

# COULD OR SHOULD CHEMICAL EDUCATION BE GLOBALIZED BY THE INTERNET?\*

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## Abstract

As a prerequisite for the globalization of chemical education, universal sharing of information, including textbooks, has been suggested. To achieve this apparently difficult goal, extensive use of machine translation (MT) serves as one possibility. To test the feasibility of this method, a program was organized and this was proposed to IUPAC for financial support. The possibility of the use of cellular phones as terminals for the network to be used in chemical education is also discussed.

## Introduction

Over the last ten years we have eagerly attempted to “internationalize” chemical education through a variety of activities. Initially, our premise was that English is a universal language or at least a common language to be used at large, and that information written in a language other than English should be translated into English whenever it is desired to disseminate throughout the world. “*Chemical Education in Japan, 2<sup>nd</sup> version*” (1994) [1] and “*Chemical Education in Asia/Pacific*” (1997) [2], both written in English, were typical examples of such activities.

Meanwhile, the development of the World Wide Web (WWW) has progressed much more rapidly than initially expected. The role of the Internet in the attempt to internationalize chemical education has become critical, and our activity has necessarily shifted to extensive use of the Internet. In 1996, we founded the Asian Chemical Education Network (ACEN) [3], which is essentially a part of the website of the Federation of Asian Chemical Societies (FACS). In 1997, we set up the website for the IUPAC Committee on Teaching of Chemistry (CTC), now the Committee of Chemistry Education (CCE) [4]. In addition to this, we established the World-wide Chemical Education Network (WCEN) [5] as a center for activities aimed at the internationalization of chemical education. We also distributed the free software MOLDA [6], the platform-independent, molecular modeling software already used widely.

## **Internationalization vs. Globalization**

At the same time as the above activities were being carried out, the word “globalization” was becoming fashionable and very rapid globalization was occurring in many fields, including politics, economics, mass communication, *etc.* According to our understanding, there is a distinct difference between the concept of “internationalization” and “globalization”. Internationalization requires “a region” or “nation” as the prerequisite, and under this prerequisite, nations, organizations, companies or individuals work together or exchange information among them as long as one has common interests with the other. For nations, internationalization is literally a matter of interaction between nations.

On the other hand, globalization requires that each nation, organization, company or individual will, when necessary, look internationally for a rational solution which may rise above the restraints of the nation. For individual nations, globalization will make the boundary less important.

In the promotion of globalization, and similarly of internationalization, the Internet has taken a key role. Restrictions caused by the compelling forces of time and distance were substantially reduced by the wide use of the Internet. A variety of networks of global scale have been established among nations, organizations, companies or individuals.

The wave of globalization sweeping the world necessarily has also been affecting the world of chemical education. So far, chemical education, or rather, education in general, tends to be regarded as a national matter. It is true that exchange of information has been promoted for many years by IUPAC CTC and other organizations. On the other hand, the fundamentals of education, of which the curriculum of a subject forms one example, have been regarded as a national matter. In the era of globalization, is it appropriate to think that what should be taught, for instance, at the undergraduate level, for example, may or should remain as each country’s discretion? There are now very many students, engineers, professors and professional chemists studying or working abroad. Globalization of human-power at all stages is in progress. Education must keep pace with this progress. It must be pointed out that this globalization will sooner or later be bi-directional. As for chemical education, what should be achieved is a constant flow of information between north and south, and between east and west.

Globalization of education as defined above may be affected in several ways. One is the common curriculum. If the contents of chemistry teaching that first year college students will learn is much the same in every country, then difficulties associated with study abroad would be much reduced. In the mid-1990s, one of us proposed to IUPAC Commission on Physical Organic Chemistry, III.2, to start a kind of feasibility study toward a common curriculum of organic chemistry at the undergraduate level and also proposed to the IUPAC CTC a common curriculum of general chemistry at the 1<sup>st</sup> year college student level [7].

At that time such proposals failed to attract much attention. The general trend at that time was that education, particularly curriculum design, was a national matter and out of the scope of IUPAC. On the other hand, some professors have been interested in this kind of project. Prof. Nudelmann, in Argentina, showed an interest to organize a curriculum for organic chemistry, while Prof. Todesco, in Italy, initiated a project to make some form of curriculum common to all European countries [8]. In the age of a common currency, the Euro, a common curriculum is not necessarily an extraordinary thing. It seems to us that the idea of globalization of chemical education has gradually gathered supporters. Details of this were reported in the previous paper [7].

## Criticism against Globalization

Globalization has become the slogan of the 21<sup>st</sup> century with the expectation that it would greatly promote the welfare of humankind. The Internet, for instance, has led the globalization and has brought a splendid convenience to human life. This is the "light side" of the Internet and globalization. On the other hand, there have been many examples of problems caused by abuse of the Internet. Trouble in the huge Internet network system has been proved to cause disaster. Such was the case recently, when some large banks in Japan unified into a mega bank. The ATM system of the new bank did not work properly for many weeks. There indeed is a "darker" side to the Internet and globalization.

More serious is the criticism against the globalization of economies. Critics say that globalization has reduced the gap of time and distance while it has enlarged the disparity in wealth. In fact in April 1999 more than 1000 NGO powers congregated in New York at the General Assembly of the IMF and World Bank. Their criticism was that, in the long run, globalization will cause an oligopolistic economy run by a few nations or a few enterprises. This will affect the economy of the 3<sup>rd</sup> world or developing countries. If the oligopoly tends are to be associated with globalization, care must be taken to reduce the damage caused by this unknown factor.

As we are planning to promote globalization of chemical education, we have to determine whether or not there could be a darker side to such endeavors. In other words, is there likely to be any kind of oligopoly in the globalization of chemical education? There would be many areas or countries where textbooks or laboratory equipment are not sufficient, but such problems are different from what we have to discuss. What we mean here is the oligopoly of information related to chemical education.

The most important objective of globalization in any field is a common ownership of information. Information in this context is to be interpreted in a broad sense; information includes everything; starting from textbooks teachers guidebooks, curricula, manuals for experiments, and even news on chemical education. Information in this context should be shared by all educators and to some extent by students all over the world. Such must be the final goal of globalization of chemical education. We have carried out our activity so far with this aim.

Let us explain the situation. Before computers and the Internet appeared, the world-wide distribution of information had been extremely difficult because the cost of translation and that of postage was very high. The world of education always remains relatively poor financially, but the advent of computers and the Internet changed the situation dramatically by enabling the possibility to distribute information in computer-readable form, not in the conventional printed form, at relatively low cost. The Internet thus made the cost of distribution almost zero. Computers and the Internet have thus been a great boon.

What we have done so far along this line is to translate materials written in Japanese into English, or to write in English. At the initial stage of our efforts, such policy would have been well justified. After World War II, English became a kind of world language in many fields, and if the information was written in English, then there would be a relatively good chance for it to be read by many scholars across the world.

It occurred to us, however, that this situation is not completely desirable. As far as education is concerned, the majority of the users of information are pupils, students and school teachers. For a large percentage of them English is not their mother language, and we must assume most of them are not familiar with English. This may mean that there is a danger of oligopoly of information by one language. This problem would be

serious since education is relevant to everyone in the world. What we have done may have accelerated this oligopoly by one language.

In principle, the way to avoid this oligopoly is simple; first, to translate information written in English into one's own mother language and to disseminate nationwide these translated materials *via* the Internet, and, secondly, translate the information written in one's own language into English and to disseminate that information in English world-wide *via* the Internet.

There are two difficulties in practice if the strategy mentioned above is to be carried out. One is the infrastructure related to the Internet and use of computers. We know there are countries or areas where a constant supply of stable electricity is not always possible. In these places the strategy is beyond the realms of possibility at the moment. Such a situation is, however, beyond the scope of education and we could probably expect that the situation would gradually be improved with time. We would like to start with a view that a minimum infrastructure is ready for use. This in turn implies that we have to start with an assumption that the problem of dissemination of information is small if not non-existent.

### **Cost of Translation; How to Solve this Problem**

The remaining problem is the cost of translation. In our case, translation from English into Japanese is easier than the reverse. Probably some expert teachers can do that on a volunteer basis. Teachers are, however, always very busy and it is not practical to depend only on volunteers when large amounts of material are to be translated. The problem would be much more severe where translation from Japanese into English is concerned. Usually one needs to ask professional translators to undertake the preparation of easily readable materials when world-wide distribution is required.

The actual problem is the cost. Good professional translation is fairly expensive. Here is one example from the price list of a translation company in Japan. An English text of one A4 page in length, typed in double space, may cost 40 USD (not 4 USD) to be translated from Japanese. Translation from English into Japanese is much cheaper, probably one-third of the price, for the same volume of the text. One might inquire as to who could pay such an expensive bill. The customers of such translation companies are usually companies which need documents on patents or contracts translated quickly. Few educational organizations can afford such costs.

Here we would like to propose the use of machine translation (MT) as an alternative to expensive human translations as a means to disseminate information on chemical education *via* the Internet. Generally speaking, translation software technology seems to have made considerable advances in the last five years or so. This is in parallel with the advance of personal computers in general. At least a dozen translation software packages are now commercially available in Japan. Almost of all of them are bi-directional, that is, the software can translate Japanese into English and *vice versa*. The prices are variable; starting from 100 USD and reaching 1000USD, or even higher. Probably there may be even more expensive ones used by professional translators. Most of them are equipped with an engine that can analyze sentence structure and with a series of dictionaries of technical terms. In one example, software named PC-Transer [9] has 19 kinds of dictionaries and one can install some or all of them according to the need. The following is the list of dictionaries and the number of words contained. Needless to say, the dictionary is bi-directional.

**Table 1.** The size of dictionaries of technical terms in one MT software in Japan

Field	number of words	Field	number of words
Computer	100,000	Marine	12,000
Machine	75,000	Aviation & space	16,000
Electric and electronics	80,000	Civil engineering	27,000
Medical	100,000	Energy	15,000
<b>Chemistry</b>	<b>95,000</b>	Defense	5,000
Biotechnology	50,000	Law	40,000
Business	50,000	Finance	65,000
Mathematics & physics	70,000	Trade	20,000
Earth & environment	30,000	Chemical engineering	75,000
Metal	22,000		

For chemistry, 95,000 words are included, which is a good number. In addition, there are many FREE software packages that one can use on the Internet, which indicates that there are many users in Japan. Our guess is that now there are many young Japanese people who want to read websites written in English. So, while the present situation concerning machine translation software does not have any relation to education, this situation is advantageous to our proposal since machine translation usage is a matter of course for many people.

When we consider machine translation as an alternative to human translation as a means to disseminate information on chemical education *via* the Internet, the following three points should be taken into consideration.

- a) quality of translation
- b) number of languages for which machine software is available
- c) possibility of bi-directional translation

The most important aspect is actually the quality. Before discussing this aspect, however, we like to report first on b) and c) since the situation in Japan may be exceptional.

### Availability of Machine Translation Software

With the aid of Internet Explorer and of a search engine, we tried to find out how often machine translation software is quoted in the 2,073,418,204 web pages covered by the search engine Google Japan. To our surprise, the answer is about 460,000. This certainly shows that MT is popular, at least in Japan.

The general situation elsewhere seems to be much the same. Apparently there is a great demand for MT. One example is a MT software company, SYSTRAN, which has about a half-century history of technical development. Judging from their catalog, it seems that the most capable software they supply is SYSTRAN PROfessional premium [10]. It can handle bi-directional translation of seven languages, and mono-directional translation of two languages. Dictionaries of technical terms are apparently incorporated, although the sizes of the dictionaries are not specified. The price of this premium version is about 1000 USD.

Another example is the Translation Experts, Co [11]. With the headquarters of this company being in Croatia, they seem to be more concerned with Eastern European

languages. According to their classification, machine translation software is divided into two categories; one is “grammar-aware” software, while the other is not. They can now provide “grammar-aware” software for eight language pairs as shown below.

German-English, French-English, Spanish-English, Hungarian-English,  
Polish-English, Croatian-English, Bosnian-English, Serbian-English.

They can also provide many more “grammar-unaware” software programs for any combination of languages listed in Table 2 below.

**Table 2.** Languages for which “grammar unaware” software is available.

English	British English	American English	French
European Spanish	Latin American Spanish	German	Italian
European Portuguese	Brazilian Portuguese	Japanese	Dutch
Danish	Norwegian	Swedish	Icelandic
Finish	Polish	Romanian /Rumanian	
Bulgarian	Russian	Serbian	Bosnian
Croatian	Hungarian	Slovenian	Greek
Welsh	Filipino / Philipino / Tagalog	Hindi	Turkish
Korean	Vietnamese	Latin	Czech

Based on this simple survey, it seems that there may be a good possibility for the availability of MT software as far as European languages, including Eastern European languages, is concerned. The availability is not as clear-cut for Asian and African languages where MT software is more urgently required. It can be expected also that in these areas the development of MT software is in progress. If a more extensive survey were to be carried out, locally developed MT software would probably be found.

### Capability of MT Software

It is difficult to examine the capability of MT software because one must be proficient in other languages if one aims to be a good referee. So, here we would just like to quote a few simple examples.

One example is a translation of English text into French by NeuroTran of Translation Experts,, a grammar-aware software package.

(English) His literary talent became evident during his high school years. He began to frequent salons such as Mme Arman, a friend of Anotole France. Under the patronage of the latter, Proust published in 1896 his first book, *Les Plaisirs et les Jours*, a collection of short stories, essays and poems.

(French) Son don litteraire est devenu evident au cours de ses ans de lycee. Il a commence de frequenter salon comme celui de Mme Arman, une amie d'Anotole France.

Sous le patronage du demier, Proust a edite dans 1896 son premier livre, *Les Plaisirs et les Jours*, une collection de courtes histories, essais et poemes.

We can only guess, from the example above, that the quality of MT among European languages is reasonable

What is the quality of MT between English and non-European languages? A translation from Japanese into English will be quoted as an example. In the following, two MT software types were used to translate a simple sentence on stereochemistry.

The software is not “trained.” It was used as it was delivered.

(a) With that 4 hydrogen atoms of the methane are equivalent what kind of structure is considered for the methane.

(b) Supposing four hydrogen atoms of methane are equivalent, what structure can be considered to methane?

It is evident that the capability of software is indeed variable. The software (b) can give better English. More complex sentences can also be treated.

(b) When a molecule model expresses multiplex combination, there is two form. In the 1st form, multiplex combination is expressed by changing a joint angle and the length of combination with single combination. It expresses directly that the 2nd form has combination of one or more between atoms by a certain method.

Note that no training has been performed. After a very small amount of training (use), the technical terms will be incorporated into the translated material.

(b) When a molecule model expresses *multiple bond*, there is two form. In the 1st form, *multiple bond* is expressed by changing a *bond* angle and the *bond* length with *single bond*. It expresses directly that the 2nd form has one or more *bonds* between atoms by a certain method

In conclusion, there is no doubt that human translations are better in quality than translations done by computer. However, computers can translate much more quickly and are more cost effective than human translators. If you need to publish a perfect translation, such as a company brochure, you need a human translator. However, if the general meaning of the text is sufficient for your needs, then MT will provide an adequate translation at nominal charge.

It must be emphasized that human translation, perfect human translation in particular, is expensive, and such cost is usually beyond our reach, so it is not relevant to compare MT and human translation as far as education is concerned.

### **Our Project to Promote MT in Chemical Education**

After such consideration, we thought it appropriate to introduce MT into the world of chemical education so that all information can be shared by all people, regardless of language. To put this idea into practice, we submitted a project to IUPAC, seeking some financial support. The title of the project is: A feasibility study of the scope and limitation of machine translations as a means of disseminating useful reading material for chemical education to be used on the Internet.

The purpose of the project is:

To attempt the bi-directional translation of chemical education material from English to other languages and *vice versa* using commercially available machine translation software, and to carry out a feasibility study on the establishment of local translation centers.

The initial stage of the project is:

- 1) to find volunteers who will promote this project in various countries
- 2) to “train” an appropriate software package by incorporating terms and phrases

related to chemistry and chemical education.

3) to link the translated material with IUPAC CCE homepage as a part of WCEN contents.

As a preliminary study, the following languages will be tested by eight volunteer chemists if the grant application is approved. These are:

French, Spanish, Russian, Portuguese  
Japanese, Chinese, Korean, Malaysian

We believe the number of languages is sufficient for a preliminary, feasibility test. As for the materials to be translated, we have to take two points into consideration; one is the problem of copyright and the other is appropriateness.

For translation from English into a non-English language, articles in *Chemical Education International*, *Chemistry International*, and *Pure and Applied Chemistry*, would be best. There would be no problem of copyright, and the articles are most suitable for world-wide circulation.

For translation from a non-English language into English, articles in the national journals for chemical education will be suitable. For instance, the Chemical Society of Japan (CSJ) issues a monthly journal, *Kagaku to Kyoiku*, meaning chemistry and education. We believe most countries have this kind of publication, and some articles must be appropriate for world-wide circulation.

In addition to these materials, textbooks for university chemistry may also be translated and disseminated, an example of which is reported elsewhere [12].

### **Expanding Possibilities by Using Cellular Phones**

In developed countries, the infrastructure associated with the Internet is generally in a satisfactory state, while in developing countries, the situation is variable with some areas not guaranteed of access to the Internet. For this reason it would be desirable if some alternative to the Internet could be found.

We thought we might consider the use of cellular phones in view of the increasing number of users. The expectation will be increased if we consider the capability of the so-called next generation cellular phones, which will be more advanced compared with present capabilities.

In January 2001, NTT DoCoMo, the largest cellular phone company in Japan, issued a new type of phone which can deal with Java text. Through this improvement, it is now possible that users can write and run a program to develop a personalized application, and to disseminate this application to other users of cellular phones if these are *i-mode* machines, which is the standard mode of NTT DoCoMo.

With this in mind, and with the expectation that cellular phones could serve as terminals of the network in the future, one of us developed the molecular graphic software *i* MOLDA [13] which can be handled on the cellular phones. MOLDA, being a platform-free software, has more than a ten year history, and has been used by many chemists and students.

The requirements for developing software are as follows:

J2ME Wireless SDK for the DoJa (obtainable from NTT DoCoMo) [14]  
Java2 SDK (obtainable from Java) [15]

At the moment there are a few problems with Java for *i-mode* application.



- a) The size of application is limited to 10 KB.
- b) Lack of capability for floating-point arithmetic
- c) Some types of cellular phones cannot respond correctly.
- d) The speed of calculation is rather slow (20 sec for receiving the structure of aspirin)

Nevertheless, this trial seems to have opened a new possibility for exchanging information among cellular phone clients and for an appropriate data server that can deal with this *i* MOLDA application. Attempts along these lines are in progress in our laboratories.

In the future, the cellular phones will also serve as handheld computers with the function of an complete Internet terminal to receive any kind of information, text, graphic, audio visual, and programmed, including that on chemical education in one's own language, and even to disseminate it to all over the world.

## Conclusion

We believe that the globalization of chemical education can be done and should be done with the aid of the Internet under the condition that all materials disseminated *via* the Internet should be available in two languages; English and the first language of the user. This condition may be achieved by the effective use of the machine translation software.

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