

The Role of Chemistry Museums in Chemical Education for Students and the General Public

A Case Study from Italy

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Scientific museums and science centers are usually deficient in chemistry, especially in comparison with physics and biology (1). The reasons for this deficiency are quite complex, yet most can be attributed to either the inherent difficulties in showing the principles of chemistry or the negative perception of chemistry in the general public (2). This aspect has been widely investigated (3) and several reviews about the images of chemistry coming from different types of communication (such as literature, cinema, and iconography) have recently appeared (4–6).

The crucial difficulties found to hinder the representation of chemistry inside a museum are both practical and economical ones. Practically, (7, 8) building a chemistry exhibit requires a lot of time and money in order to build and maintain a safe and successful environment. A recent great opportunity was the European project called Chemistry for Life (9), which brought fifteen large scientific museums and thirteen chemical industries to work together in creating and realizing prototypes of chemistry hands-on exhibits. The final goals of this project were only partially reached. In fact, few exhibits dedicated to chemistry derived from this European project have been included in the permanent expositions of these scientific museums and science centers.

However, chemistry is the main object of the educational activities organized by such institutions for school students, such as laboratory activities, and chemistry is often the central theme of successful temporary expositions. In the international context, there is only one example of a science center completely devoted to chemistry: Catalyst (10), an interactive museum with tens of thousands of visitors per year. Here, some innovative ways to present chemistry were developed and tested with success (11). Most frequently, the museums entirely centered on the science of chemistry are historical museums and conservation centers (12). For instance, in Europe, several large or medium museums of chemistry are in university towns, often inside departments of chemistry, or in industrial regions (13).

What Role Do Museums of Chemistry Play in Society?

The impact of museums of chemistry on the general public in Italy is quite low, mainly because of the relatively small number of visitors. Moreover, despite the great historical and scientific value of chemistry, the image of chemistry emerging from these institutions can be roughly summarized as dated, static, and quite removed from “real” society. One of the immediate challenges of these museums is to change this image to get more in touch with the society (14), and to show (rather than obscuring) the role and impact of chemistry in everyday life, in both negative and positive regards (15).

A starting point of this change could be the relationship between these museums and the students coming from all levels of

education, from elementary to university students. In fact, there are at least two levels of potential involvement of the schools in the museums' activities:

1. Ask the students to be part of the organization of the educational activities (16, 17, 18), as well as involving them in cataloging and situating expositions and exhibits
2. Include activities specifically designed for students (didactic laboratories, demonstrations, guided tours, interactive and online projects) in the task of the museums

In both cases, students are active participants at the museums, albeit with a different role.

In this paper, I focus my attention on the Italian context, exploring for the first time the museums and collections of chemistry in Italy (19) and the role of these institutions in chemical education, through the analysis of the specific activities carried out with and for the students. In the following sections several successful programs and activities are described and new perspectives for the future in order to consolidate the relationship between schools and museums are underscored. The online supplement of this paper includes a detailed analysis of the museums entirely dedicated to chemistry in Italy as well as Italian scientific collections having a permanent section devoted to chemistry. The image of chemistry emerging from such institutions is also discussed in the frame of the public perception of chemistry (20, 21).

Museums of Chemistry and University Students

In Italy there are 13 chemistry museums and collections of chemistry strongly connected with a university. Most of them (8) are part of the departments of chemistry, whether in a specific area or spread over the main building. Despite the vicinity of these museums within the area reserved for the university students, few students really know about the activities and the mostly historical content of these chemistry collections. This problem has been identified by the curators, often chemistry researchers or professors employed in the same department. The reason for the lack of real contact between the students and the museum is the lack of relevance given to chemical education, including didactic and history of chemistry topics in university chemistry classes.

Some examples do exist of successful involvement of the university students in the museums' activities, however. Recently, at the Museo di Chimica–Giacomo Ciamician in Bologna, university students have actively participated in the preparation and presentation of chemistry shows and demonstrations during the Festivals of Science held in Casalecchio di Reno, close to Bologna, which is one of the Italian Festivals of Science. These shows are repeated by the students from January to May (the central period of university lessons and courses) to a larger and larger public every year.

Another way that university students have become involved has been adopted at the University of Pavia, where a historical collection concerning chemical research in 19th-century Italy is displayed inside the department of chemistry. Here, a qualification course of history of chemistry, strongly connected with the historical collection, has been introduced in the program of both the chemistry Ph.D. and scientific teacher (SILSIS) schools. In contrast with most university chemistry collections in Italy, the graduate students actively participate in the management, cataloging, and organization of the chemistry collection itself.

Connecting Museums of Chemistry with High School Students

This study examined eight scientific collections located within high schools in which the collections had a relevant, permanent section devoted to chemistry. Six of them are licei, while two are technical and industrial institutes.¹ Compared to the university museums and collections, the high school collections successfully play an educational role. The chemistry and historical collections are near laboratory and interactive spaces (22) where students can practice and experience chemistry directly. One of the most significant experiences from the educational point of view is the use of new instruments versus old ones. For example, through the practical use of a pH meter from the beginning of the 20th century, and a current generation pH meter students can really understand how research has developed, as well as better understand the principles of the instrument itself. High school students are also involved in the activities of the museum, such as in the case of the Liceo Foscarini in Venice. Students from the third, fourth, and fifth classes attend a specific course during the afternoon (as additional hours) called “Studenti Guide” (student guides or presenters). In this course the students learn how to present an experiment to young students and visitors, and how to present a simple demonstration using old equipment in safe conditions (23).

Most of the curators of university and high school chemistry museums emphasized that the involvement of high school students is the most difficult one, because it requires the active participation of the curators in the interactive laboratories as well as in the organization of the activities of the museum. Another important aspect is the preparation of the high school students in their classroom before visiting the museum, especially in the case of an historical museum. The role of the teacher is very important in properly preparing students, in order to catch their attention, and stimulate their curiosity. An example of didactic approach, tested with success by Errico Zeuli, past director of the Museum of Chemistry in Rome, requires collaboration between school teachers and museum guides. This educational method is made of three steps: observation of the equipment or experiment proposed by the guide, explanation of the theory and principles by the teacher, and further observation of the experiment with active participation of the students (19).

Connecting Museums of Chemistry with Elementary and Middle School Students

According to museum of chemistry curators, elementary and middle school students are able to absorb much more from a visit in these museums than other visitors (24, 25). Even in this case, however, these students’ curiosity should be stimulated by the teacher before visiting the museum. The youngest students, and children 6 years old and younger, too, are especially at-

tracted by the spectacular aspects of chemistry: the colors and the smells, the unexpected changes of matter under external conditions, such as liquid–gas (i.e., N₂) or solid–gas (i.e., CO₂) phase transitions. These activities are carried out in the “Museo di Chimica” in Rome, which is Italy’s only museum of chemistry with hands-on activities and exhibits. Another aspect that makes the educational role of museums of chemistry more effective is the human aspect of chemistry, through the biographies of the scientists and the human stories related to major discoveries. This can be easily realized in historical museums where a single object can stimulate the memory of such stories, which particularly attract and astonish students and young children.

Connecting Museums of Chemistry and the General Public

Low annual attendance is a very critical issue facing museums of chemistry in Italy today. Most of the chemistry museums and collections have less than 1000 visitors per year. The best case is that of the Museo di Chimica in Rome, reaching 3000–4000 visitors per year. These numbers are extremely low when compared to those of big Italian scientific museums, such as the Museo Nazionale della Scienza e della Tecnologia–Leonardo da Vinci in Milan, or the Città della Scienza in Naples, with visits of 200,000 school children alone each year. Small and medium-sized institutions with a different structure and formulation, such as the interactive science centers Immaginario Scientifico in Trieste and Museo del Balì in Saltara, have larger numbers of visitors (20,000–80,000 visitors per year).

This problem reflects the low impact that these museums have had on society and on the realization of the educational role of chemistry museums for the general public (26). However, in some of the examined museums and collections several activities open to the general public have been introduced. For example, every year in March, during the Settimana della Cultura Scientifica—a week dedicated to the dissemination of science and promoted by the Italian Ministry of University, Innovation, and Research—the number of expositions offered increases. Most of the exposition topics are strongly related to everyday life (27),—such as Chemistry and Food, Chemistry and Biodiversity, Chemistry and Environment—or to the local region and local activities, such as Chemistry and Restoration of Pictures, and Chemistry and Oil (Museo di Chimica, Rome).

Expanding the Role of Museums of Chemistry in Italy

The role of museums of chemistry should not be different from that of other scientific museums, thus reflecting the development of museums through the centuries (28). These museums should show the evolution of science, thus having a historical and conservation role; on the other hand, museums should also entertain the visitors, by showing the amusing and spectacular aspects of science. Moreover, the role of such institutions is of course an educational one. Museums of chemistry should have an important role in chemical education, through laboratories, exhibits, and other didactic activities. They should stimulate interest in chemistry, through the beauty of its principles and the usefulness of its applications (29). In fact, depending on the audience, these museums can offer opportunities to learn chemistry principles, deeply understand concepts, and discover the chemistry hidden in the everyday life. At a higher level, museums can provide an environment for thinking about the re-

relationship between science, in particular chemistry, and society, finding details to debate about the more controversial aspects of this complex relationship. Moreover, especially with students and young children, these museums should evoke the human side of chemistry recurring in the life stories of the chemists, often invisible protagonists of the fascinating world displayed in the museum.

These points are important in order to understand the great opportunity that such museums can offer to school teachers (25). Students can indeed be part of the museum, being involved in the activities with different roles, depending on their age: as active visitors, as well as presenters and guides. This is the trend of several museums of chemistry in Italy, based at universities and at high schools. The next step is incrementally increasing the number of interactive activities (22) in addition to the didactic laboratories. This future plan includes the development of multimedia resources, such as online databases, virtual visits to the museum, interactive explanations of chemical experiments, all prepared with student collaboration with staff at the museums.

Conclusions

This study examines the role of museums of chemistry in chemical education through the analysis of Italian museums and collections of chemistry. A new projection of these institutions toward the public, and in particular toward young people, is demonstrated by the new activities specifically introduced in the plans of these museums. This positive trend is a common feature among the museums investigated, which promise to improve their role in chemical education and their impact on the general public dramatically. However, this new purpose has several practical limitations, as described in detail in the online supplement, mainly concerning funds, space, and staffing involved.

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Note

1. In Italy, high school students are placed in one of two possible educational settings: either technical institutes, or *licei*. Schooling at the technical institutes prepares students for specific jobs (accountant, technician, etc.); these schools are also called “professional schools” or “technical and industrial institutes”. Schooling at the *licei* provides students with a more general preparation in several subjects, including the humanities and sciences. Students attending *licei* usually continue their studies of a specific subject at the university.

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Supplement

Summary of the main results of the research and a catalog of museums and collections of chemistry in Italy

Detailed information about locations, contents, funding, schedules, and public events of chemistry museums in Italy