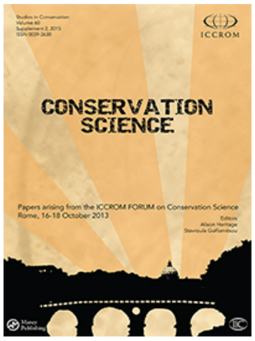

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Position paper

Educating future professionals in conservation science: The challenges of an interdisciplinary field

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Training and education paths in conservation science have been the subject of ongoing debate over the last two decades. A key issue is that conservation science, although not a new field, is not adequately defined, which leads to a lack of consensus regarding the competencies needed. During the ICCROM Forum 2013 on Conservation Science, education for conservation scientists was discussed, with a particular focus on those necessary competencies which exceed the scientific domain. This paper reflects on the outcomes of these discussions as well as the results of surveys carried out by ICCROM in preparation for the Forum on education, job advertisements, and the relationship between conservation professionals and science. Challenges identified included current professional paths, dissemination of scientific findings, use of specialized terminology, and the need for professionals who serve more than one area of specialization. These challenges could be viewed as an opportunity to revise and modify educational programmes. New interactive platforms could be used to facilitate participative science projects, and could change the way projects are carried out in the near future.

Keywords: Conservation science, Education, Interdisciplinary research, Transdisciplinarity, Participative science, ICCROM

Introduction

While conservation science is considered by many as a relatively new field, science has played a major part in the development of cultural heritage conservation for over a century – as evidenced by the early establishment of laboratories in museums such as the Rathgen Laboratory, Berlin, Germany; the British Museum, London, UK; and the Louvre, Paris, France, in the late nineteenth and the first half of the twentieth centuries. Considering the variety of scientists who work within the sector, and the diversity of scientific research undertaken, it is safe to say that conservation science as a field is neither new nor has it been the outcome of a specific educational system. Science became part of conservation and following this, conservation science became a field in its own right. However, the recognition of conservation science as a profession is still ongoing.

The definition and the role of conservation scientists have been the subject of several debates over the last two decades (see, for example, Mazzeo & Tabasso, 2000). In 1997, an ICCROM survey on conservation science showed that conservation scientists were primarily professionals trained in one of the natural sciences who entered the field directly through employment (Mazzeo & Tabasso, 2000, p. 4). In the subsequent 1999 ICCROM meeting regarding education and university curricula for conservation scientists, much attention was placed on the definition of the professional and his/her educational background and skills, rather than the aims and operational domain of the profession.

During the ICCROM Forum 2013 on Conservation Science, education and the desired attributes of conservation scientists were discussed extensively. On the final day of the Forum, a discussion group was formed to focus on this topic, chaired by the author. The group comprised diverse professionals from different educational and cultural backgrounds, who provided very different perspectives of education in conservation science. The recommendations arising from this group form the starting point for this paper, which were then combined with reflections from the author's own experience (both as a graduate student and as an educator in conservation), and the results of a number of surveys undertaken by ICCROM in September 2013 in preparation for the

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Forum. These surveys were intended to capture current views regarding educational pathways for conservation scientists, the use of science by conservators, and the skills sets employers are looking for when employing conservation scientists.

With these considerations in mind, this paper then moves to discuss some of the underlying issues related to the definition of conservation science as an operational domain, issues in defining competences in interdisciplinary studies and the use of terminology which in theory improves communication but in practice can complicate matters. Regarding terminology, in this paper the word 'educator' refers to anyone involved in the training of conservation scientists.

Findings of the Forum discussion group on education

The diversity of the members of the discussion group lead to thought-provoking and enlightening debates, however, selecting the main points to be given as recommendations to educators was quite challenging. The recommendations and findings on messages to educators are reproduced unedited here below.

Key messages to educators

Why? Education is the future of our profession

- Educators should have a clear understanding of the vast array of necessary sciences that contribute to conservation to ensure graduates can bridge these different disciplines.
- Educators should value traditional knowledge systems as part of the cultural heritage in their own right. Conservation science could be used as a means of better understanding this traditional knowledge.
- Conservation education should consider the social and political dimensions of conservation in addition to technical and scientific aspects. This should include how conservation can contribute positively to societal priorities.
- Education should empower students with skills that could be adapted to meet local needs.
- Education should foster solution-oriented learning attitudes that seek cost-efficient outcomes.
- Conservation education should expand beyond concern for material culture to consider emerging issues such as intangible heritage and sustainability.
- Educational programmes should respond to the needs of the profession as well as ensuring that graduates have the skills necessary to be employed.
- Educational programmes must provide communication skills so that students may participate in effective dialogue with a variety of audiences (political, community, professional, etc.) and be strong advocates for conservation.
- Conservation education should foster collaboration at the university, professional, governmental, and community levels.
- Educational frameworks should be developed to be flexible enough to take into account local, governmental, and social conditions.

Exploring the issues

Despite the fact that a significant proportion of current conservation scientists first trained as chemists, there is no single scientific discipline that could serve as the sole foundation of an educational programme for conservation science. The complexity and range of issues encountered in conservation require inputs from many different disciplines and specializations. There is, however, general agreement that conservation scientists should be trained in 'a science' and use their knowledge for the conservation of cultural heritage (Corbeil, 2000). Price (2000) suggests that conservation scientists in addition to their scientific background need to be acquainted with the ethos and the principles of conservation, suggesting that scientists need further training in conservation to understand the constraints but also the broader research horizons under which conservation professionals operate. Inevitably, the definition of conservation science surfaces in the discussion, which in turn raises a number of questions regarding educational pathways. More often than not the focus has been on who the conservation scientist is rather than defining what the field of operation should be. However, it would perhaps be more pragmatic to focus more on the latter rather than the former, as this would help establish conservation science as an independent scientific domain, set professional goals and thereby assist educational institutes in their training of future conservation scientists. This particular challenge is by no means unique to conservation science, but rather is common to all interdisciplinary fields, where the lack of definition of the specific operational domain hinders the specification of required competencies, and consequently the development of relevant training programmes.

In lieu of a definition, for the purposes of this paper the author would like to attempt a short description of the operational domain of conservation science, in order to provide a starting point for the subsequent discussion regarding conservation science education and its links to the different facts of cultural heritage conservation. Conservation is considered here as an overarching field that seeks to preserve cultural heritage both in terms of the physical object itself, and the diverse values and information it carries. To this end, in addition to technical issues concerning the material composition, construction and properties of objects, conservation also considers why and how objects become cultural heritage from the perspectives of different interest groups, and how perceptions of value can change over time due to physical alterations (e.g. through ageing and interventions) or through societal and cultural changes. Within this context, conservation science is a scientific domain where diverse scientific knowledge and methodologies are applied to understand, characterize, and preserve not only the component materials, but also the values of the heritage. Consequently, the operational domain of conservation science cannot be limited solely to materials science, but must encompass diverse disciplines, from natural sciences to social sciences and humanities, each contributing towards the same goal that is promoting the understanding, preservation, and management of cultural heritage, its values and its sustainable use.

Training and educational pathways in conservation science

There are very few undergraduate or postgraduate programmes dedicated to conservation science, as opposed to those for conservators. Moreover, education in conservation science is highly variable and complicated to evaluate. To better understand training pathways for conservation scientists, in preparation for the ICCROM Forum 2013 on Conservation Science, ICCROM together with the support of the ICCROM Forum consortium partners undertook an online survey of educational programmes in conservation and ostensibly conservation science in September 2013 (Heritage *et al.*, 2014). The results of the survey offer some interesting insights.

The majority of the educational programmes surveyed offer postgraduate courses (at masters and doctoral level) focusing primarily on museum collections and site-based conservation (73% and 56% respectively). The percentage of the student intake with a degree in a scientific discipline varied greatly: from less than 10% (for 54% of training programmes) to more than 90% (for 22% of training programmes). Interestingly, the percentage of students undertaking research generating scientific information through their studies are somewhat higher with the majority of students in around 40% of training programmes carrying out science-based research. The above indicates that scientific research in training programmes is strongly linked to the objectives of the programme. Additionally, it is worth mentioning that the research interests of the academic staff in an educational department as well as the facilities available strongly influence the research undertaken by students. The survey also revealed that little of this student research is published – which is not altogether a surprising finding as this is known to be a common issue in most tertiary education institutions (Cather, 2013, personal communication; Pye 2013, personal communication).

The survey results are less clear when it comes to what qualifications are needed for a career in conservation science. It was clear from the responses that there are several possible paths, however, the majority (87%) of the educators agreed that both science and conservation qualifications are necessary, with a first degree in science and a masters in conservation being the most favoured combination. Moreover, the general consensus was that training in conservation science should be pursued at postgraduate level, either as a doctorate (60%) or a master's degree (44%), with only a small percentage supporting the need for a specialized bachelor (first) degree (14%). A number of educators commented on the employability of graduates with doctorates in conservation science, compared to doctorates carried out in a 'mainstream' science discipline which they considered to offer more employment possibilities. Employability is linked to needs and opportunities within the sector at the time of graduation; however, the skills acquired are transferable and not limited to the cultural heritage field.

What are employers looking for?

To understand what employers typically require from conservation scientists, ICCROM undertook a survey of posts advertised for conservation scientists on the website of ICCROM and the *Conservation DistList* between 2008 and 2013 (Heritage *et al.*, 2014). In total, 89 job advertisements were surveyed, the majority of which were for positions in North America and Europe (93%). However, jobs advertised at national level and in languages other than English were not traced and these results are discussed with these limitations in mind.

Within the adverts surveyed museums and academic institutions appear as the main employers for conservation scientists with only few positions advertised in the private sector. The majority of these posts were for mid-career professionals with only a small number at entry level, indicating the difficulties new professionals face when attempting to enter the field. Moreover, the lack of entry level positions might in part explain the increasing take-up of post-doctoral positions which offer graduates an opportunity to gain expertise and experience in the field prior to obtaining a job. Interestingly, less than half of the job positions advertised in conservation science listed a Doctorate as an essential qualification. Very few senior positions were advertised.

In general, only 45% of the adverts highlighted experience in the sector as a pre-requisite, even though the positions advertised were for conservation scientists. Contrary to the opinions polled during the educators' survey, the adverts often did not specify whether the required academic qualifications should be in science or conservation, with the exception of Doctorates which, when requested, 68% of the adverts specified it should be in natural sciences or engineering.

Conservation and science: an affair to remember

Educational programmes in conservation and restoration are highly varied, ranging from vocational courses to Bachelor's and postgraduate degrees, such that the training offered differs from one country to another, and often within the same country. Similarly, the level of science required to enter conservation programmes also ranges dramatically (e.g. from intermediate and advanced certificates in science to college level science courses). As a result, even though established training programmes have been in existence for several decades there is no conformity in conservation training, and the related science entry requirements.

One of the key themes of the Forum was how to improve the relevance and impact of science within conservation. It is logical that at least part of the answer to this question lies in the effectiveness of interdisciplinary collaboration within the field – i.e. in what ways, and how effectively different professionals communicate and work together. In regard to this, education and training plays a crucial role. While discussions regarding education for conservation scientists have highlighted the need for scientists to be educated in conservation ethics and principles, similarly, conservation training also needs to focus on improving science literacy, and in particular the application of scientific principles and methods to conservation.

To better understand the relationship between conservators and scientists and in particular the access to and use of scientific information and services by conservators, an online survey of conservators was undertaken by ICCROM during September 2013. More than one thousand two hundred conservators from around the world participated in the ICCROM survey which was advertised through professional conservation websites and social media (see Heritage *et al.*, 2014, for more information). Similar to findings of the survey of job advertisements, the majority of the conservators who responded were employed in museums (55%) with site-based conservators being the second largest group (43%). Of the conservators surveyed, the majority cited their academic training as the primary source of scientific knowledge used for their work (69%), in comparison to conservation science literature (11%) and direct exchange with scientists (9%). This highlights the importance of training programmes as a fundamental resource – and sends a clear signal to educators that this is a vital window of opportunity for enhancing levels of scientific literacy. Moreover, while conservation science publications, seminars, and workshops are also significant resources for knowledge exchange, nevertheless financial constraints and lack of accessibility were reported as significant barriers, particularly for operators in private practice who, for example, do not have access to subscription-based publications through an institution.

While in general terms, communication and collaboration with scientists was reported in the survey as being good, nevertheless, from the respondents' qualitative comments the precise terms of these collaborations warrant closer examination. Increasing scientific literacy without doubt facilitates communication and understanding at the intersection between different disciplines, and improves levels of collaboration. Indeed, academic programmes already deliver syllabi with this in mind at different training levels. While the degree of scientific literacy and competence of conservators need not match that of conservation scientists since the professional objectives of each are different, conservators with an advanced understanding of science can and do lead research projects in conservation, particularly where the focus is on applied practical aspects. As a result, this bridges the gap between conservators and academics as well as conservation scientists, leading to more effective co-working and ultimately projects of greater practical relevance to conservators.

The paradigm shift from the craftsmen and artisans who characterized the field 40–50 years ago, to current day science-based conservators, is quite significant. While the modern scientific approach without doubt has led to many advances, it is important not to lose these vital practical roots which are an essential knowledge resource. Conservation is as much linked to arts and crafts traditions as it is to science – and this traditional knowledge base should be acknowledged and incorporated within conservation science research as a means to enrich understanding, and enhance conservation methods.

The use of surveys

Surveys are helpful to get a snapshot of the field at a specific moment in time. However, they do have significant limitations, since the outcomes of a survey depend on the objectives and the design of the questions and, in the case of quantitative surveys, the pre-selected options for answers. In quantitative surveys one expects to reveal some of the general tendencies that are influenced by personal experiences, rather than a more in-depth analysis that is afforded by qualitative methods using for example in depth interviews (Creswell, 2014). While it is understandable that a primarily quantitative approach was adopted for the Forum surveys – given the short space of time available for their design and execution, and the ease of analysis that these afford, nevertheless further qualitative research would help to elucidate some of the results obtained.

Comparative analysis of the data collected during the different surveys yields further insights. For example, the relationship between conservators and conservation scientists, and also the access to scientific information and services, is conditioned by the working environment. From the survey data gathered, it is possible to see some clear similarities, and also some dissimilarities, between the various groups. While the primary areas of employment for both conservators and conservation scientists were museums and site-based organizations, nevertheless almost half of the conservators surveyed reported themselves as working freelance or in private practices. In contrast, this is rarely the case for conservation scientists, the vast majority of whom are institutionally based, in museums, universities, and cultural heritage organizations. Indeed, the extent to which shared working environments influences the effectiveness of interdisciplinary collaboration between scientists and conservators is worth investigating further.

Another important issue highlighted by the surveys is the degree of access to new knowledge and scientific advances, which at present is often limited by journal subscription costs. Again this is an issue that affects the various groups differently depending on their work context (i.e. whether institutionally based or in private practice). Although a number of organizations and educational institutions support open-access publications, the majority of scientific papers are still published in subscription-based journals. These issues cannot be overlooked as the field expands far beyond the universities and museums of developed countries. As open access journals become more established and the benefits of delayed open access publications (papers of subscription-based journals which become open access by the publisher after a predefined period of 'embargo' time) are better understood (Laakso & Björk, 2013), such obstacles to the dissemination of new information should diminish. In particular, research carried out to understand better the benefits of open access has highlighted a number of advantages to publishers, which in addition to the more obvious, also include an increase in citations and accordingly an increase in the journal impact factor (see Bernius *et al.*, 2013).

Interdisciplinary, multidisciplinary, and transdisciplinary research

A strong message of the Forum was that conservation science will benefit from a more inclusive attitude towards other scientific disciplines, including humanities and social sciences. Conservation science is traditionally linked to natural sciences such as chemistry, physics, biology, geology, and materials science. However, an increasing number of disciplines are now becoming included in conservation research, and in particular the adoption of a value-based approach has led to the incorporation of disciplines such as anthropology, psychology, and sociology as a necessary component in scientific research projects (see Dillon *et al.*, 2013).

Conservation science has for a long time been described as 'multidisciplinary'; however, increasingly the term 'interdisciplinary' is used. While multidisciplinary research involves the collaboration of several disciplines working towards a common goal, nevertheless, each remains distinct, producing results which are typically published separately in journals relevant to the disciplines involved (Aboelela *et al.*, 2007). Conversely, interdisciplinary research is associated with the use and integration of theories, concepts, tools, methods, models, data and paradigms of two or more disciplines to solve a problem (Porter *et al.*, 2006), and results of findings in jointly authored publications. Interdisciplinary research not only borrows from different disciplines but also integrates them, and is characterized as an 'intellectual landscape of knowledge, not disciplines per se' (Huutoniemi *et al.*, 2010). In view of these considerations, the term 'interdisciplinary' would seem the better fit since conservation science research starts from a question, and through the synthesis and integration of sciences and humanities, results in the production of new knowledge.

The interdisciplinary nature of conservation science is also evident in the use of specialized terminology borrowed from disciplines both in humanities and mainstream science. The language and the methods used to communicate research findings merits further investigation, as a significant proportion of conservation science findings are published in mainstream scientific journals, with little or no dissemination in the conservation literature. This trend is largely dictated by university requirements and departmental priorities, which are often ranked in terms of their publication outputs for which the journal's impact factor is a key criterion.

Nevertheless, the use of language and the factors that influence its selection is significant as a key determinant for communication and hence interdisciplinary collaboration. The breadth of knowledge needed for conservation research has required the integration of an increasing number of scientific disciplines within conservation science: from natural sciences and engineering to mathematics, computer sciences, statistics, and social sciences. This leads to an increasing multivocality within the field. Moreover, the significance of language comes to the fore as the field transitions from interdisciplinary towards transdisciplinary research. Transdisciplinary is described as a problem-oriented research that requires cooperation between researchers and practitioners, bridges science with society, and ultimately results in mutual conceptual and methodological frameworks (Jahn *et al*., 2012). Consequently, with roots both in the crafts and the sciences, conservation science has developed to a large degree along the lines of transdisciplinary research.

Communication, politics, and conservation science

The lack of effective communication among different professionals within and outside the field, as well as between different interest groups, was a recurring theme highlighted during the Forum. Scientists need to have a broad understanding of the extended field and to be able to make connections between the different professionals. Communication should include institutional communication with the public, interdisciplinary exchange, communication between different professionals within an institution and transmission of scientific concepts to different interest groups. The last few years have witnessed a number of conservation professionals including scientists advancing in key managerial roles in various cultural heritage institutions. This facilitates the dialogue between different experts and stakeholders, and more importantly adds cultural heritage to the general agenda focusing on societal needs. Cultural heritage is often marginalized outside the field and it is apparent that the significance and the stability it brings to society is not communicated properly at higher levels of leadership. The reasons behind this are far too complex to discuss in this paper, however, part of the issue is related to the methods, terminology, and language used in specialized fields such as conservation science, which make communication with the general public, policy-makers and other professionals difficult. It is worth learning to corroborate the value of our work using common language and nomenclature to communicate competently and effectively. Communication skills that could help advocate for cultural heritage should be acquired via educational programmes and further professional training.

Another dimension to the above is the use of Internet sources and interactive platforms to design and communicate scientific projects in cultural heritage. Participative science projects could be developed in conjunction with different citizen groups. A number of crowd sourcing projects are currently online; a successful example of this is the MicroPasts project (see Bonacchi *et al*., 2014). Apart from the benefit that this type of projects brings to data sourcing and analysis, they are beneficial for the society as citizens become part of a larger scientific community. A number of platforms are currently available (see Zooniverse, CrowdCrafting, PyBossa, Thinkable, Marblar, and Ushahidi)[1] and can also be used to design projects with the public. Interactive platforms like these and many more that are not mentioned here can provide data and evidence, which in addition to informing processes and standards, can act as an indispensable communication tool for the field of conservation science.

Towards a new paradigm for conservation science education

There are very few programmes in conservation science around the world. An example of a dedicated project in training conservation scientists was the European PhD in Science for Conservation (EPISCON). The project was funded by the European Union in 2004 and was concluded in 2009. Another noteworthy current example is the Centre for Doctoral Training in Science and Engineering in Arts Heritage and Archaeology (CDT-SEAHA), based in University College London (UCL), London, UK, which is designed to address issues in heritage in collaboration with heritage organizations and industry partners (www.seaha-cdt.ac.uk). This programme envisages career paths which are not limited to heritage organizations, but which will extend to industry and policy making, multiplying employment options as well as addressing wider communication issues. The initiative is remarkable because of its outward-looking approach and the involvement of new partners in heritage science. This model of studies is worth exploring further, as it provides a larger framework within which heritage scientists could operate.

However, due to the heterogeneous nature and breadth of knowledge required in the field, designing a degree in conservation science is challenging (Golfomitsou *et al*., 2015). The multifaceted nature of conservation science demands creative solutions within educational programmes to further advance the field. The lack of definition regarding conservation science makes the design of any syllabus complex, because any degree programme must have clearly defined learning outcomes. Educational programmes are designed following tested and conventionally

[1]CrowdCrafting. 2015 [accessed 15 February 2015]. Available at: <http://crowdcrafting.org/>.
Marblar. 2015. [accessed 15 February 2015]. Available at: <http://marblar.com>.
PyBossa. 2015 [accessed 15 February 2015]. Available at: <http://pybossa.com/>.
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accepted methodologies. The professional reality, however, would be best suited to flexible programmes both in terms of student profile intake and specializations offered. The focus of such a programme should be on the diverse range of competences required, which go over and above scientific expertise (see the findings of the Forum discussion group above). The breadth of these skills require the exploration of new pedagogical approaches both within and outside the discipline. For example, research-based teaching linked to workplace training could contribute to translating research findings into practice. Similar to conservation science, a number of professions require theoretical understanding of processes combined with development of motor skills and critical thinking (Sadideen & Kneebone, 2012 ; Papp *et al.*, 2014). The integration of theory, research and practice should be encouraged, and models used in other fields can assist in developing suitable training paths.

Inquiry-based learning (IBL) is a pedagogical approach which is based on problem-solving, research and real-life projects, and scenarios (Aditomo *et al.*, 2013). Students participate actively, and teaching can take place outside the classroom, e.g. in a museum laboratory. This model is used to a certain extent by several university programmes, where students carry out practical work in museums/sites affiliated to the programme. Conservation science in its complexity and interdisciplinarity makes inquiry-based learning imperative. IBL increases awareness of real-life problems and contributes to the development of professionals who can think and act critically.

The latter is immensely important, as conservation scientists, like all cultural heritage professionals, should be communicating with broader society in matters that affect our understanding of the past. The value of heritage is not necessarily evident to a lay person, and specialists often fail to communicate its worth due to the assumption that its value is self-evident. The complexity of conservation science lies in the preconception that it is a scientific discipline; however, it is based in a field that has numerous socio-cultural consequences. Enhanced partnerships among educational institutions, museums, and relevant organizations can bring academic programmes forward, as they should not only respond to present needs, but also predict the requirements and predicaments of the near future. The latter cannot be done in isolation but only within a wider context where scientific developments as well as general scientific and societal trends are considered, assessed, and incorporated into the training.

In addition to research and analytical skills, education in conservation science should equally cover the intangible values of cultural heritage. Transfer of craftsmanship knowledge, sustainable conservation methods as well as emerging forms of cultural heritage should be included. Facilitating access to information at both local and global levels is imperative and luckily there are many available platforms that can be used for this purpose. Participating in projects linking local and global knowledge, questioning existing knowledge systems and creating interactive platforms for sharing knowledge should be in the immediate priorities of any educational programme in an ideal world.

In view of this, it is clear that all conservation scientists should be well-versed in more than just conservation principles. They also need to understand the field and the stakeholders to be able to communicate with different interest groups at different levels, and to participate in effective interdisciplinary projects. Conservation scientists cannot be isolated from the cultural heritage sector and the cultural heritage sector cannot be isolated from the rest of the society. In particular, critical and reflective thinking are needed to develop context-specific research projects that will inform decisions in different sectors. Accordingly, communication skills are quintessential in these multi-, inter-, or trans-disciplinary studies, and more emphasis should be given to them. This way programmes can ensure that future professionals are not only connected with the advances in their respected scientific field, but also they also learn to operate in an inclusive fashion.

Yet the role of educational institutes and academics in conversation science is not merely limited to the training of future professionals. Educational institutes in addition to their role of educating future professionals and producing knowledge through research have a key role to play in the development and promotion of the discipline. This includes a necessity for well-founded public outreach activities to positively influence public perception in relation to heritage, the importance of preserving it and the role it plays within a community. Academic institutions should identify future research tendencies and drive developments in the field. They should also in collaboration with partners such as ICCROM offer mid-career continuing professional development which can result in real-life solution-oriented training. ICCROM provides a link to practitioners and the challenges encountered around the world; both are essential to academic institutes. Apart from continuous training in new pedagogical methods, educators need to maintain a connection with the field and its challenges, which can lead to new creative ways of delivering problem-based teaching.

An additional concern in relation to education is the lack of dedicated conservation science textbooks (Tennent, 2013). Didactic resources in a variety of forms are needed to match different modalities of learning. For example, online platforms with case studies could provide an alternative and stimulating way of learning and also act as a communication channel for students and professionals around the world.

Conclusion

Societal changes, scientific developments, and new challenges across the field require the implementation of a more pragmatic approach to the education of conservation and heritage scientists. Definition of the operational field will allow educators to define professional competences and learning outcomes required for future conservation scientists. A programme aimed at educating conservation scientists should include training in the intangible values of cultural heritage and should be inquiry-based with strong links to museums, heritage organizations and institutions, as well as covering communication skills, and an appreciation of the craft roots of the profession. It should encourage communication with stakeholders and the planning of projects that benefit wider society. It should allow specialization and encourage dissemination of research findings to a variety of audiences and through different channels. Educational programmes should accept students from a wide range of scientific backgrounds and build upon their strengths following a student-centred approach. Research-based learning allows students to participate actively in research projects.

Effective interdisciplinary collaboration requires effective communication, which rests upon all parties being sufficiently literate in both conservation and science. Emphasis on key transferable skills related to communication, adaptation, flexibility in methodological approach, and innovation will allow graduates to establish efficacious partnerships which will go above and beyond traditional research pathways, and will contribute in moving the field forward.

Finally, education of conservation scientists should be based on programmes designed to train a diverse body of students in distinct specializations both in science and conservation. This would break restrictive barriers between the distinctive fields, raise awareness of the mutually complementary roles various professionals have in the field, and contribute towards building future effective partnerships. Flexibility in academic curricula will allow the formation of professionals that can 'think globally, act locally' and work at different local, governmental, and institutional levels.

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