Mainstreaming Multiple Uses of Chemicals in Chemistry Teacher Education Programs of Africa

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ABSTRACT

Many compounds can be used for or manipulated to serve a variety of purposes. Chemistry teachers and the chemistry curricula they use, however, do not directly deal with the idea of the use, misuse, and abuse of multi-use chemicals. This paper therefore attempts to explore strategies in mainstreaming the concepts of multi-use chemicals in Chemistry teacher education programs. It is believed that teacher education programs have multiplier effects since they are intended to cover both pre- and in-service chemistry teachers.

INTRODUCTION

Whereas a toxic chemical is conceptualized as any chemical which through its chemical action on life processes can cause death, temporary incapacitation or permanent harm to humans or animals, its precursor is defined as any chemical reactant which takes part at any stage in the production by whatever method of a toxic chemical (1).

IUPAC undertook in 2002 an evaluation of the scientific and technological advances in chemical sciences that might have an impact on the implementation the CWC (2). Prior to the commencement of IUPAC's evaluation, the Director-General of OPCW stressed the importance of this evaluation as an assessment of the scientific foundations of the Convention in preparation for the First Review Conference of the CWC held later on 28 April 2003.

In 2004, IUPAC and OPCW agreed on a proposal for a joint project on chemistry education, outreach, and the professional conduct of chemists that led to a joint IUPAC/OPCW international workshop held in Oxford/UK on 9–12 July 2005.The Director-General of OPCW then established the Temporary Working Group on Education and Outreach in Science and Technology (TWG-EOST) in November 2011 in the framework of the Scientific Advisory Board (SAB) of OPCW. The TWG-EOST accomplished its tasks and made relevant recommendation sometime in 2015 for the sustainability of the E&O activities in OPCW.

Such sustained/continued efforts by the OPCW in promoting education and outreach among the scientific communities and the public at large in relation to the CWC and its implementation are to be applauded since they clearly indicate that chemists and chemistry teachers have a great stake in this process.

If chemists and chemistry educators agree that education and outreach in relation to the CWC is a necessary part of their professional obligations (as rationalized above), then they need to devise strategies that accomplish these obligations. Based on previous works by IUPAC and OPCW it seems that there is a general agreement that preparation and use of educational materials specifically devoted to the CWC and their implementation will be an unavoidable strategy.

On the other hand, it is clear that the existing educational materials for school science and university chemistry students are written mostly for a specialist audience, or have dealt only marginally with the topics central to chemical weapons or the CWC in general. It is also clear that revising or updating the existing chemistry education materials to address and deal with the CWC may not be realistic in the near future, particularly in African countries, mainly because of the financial, institutional and human requirements (3).

By way of validating the above efforts and claims at least in Africa and identifying other challenges and the way forward, I conducted a survey study in 2015 (4). Various approaches were used to collect data for that work, some of which were the following. I made a brief look at the Ethiopian secondary school and the undergraduate Harmonized Chemistry Curricula contents in relation to multiple uses of chemicals and the work of OPCW. I also administered a brief test on the same issues in selected senior secondary schools and a University in Ethiopia. The test consisted of eight questions, some in true-false and others in multiple choice formats. The questions were asking whether a single chemical can be useful or dangerous depending on its use, whether chemists played an influential role in the development of chemical warfare, what CWC stands for, etc. A sample of 52 senior secondary school students, 5 secondary school chemistry teachers (BSc degree Holders) and 11 University Lecturers (MSc degree holders) participated in answering the test. These samples were selected on availability and willingness basis.

I also facilitated, upon request by OPCW, the E&O group at the Twelfth Regional Meeting of National Authorities (NAs) of States Parties (SPs) in Africa, from 4 to 6 June 2014 in Nairobi, Kenya. I posed certain questions and issues to guide them through the discussion process. Some of these were:

- Could professional societies like national chemical societies, continental federations, and international unions be in a position to take the burden? How feasible is this in your country? Why?
- Is there any hope that States Parties in Africa can be the major players in this regard? Do you have specific experiences in your country? What are the challenges and opportunities?

- What are the most feasible strategies to convince education policy makers and curriculum developers to integrate issues related to CWC in already ‘crowded’ curricula in African/your education systems?
- Given the fact that that ‘one size fits all’ kind of educational material cannot work here, what are the most plausible and yet cost-effective approaches to address the various stakeholders (science and technology/education policy-makers and shapers-- including politicians and the media, diplomats, senior military personnel, researchers and students of Chemistry/Science)?

That occasion gave me the opportunity to get the views and opinions of representatives of the participating African countries. In particular the participants expressed the challenges they faced in their respective countries in relation to the CWC’s education and outreach activities. They also suggested the way forward.

The findings of the study (4) suggested that a lot has to be done in order to fully and effectively promote the ideals of the CWC among the various stakeholders. The most relevant finding for this paper, posed in a form of a questions was that: Can we assume that these university instructors (the majority of whom scored about 20% on a test prepared for high school students) are ready to teach secondary school chemistry teachers in relation to the concepts investigated? In fact, some of the secondary school chemistry teachers scored lower than their students in the test. We can thus safely say that our university instructors, high school chemistry teachers, students and their corresponding curricula are not ready for multiple uses of chemistry concepts or not ready to contribute meaningfully to the ideals of the CWC.

As a continuation of the previous works (3 and 4), this paper attempts to explore strategies in mainstreaming the concepts of multi-use chemicals in Chemistry teacher education programs. It is believed that teacher education programs have multiplier effects since they are intended to cover both pre- and in-service chemistry teachers.

MAINSTREAMING STRATEGY

It is now well known, and perhaps well accepted, that the knowledge base for teaching in the 21st century is the technological pedagogical content knowledge (TPCK, later referred to as TPACK for ease of remembering it as a word). The framework was proposed (5) as depicted in figure 1.

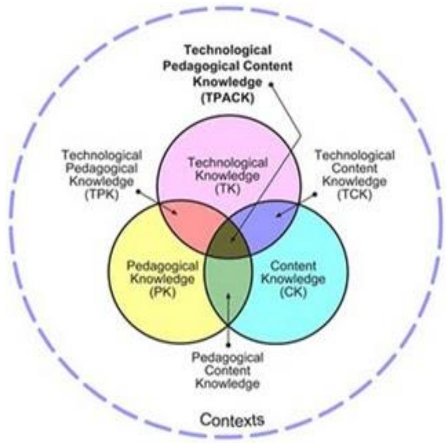

Figure 1. Technological Pedagogical Content Knowledge framework [5, p. 1025]

As Mishra and Koehler (5) argued "though Shulman's approach [of the PCK as the knowledge base for teaching] still holds true, what has changed since the 1980s is that technologies have come to the forefront of educational discourse primarily because of the availability of a range of new, primarily digital, technologies and requirements for learning how to apply them to teaching" (p. 1023). It thus became natural to propose for the integration of technology with PCK, resulting in the amalgam knowledge called the technological pedagogical content knowledge (TPCK/TPACK). The TPCK framework "emphasizes the connections, interactions, affordances, and constraints between and among content, pedagogy, and technology. In this model, knowledge about content (C), pedagogy (P), and technology (T) is central for developing good teaching. However, rather than treating these as separate bodies of knowledge, this model additionally emphasizes the complex interplay of these three bodies of knowledge" (5, p. 1025).

However, TPACK is not a professional development model; rather it is a framework for teacher knowledge (6). Planners of professional development for teachers may use it by illuminating what teachers need to know about technology, pedagogy, and content and their interrelationships. More importantly, the TPACK framework does not specify how this should be accomplished, recognizing that there are many possible approaches to knowledge development of this type.

In response to such criticisms, the ICT-enhanced teacher development (ICTeTD) model (7) was thus developed as one of the approaches for the professional development of teachers at all levels (including higher education instructors) recognizing TPACK as the knowledge base for teachers and as the backbone of the ICTeTD. The ICTeTD model (figure 2) is expected to serve as the guide for the preparation of pre-and in-service teachers for the 21st century. The tetrahedral framework recognizes and indicates the progressive, transformed and dynamic nature of TPACK. It conveys the transformed nature of TPCK from its constituent content knowledge (CK), pedagogical knowledge (PK) and technological knowledge (PK). Furthermore, the entire knowledge base for teachers is embedded within a context.

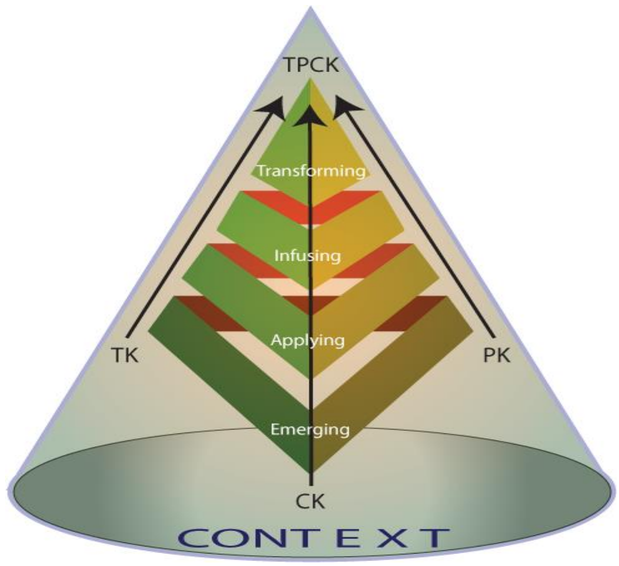

Figure 2. ICT-enhanced teacher development model (7, p. 19)

In the context of this paper, the content knowledge (CK) refers to the actual chemistry (of use, misuse, and abuse of multi-use chemicals). Such contents can be derived from relevant sources, the most notable being the Multiple Uses of Chemicals site http://multiple.kcvs.ca/site/index.html. Whatever the sources maybe, the contents need to be reorganized to fit the ICTeTD model in such a way that chemistry teacher educators at the Emerging Level will deal with the most basic aspects of multiple uses of chemicals, with those chemistry teacher educators at the next higher levels (Applying, Infusing and Transforming) dealing with progressively advanced aspects of the CK.

The pedagogical knowledge (PK) is also expected to progress with the CK, with the Emerging level being more traditional in the sense that trainers are expected to familiarize trainees with basic facts about the multiple uses of chemicals. The other levels progressively employ more activity-oriented, innovative and transformative pedagogical strategies. The technological knowledge (TK) is also part and parcel of the progressive development in the sense that basic productivity tools being dominant at the emerging level, and other advanced and more interactive digital technologies progressively applied throughout the ICTeTD ladder.

The strategy proposed and described above does not expect to create a standalone course on multiple uses of chemicals. Rather all chemistry teacher educators in a given institution would be trained to use the approach throughout their chemistry teacher training programs (hence the term mainstreamed) of pre-and in-service teachers (hence ensuring the multiplying effect of dealing with chemistry teacher education programs).

Finally, it is important to stress the role of Context in the entire approach and as depicted in figure 2. The context defines the application of a certain stage/level in a more meaningful way. For instance if teachers are more acquainted with being the authority in the classrooms who deals with verified knowledge and impart it to students, pedagogically speaking it is hard to immediately put such teachers at a higher level than emerging one. Similarly, some teachers might have developed technology literacy skills through personal initiatives whereas others (mainly in resource-constrained countries/institutions) might not have ever touched a computer mouse. Again some chemistry teachers might be aware of the multiple use chemicals through various media (TV, radio, Internet) while others are just naïve about them. It is thus extremely useful to analyze the context while mainstreaming the multiple use chemical in chemistry teacher education programs.

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