can be used to stimulate discussions of scientific responsibility and integrity in the context of applications of various concepts in general and organic chemistry, or to support courses in ethics. Interactive resources for students include role-playing scenarios, case studies, and a variety of personal and discussion questions. The Educators and Policymakers section contains tips for implementing the resource into presentations or classroom discussions, as well as a list of learning outcomes for each topic, supplementary resources such as worksheets for students, and links to other websites that may be useful in preparing presentations or lectures. The website is divided into four major sections: Multi-Use Chemicals, Responsible Choices in Chemistry, Convergence of Chemistry and Biology, and Codes of Conduct. Most of the content is in the first two sections, where users are introduced to the concept of multi-use chemicals and the problems associated with their regulation and distribution.

The Multiple Uses of Chemicals resource was pilot tested at several workshops for chemists and educators, including the August 2013 44th IUPAC World Chemistry Congress in Istanbul. The video of this workshop is available on the project website, to give presenters tips for implementing the resource into their own presentations and discussions. Another workshop was held at the OPCW regional meeting on responsible use of chemicals in Argentina in April 2014, and a third during the 5th IUPAC Conference on Green Chemistry in South Africa in August 2014.

Profiles of the updated *Multiple Uses* resources on both the IUPAC and OPCW websites led to substantial increases in traffic to the site. In addition to further updating during the summer of 2017, in 2010 the materials will be translated into all official OPCW languages.

The "Fires" Project

Four short films are available as part of the "Fires" project, which originated with the goal of raising the visibility of the OPCW and humanising its work for a broad audience. CW issues are presented from a human society perspective. The characters range from everyday people to OPCW staff members to victims of chemical weapons and those trying to recover the history of past CW use, showing stories of real people connected to chemical weapons, emphasising that they are a concern of everyone.

The film project is based on a fundamental insight about the nature of effective outreach to a general audience.

> Many institutions, because they try to communicate about their achievements, watch themselves in a mirror. Their messages speak about themselves and so cannot

[67] P. Mahaffy et al., "Multiple Uses of Chemicals – IUPAC and OPCW Working Together Toward Responsible Science," *Chemistry International*. Vol. 35, No.5 (2014).

> properly address a wide audience. The everyday person does not care about them – why would they? The mirror between the institution and the audience looks like a blind screen. To efficiently communicate, it is worthwhile trying to invert the mirror towards the audience. When the viewers see themselves in the mirror – i.e. when he or she identifies with the characters on the screen, when they can relate to the stories being told – they understand that the author cares. Their attention is caught and the audience watches towards the source, towards the institution. By showing, episode after episode, intertwining stories of simple individuals who, as survivors, scientists, humanitarian workers, international staff, are involved with chemical weapons, the Fires Project tries to address the mirror case: by inverting the mirror towards people, it helps them to grasp that the CWC is first and foremost of public interest. It is for them.[68]

The first film, *A Teacher's Mission,* introduces Chrétien Schouteten, a retired high school chemistry teacher from Groningen in the Netherlands, who has spent most of his career being concerned about chemists' responsibilities towards society. A scientist's knowledge is a powerful tool that can serve many purposes, but what is the value of science to humanity without ethics? Long before the signature of the CWC and the Nobel Peace Prize, Mr. Schouteten was already sensitising his pupils to the issue of ethics and chemistry, challenging them to imagine what they would do if their knowledge were sought for evil purposes rather than noble causes.

To reach a wider audience on this theme, Schouteten wrote a theatrical play about the life of Fritz Haber, the father of modern chemical warfare who also won the Nobel Prize for inventing the synthesis of ammonia – an invention that enabled the mass production of fertilisers that have fed the world ever since. Schouteten's enduring aim is to create awareness about the potential misuse of chemistry as a contemporary issue, not buried in the past, but one that engages and affects all.[69] CW were designed by scientists, so it is important to sensitise future scientists when they still are young pupils. Sensitisation and knowledge are like fires, he says. If everyone, with his own little fire, contributes to global knowledge, then the world would be safer.

The films can be found at www.thefiresproject.com, with subtitles in all official OPCW languages. In the case of *A Teacher's Mission*, Schouteten also wrote an accompanying lesson plan for use by secondary school teachers, which is also available in all official languages. Brief descriptions of the other films are provided in Box 6.

Box 6

The "Fires" Films

ICH LIEBE DICH

Kayvan Mohammad vividly remembers the Halabja chemical attack in 1988 and aftermath. To this day, Kayvan is not only scarred emotionally but continues to suffer physically from the events. Kayvan faces his hardship with unfailing optimism and in doing so provides a simple but powerful message.

COMBUSTION MAN

Dr Subith Vasu, researcher at the University of Central Florida, USA, investigates what happens to toxic chemicals during explosions. Science has brought CW into existence. Dr Vasu's work is a reminder that many

[68] OPCW, *Education and Engagement: Promoting a Culture of Responsible Chemistry*. Final report of the Scientific Advisory Board's Temporary Working Group (The Hague, 2014), 34, https://www.opcw.org/fileadmin/OPCW/SAB/en/Education_and_Engagement-v2.pdf.

[69] C. Schouteten, "Chemistry and Ethics in Secondary Education: 25 Years of Experience with Classroom Teaching on Chemical Weapons," *OPCW Today*, *Vol. 2, No. 5* (December 2014), 33-34.

researchers aspire to use science to benefit humanity and counter the menace of CW.

BURIED MEMORIES
[ABEO member] Anna Zalewska, a Polish archaeologist, arrives at the banks of the River Rawka near Bolimów. To the naked eye, this area's tragic past seems buried and forgotten. But as Anna identifies the lines of old trenches, she unearths human remains lying just under a thin layer of forest soil. When local people flock to the re-enactment of the historic battle, the past suddenly reveals its gruesome face with the pungent smell of CW, and the noise and chaos of combat.

The Hague Ethical Guidelines

In November 2014 Germany put forward a proposal to develop ethical guidelines for chemistry professionals, related to the CWC. The proposal was endorsed by the Conference of the States Parties at its Nineteenth Session, in December 2014. Ownership of this proposal was immediately passed to the international scientific and industry community, which had already addressed similar proposals.

The OPCW facilitated two workshops involving a group of more than 30 scientists and chemistry professionals from over 20 countries, including all regional groups, to discuss and draft possible ethical guidelines for the practice of chemistry under the norms of the Convention. The workshops were held on 10-11 March and 17-18 September 2015 at the OPCW Headquarters in The Hague, and were chaired by Professor Alejandra Suárez of Argentina.[70] *The Hague Ethical Guidelines* were drafted as an outcome of these workshops.

The Guidelines identify basic elements for ethical codes that support the fundamental norms of the CWC and can be used in the formulation of new codes or the assessment of existing ones. They also provide the basis for discussion of ethical issues related to the practice of chemistry under the Convention. The core element of the Guidelines is based on the premise that "achievements in the field of chemistry should be used to benefit humankind and the environment."

In December 2015, the Conference of the States Parties (CSP) at its 20th Session acknowledged the establishment of *The Hague Ethical Guidelines* as an important step to advance understanding among chemistry practitioners of the importance of nurturing responsible and ethical norms for scientific research and development. The CSP also encouraged States Parties as well as the Secretariat and all relevant stakeholders to promote awareness of these guidelines and their possible application.

Brochures containing *The Hague Ethical Guidelines* are available in all official OPCW languages.[71] The OPCW is encouraging all stakeholders to refer to and promote the guidelines when debating the vital dimension of ethics in relation to chemical disarmament and non-proliferation and the broader issue of responsible scientific conduct. The Guidelines can be used as the basis for several active learning exercises designed to promote discussion about ethical issues related to chemistry and CW.

[70] OPCW, *Report of the [First] Workshop on Guidelines for the Practice of Chemistry under the Norms of the Chemical Weapons Convention*, (The Hague, 2015), https://www.opcw.org/special-sections/science-technology/the-hague-ethical-guidelines/related-documents/, and OPCW, *Report of the Second Workshop on Guidelines for the Practice of Chemistry under the Norms of the Chemical Weapons Convention* (The Hague, 2015), https://www.opcw.org/special-sections/science-technology/the-hague-ethical-guidelines/related-documents/.
[71] https://www.opcw.org/special-sections/science-technology/the-hague-ethical-guidelines/

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Annex
Abbreviations

ABEO	Advisory Board on Education and Outreach
ABL	Activity-based learning
CCE	Committee on Chemistry Education
CSP	Conference of the States Parties
CW	Chemical weapons
CWC	Chemical Weapons Convention
E&O	EDUCATION AND OUTREACH
ICONS	International Communication and Negotiation Simulations
IUPAC	International Union of Pure and Applied Chemistry
KCS	Kenya Chemical Society
MENA	Middle East and North Africa
MOOC	Massive Online Open Course
NRC	National Research Council
OPCW	Organisation for the Prohibition of Chemical Weapons
PRIF	Peace Research Institute Frankfurt
RSC	Royal Society of Chemistry
SNL	Sandia National Laboratories
STEM	Science, technology, engineering, and mathematics
TWG	Temporary Working Group
WMD	Weapons of mass destruction