Understanding structural conservation through materials science: strategies and didactics

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“Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand”

(Confucius, 450 BC)

Introduction

The design of successful conservation strategies requires an understanding of the chemical and biological degradation processes, but also an understanding of the mechanical failure mechanisms behind damage observed in cultural objects. This is the reason why mechanics are being progressively implemented in current conservation-restoration training programs as part of the core competences desirable in future professionals. Materials science applies the properties of materials to science and engineering to investigate the relationship between the structure of materials at atomic
or molecular scales and their macroscopic properties. This is done by combining elements of applied physics, mechanics and chemistry. This paper introduces a pilot program to applied materials science in conservation which builds on the idea that teaching a combination of mechanics and structure of objects as well as structural conservation will show how the theory is directly applicable, and therefore more readily comprehended. The program has a format of lectures in materials science and structural conservation combined with simple practical tests of strength, flexibility and dimensional response of materials to moisture and temperature fluctuations. Such a program lays the foundation for a deeper understanding of cultural materials' behavior and allows students to move smoothly to more advanced levels of understanding including the use of more sophisticated equipment.

**Why Mechanics? Structural implications of damage found in artworks**

Museum objects are often composites of materials with different properties that sometimes have been made even more complex with the addition of other materials in the course of conservation treatments. Structural treatments can have negative effects due to a lack of understanding of basic mechanical and structural behavior and some treatments have therefore made objects more vulnerable to the environment. A good example of this is cradling on the back of panel paintings. It has been a common belief that fracture in materials is caused by strain/deformation and, based on this miscomprehension, that hygroscopic materials are safer when restrained. However, force is the cause of failure and deformation. Restraining objects can cause devastating forces as materials respond to the ambient environment. The fact that a large proportion of objects in most collections are treated or restrained represents a challenge to preventive conservation in terms of defining the right environment, packing or transportation for each object.

In order to avoid treatments based on miscomprehension, conservators must be able to identify failure mechanisms and address the structural needs of cultural heritage objects both when designing conservation treatments and when determining environmental guidelines. Increased knowledge about the mechanical and dimensional properties of materials has led to an international re-evaluation of environmental standards for museums (Mecklenburg et al., 2004, Hedley, 1988, Michalski, 1996). For example, research suggests that conservation treatments alter the response of canvas paintings to environmental fluctuations (Andersen 2013, Young and Ackroyd, 2001, Tassinari, 1974, Hedley, 1988). Knowledge of previous interventions is therefore essential when conservators treat objects and make recommendations of preventive measures like environmental control, microclimate frames, show cases, etc.

Sometimes decisions in conservation-restoration have to be made without the possibility of running materials' analysis and consulting experts. The reasons for this are usually budget restrictions and tight schedules and this is especially true in private practice. This means that decisions are sometimes based on a combination of deductions from experience and knowledge of the characteristics and behavior of the different cultural materials in different environments. Deduction requires an overview of general observations that can be made about the objects in question.
Traditional conservation-restoration programs have evolved and progressively incorporated the study of the chemistry of materials but little attention seems to have been given to materials’ behavior in what refers to their physical and mechanical properties and in understanding how they govern artworks’ performance and stability in the mid-to-long term. In these past years however, things seem to be changing and there is the common belief that the key to designing appropriate conservation strategies is to pose the right questions, which necessarily implies a basic understanding of both the condition of the artwork and the issues conservators are facing. Questions like: What caused the damage? How did the damage take place? What is the exact failure mechanism behind specific pathologies? help understand the condition of the object.

The materials science approach can provide much of the knowledge needed to answer these questions and make the deductions mentioned above. The course outlined here helps students to classify materials and explain why objects that can be categorized in the same class of materials often have similar structural behavior. Change in the mechanical properties can be caused by physical changes or by structural changes as a result of structural conservation, which is why it is profitable to incorporate material science to the courses in structural conservation. In this way students can be prepared for specific activities that they will be facing in their capacity as conservator.

Materials science and conservator-restorers’ competences

Knowledge, skills and competences required by conservator-restorers have been defined by the international organizations. In 1984 the ICOM-CC committee agreed on the following definition of the conservator-restorers’ work, which is still the most recent on the website: “2.1 The activity of the conservator-restorer (conservation) consists of technical examination, preservation, and conservation-restoration of cultural property” (ICOM-CC, 1984) This definition, however, seems to lack some of the competences required of a modern conservator. In a chapter on the history of the School of Conservation in Copenhagen associate professor Beate Federspiel notes that core competences of a conservator are changing. She writes that influence is essential to preventive conservation and this is reached through research and communication skills (Federspiel 2004, pp. 386-387). Communication as well as research, risk analysis, negotiation and decision-making do not seem to be included in the ICOM-CC definition of the activities of conservator-restorers’ thus excluding conservator-restorers from a more prominent position in the process of planning and making more general decisions about objects, museums or buildings.

However, E.C.C.O. has a more recent and perhaps more updated definition of the competences needed in conservation-restoration: “Skills: Specialized problem -solving skills required in research and/or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields. (European Communities, 2008:13). [...] It includes an ability to observe, collect and critically analyse relevant information in order to reach appropriate conclusions and carry out a course of actions; the ability to continuously analyse and evaluate the situation and the process in order to adjust where needed; the ability to integrate knowledge from different fields, and the ability to create new knowledge and procedures where they arise; the ability to communicate knowledge” (E.C.C.O., 2011).
Already before the introduction of the European Qualification Framework ENCoRE had formulated that "masters in conservation/restoration should be able to:

- plan, coordinate and perform practical conservation/restoration work including experimental and developmental work based on scientific methodology.
- plan, coordinate and perform elementary scientific analysis and to be able to interpret and evaluate more advanced analysis performed by others.
- make clear observations and evaluations of individual objects, and of collections, including the study of materials and techniques (identification and dating) as well as ethical and aesthetical issues, in cooperation with art historians, archaeologists and other specialists.
- Administer and manage the storage, handling and display of artifacts. - participate as a research assistant for conservation/restoration research projects" (ENCoRE, 2001)

The course proposed here aims at expanding these competences through advanced understanding of the mechanisms that make objects fail, thus allowing students to understand and anticipate failure and distortion in cultural heritage objects. Furthermore, it aims at developing communication skills on the matter through discussion, teamwork and presentation of projects. What is proposed is a course at master level, but further education in this field for established practitioners has also proved very fruitful since experienced practitioners who have handled many objects tend to have a very steep learning curve as they can relate the topic to their every-day experiences.

**Course objectives**

It is well known that chemical degradation processes have a direct correlation with changes in the mechanical properties of materials and therefore make cultural objects more vulnerable to mechanical forces. Materials’ science involves knowledge of chemistry, physics, biology and mechanics but also refers to the interaction between all of them within a single object. In order to expand students’ knowledge of the risks that cultural objects can be subjected to, such interactions have to be explored through actual studio cases. For this purpose, students are confronted with theory as well as with objects that are being tested and can be seen and touched. The impression that the senses have on the students are often more powerful than abstract knowledge and, therefore, things that have been seen or touched will be easier for them to remember at a later date. Thus, the theoretical framework behind the impressions will be more easily recollected if it has been presented in connection with workshop training in testing or treating real test objects.

With such an approach, the development of a program on applied mechanics to cultural heritage cannot be done without the appropriate structure that guarantees both vertical and transversal coordination. Furthermore it can be useful to suggest programs that can be taken simultaneously by the student, providing a deeper understanding of materials’ behavior and the structure of cultural heritage objects. From this perspective, the course is addressed to meet specific cognitive, procedural and attitudinal objectives as seen in table 1.
Table 1. Cognitive, procedural and attitudinal objectives

<table>
<thead>
<tr>
<th>COGNITIVE OBJECTIVES (KNOWLEDGE)</th>
<th>PROCEDURAL OBJECTIVES (SKILLS)</th>
<th>ATTITUdINAL OBJECTIVES (COMPETENCES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- To study the materials present in cultural heritage objects, analyze the physical-mechanical properties and the modifying effect of aging processes.</td>
<td>- To understand the technical characteristics of the constituent materials of cultural objects and their degradation.</td>
<td>- To promote:</td>
</tr>
<tr>
<td>- To evaluate the effects of temperature and relative humidity on material properties and quantify the stress and dimensional response that materials develop when subjected to temperature and humidity fluctuations.</td>
<td>- To decide about the suitability of materials and methods to be used in the conservation-restoration treatment according to a detailed analysis of the technical characteristics, needs and priorities of the object.</td>
<td></td>
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<tr>
<td>- To identify degradation agents as well as failure mechanisms in cultural objects and analyze and quantify changes in the mechanical and dimensional properties of cultural objects as a result of both natural aging processes and the interaction with degradation agents.</td>
<td>- To go over the different phases of a conservation treatment and choose adhesives, solvents, surface coatings etc. that interest or do not interest depending on the purpose.</td>
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<tr>
<td>- To analyze the structural compatibility of the materials of the work of art with the materials commonly used in some conservation treatments and establish protocols for their selection.</td>
<td>- To learn how to argue technical, professional and critical criteria and methodologies based on a thorough understanding of the materials to be treated.</td>
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<tr>
<td>- To promote reflection to design appropriate structural conservation strategies.</td>
<td>- To reflect on preventive conservation based on the knowledge of mechanical and dimensional behavior in relation to the environment.</td>
<td></td>
</tr>
<tr>
<td>- To reflect on preventive conservation based on the knowledge of mechanical and dimensional behavior in relation to the environment.</td>
<td>- To use the knowledge of the mechanical and dimensional behavior in relation to the environment.</td>
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</tr>
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</table>

Contents

This 30-hour pilot program was created to provide a basic understanding of structural and mechanical properties of cultural materials and to explain how (and to what magnitude) these properties change not only with time but also as a function of environmental fluctuations. This enables improved risk assessment when deciding on climate and conservation methods for simple materials and composites. An overview of the relevant research will be provided to the students and the effects of conservation evaluated. According to this, the contents are divided into the following units as seen in table 2.
As explained before, the course focuses mainly on providing students with explanations as to what might have happened and will happen to the objects they look at. Thus, problem solving and decision making are relevant skills and will be put into practice through the case studies selected for the course. To do this, students are also required to have some conservation-restoration skills in order to understand the constituent materials of cultural objects (both from the manufacture and artistic perspectives) and the structure of the object. It is necessary that students are able to identify factors and situations that induce damage in cultural objects and acquire basic knowledge of conservation-restoration treatments that can be applied to art objects is equally needed. As can be seen, this pilot program is addressed to gain an insight into new contents by working in a dynamic environment where students are the central element of the learning process. To achieve this, different teaching strategies can be combined depending on the expected outcomes as seen in table 3.

Teaching methodologies: strategies and didactics

Table 2. Units and contents

<table>
<thead>
<tr>
<th>UNIT</th>
<th>TOPIC</th>
<th>CONTENTS</th>
</tr>
</thead>
</table>
| UNIT 1 | Overview on applied mechanics to conservation | - History of structural conservation  
- Methods of structural conservation |
| UNIT 2 | Environmental factors affecting organic material present in cultural heritage (relative humidity, temperature and light) | - Definition of relative humidity  
- Hygroscopic behaviour and moisture in cultural materials  
- The psychrometric chart |
| UNIT 3 | Basic mechanics | - The stress-strain curve and the definition of the mechanical properties |
| UNIT 4 | Mechanical and dimensional properties of cultural materials | - Mechanical properties of cultural materials: one by one (i.e.: wood, linen, rabbit glue, starch, gelatin, oil, silkw, acrylic paints, etc.)  
- Dimensional properties of cultural materials: The response of the materials to change in T and RH (i.e.: wood, linen, rabbit glue, starch, gelatin, oil, silkw, acrylic paints, etc.) |
| UNIT 5 | Structural properties of cultural objects | - The relationship between the mechanical properties and dimensional response of materials  
- The consequences if materials with different mechanical and dimensional properties are combined. What are the implications of changes in RH and T?  
- Other failure mechanisms: Causes for degradation for beyond RH and T. Light, microorganisms, pollutants, force, etc. |
| UNIT 6 | Changing structure and mechanics of objects through conservation | - The addition of materials for reinforcement  
- The structural role of adhesives and the effects of solvents  
- The selection of filling materials |
From all the different strategies presented above, three of them have proved to be especially fruitful in the context of applied mechanics to understand failure mechanism in cultural heritage: Problem Based Learning (PBL), Studio Cases and Simulation.

Despite similarities, PBL and studio cases types respond to different learning processes and deserve a more in depth exploration to understand how they can be implemented in such a specific context. The two foster collaborative learning, promote constructivist learning and are self-directed. Nevertheless, the purpose to which each of them points is what makes them different from each other. By combining them - with their possibilities and limitations - it is possible that conservators-restorers approach materials science in a more ‘hands on’ and tangible way. The pilot program on applied mechanics presented here starts up with PBL activities where there is no need for students to have prior knowledge on such concepts. The main purpose is to know - which is a preliminary cognitive category - where what is going to be learnt is presented. In later case studies however, students are required to have a prior knowledge of the subject since they are expected to give their opinions on specific issues. Case studies have an applicative approach and require previous training to solve a problem, thus facilitating the generation of integrated concepts.

Problem based learning

Problem Based Learning is a teaching strategy that makes students face a problem or situation (usually defined by the teacher and sometimes defined by students) working in small groups, encouraging collaborative work across disciplines, identifying principles, underpinning knowledge and achieving learning objectives specifically related to reasoning and judgment, knowledge or mastery of a subject or area of knowledge, the
development of skills and competencies relating to the ability to work in teams, search and validation of information, communication skills etc.

18 PBL is aimed at solving problems that are selected or designed to achieve specific learning objectives making students be constantly involved in the acquisition of knowledge. In such a situation, the teacher becomes a facilitator and therefore, the learning focuses on the student and not the teacher or just the content. A typical sequence for the resolution of the problem or situation would be:

- Precise delimitation of the problem or task to be solved.
- Definition of different stakeholders and their interest in the object
- Find information and resources (search, access and validation information).
- Design of a coordinated work plan.
- Development of the plan.
- Sharing of results or conclusions.
- Development of a common document or report.

19 As previously explained, the teacher’s role in PBL is that of a mere tutor/facilitator that promotes the collaborative work and where the ultimate goal is not to solve the problem. The problem is the motivation for students to work in some given situations. As seen in the activity suggested in table 4, such a teaching methodology is intended to promote critical thinking, creativity, decision-making skills, self-directed learning, communication and public speaking skills. Furthermore, PBL promotes the ability to identify, find and analyze information necessary for particular issues as well as the ability to work collaboratively and with empathy. Through PBL the student gains the ability to identify his/her own strengths and weaknesses.

Table 4. Activity 1

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>A library of images representing different pathologies typically found in cultural objects has been collected. In small groups, students are required to describe what they see and deduce the technical characteristics of the artwork they are looking at.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPECTED OUTCOMES</td>
<td>PROCEDURAL It has been proved that PBL students are intrinsically motivated to study the subject matter being more capable of integrating basic science knowledge into the solution of case-studies problems by developing some self-directed learning skills than students usually do in a conventional curriculum. By doing this, knowledge retention seems to increase in PBL students. COGNITIVE At a cognitive level and in the context of novel paintings, it is expected that students can: A. identify the techniques (oil, acrylic, etc). B. identify the support (canvas, panel, wall, etc). C. identify a period (ancient, modern). D. describe the pathologies (cracks —location, extension, morphological aspects, crack patterns, etc.), degradation, blisters, efflorescence, bleaching, protrusions, erosion, etc.</td>
</tr>
</tbody>
</table>
| STAGES | ⇒ stage 1: distributing the groups of students  
⇒ stage 2: distribution of images  
⇒ stage 3: discussion in groups  
⇒ stage 4: oral discussion: each group explains to the rest of the students the information deduced from their picture. |
| DURATION | 90 minutes |
| ASSESSMENT | Traditional assessment methods are usually almost exclusively content-oriented and cannot be the sole to evaluate students who have undergone PBL curricula. As stated in similar PBL experiences in related fields, students are expected to “understand concepts, formulas, and skills which constitute the knowledge base of a discipline or profession. But we also want them to recognize the kinds of problems faced by specific disciplines and professions, and the means by which practitioners go about solving them”7. For this purpose the assessment of PBL activities can be carried out at different levels:  
- the feedback students receive from their peers (up to 25% of the final grade). That considers aspects such as attendance, degree of preparation and involvement, listening and communication skills, ability to bring new and relevant information to the group, etc.  
- students' evaluation of their own performance (up to 25% of the final grade)  
- professor’s evaluation (up to 50% of the final grade) |

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Table 5 presents an activity to promote learning through case studies. Case studies could be fictional or based on a real problem. As a teaching strategy, the objectives of facing case studies include:

- Analysis of cases where the solutions taken are analyzed by experts.
- The application of principles, where students are trained in the selection and application of standards and legislation for each case, and
- Training in solving situations, not giving the correct answer beforehand but being open to different solutions and consideration of uniqueness and complexity of each case and context.

Case studies also facilitate and reinforce:

- Understanding the divergent problems and adopting solutions through reflection and consensus.
- Retention of the acquired information and knowledge to discuss and practice on the concepts used
- Meaningful learning, as the student uses prior knowledge to the problem analysis and the proposed facilitating the generation of the concepts used solutions.
- The development of various learning styles; group learning and teamwork.
- Troubleshooting generates knowledge and promotes creativity.
- Retention of information through discussion and practice
- The development of communication skills: ability to explain, question and answer, using the specialized vocabulary, socialize, meet and understand others. The interaction with other students is a good preparation for the human aspects of management.

Table 5. Activity 2

| DESCRIPTION | After some theoretical lessons dealing with theory content of the program, the same library of images representing different pathologies typically found in art objects is again distributed among students. In this case and again in small groups, students are required to explain what happened to the artwork.
| EXPECTED OUTCOMES | Even if the achievements with each group of students can vary significantly and depending on multiple factors, it is expected that students are able to carry out research and reflective discussion that will lead them to reach professional reasoning but in a simulated and ‘safe’ environment. By doing this a higher order thinking is encouraged that allows students to develop realistic solutions to complex problems. More specifically and in the context of good pairings, experience shows that students are able to: A. Identify degradation agents (ID, temperature, light, vandalism, etc.). B. Identify what failure mechanism caused damage C. Explain how damage took place and why such pathologies can be observed.
| STAGES | ⇒ stage 1: distributing the groups of students ⇒ stage 2: distribution of images ⇒ stage 3: discussion in groups ⇒ stage 4: oral presentation, each group explains to the rest of the students what they have.
| DURATION | 90 minutes
| ASSESSMENT | Case studies allow the assessment of students’ understanding of a given matter. Equally significant is the evaluation of the acquisition of specific cognitive skills such as the ability of interpreting evidences, identifying problems (and their causes), building up hypotheses and approaching—in the case of the context use we are dealing with—an eventual conservation strategy. Again, for this purpose the evaluation can be carried out at different levels: A. the feedback students receive from their peers (up to 10% of the final grade). That considers aspects such as attendance, degree of preparation and involvement, listening and communication skills, ability to bring new and relevant information to the group, etc. B. students’ evaluation of their own performance (up to 10% of the final grade) C. professor’s evaluation (up to 80% of the final grade)

In this case, the percentages are slightly different and basically deal with the need of assessing not only the group dynamics but more elaborated issues such as the process of analysis and the quality of research, the solutions presented and the way they are argued, etc.
Simulation

A simulation activity is shown in table 6. Simulation is a term used for a number of different learning scenarios. In this context, simulation is defined as a teaching strategy that allows students to check the effect of certain stimuli to test objects in order to comprehend the consequences of certain possible events like bending, tensioning, joining, separating, modifying objects etc. or changing the ambient climate. Since real cultural heritage objects can rarely be tested for mechanical and structural properties, simulation is often used in research as a first approach to understanding the consequences of different scenarios. As a teaching strategy, simulation is ideal to promote students’ inclination to perform research or study research done by scholars. Simulation requires the ability to simplify scenarios and point out parameters that can influence the results achieved. Furthermore, it requires the ability to plan and carry out a protocol for the simulation, thinking through all the possible outcomes—desired and undesired. In order to do simulation, it is necessary to be able to hypothesize regarding expected outcomes which again stimulates the student to study other scholars’ research projects.

The methodology of simulation is therefore the same as for a scientific experiment and can be summarized as follows:

- To define the question that should be answered through the simulation. This will be done by the professor.
- To study the approach to this question taken by other scholars (depending on the amount of time available)
- To make a hypothesis regarding the answer to the question
- To define the parameters that can influence the outcome of the simulation
- To define variables and numbers of variations
- To define the number of repetitions
- To choose suitable mock-up materials
- To choose suitable measuring methods
- To set up simulation protocol including time frame
- To set up simulation and do precise and repeatable measurements
- To disseminate the results and compare to the results of other scholars

Table 6. Activity 3

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>Simple materials tests with the purpose of expanding students understanding of materials and more advanced tests for more advanced studies. This could be bending, stretching, swelling, compressing, separating or dropping a number of different objects with different properties.</th>
</tr>
</thead>
</table>
| EXPECTED OUTCOMES | (In the context of excel paintings, it is expected that students can:
  A. identify the parameters that affect the outcome of the simulation/test
  B. perform the test
  C. present and explain the outcome of the test) |
| STAGES | ⇒ stages 1: distributing the groups of students
  ⇒ stage 2: distribute different simple material’s tests
  ⇒ stage 3: the groups perform the test and discuss/gain the dissemination of the results
  ⇒ stage 4: oral presentation; each group explains to the rest of the students what they have done and the results are discussed. |
| DURATION | 90 minutes |
| ASSESSMENT | As explained above, simulation is a teaching strategy but it can also be used as an evaluation or competence assessment tool to check:
  A. Students’ active involvement
  B. The value of the simulation compared to real life situations
  C. The value of the results obtained |

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Evidences of the outcome

The implementation of such dynamic methodologies can usually be assessed by a combination of tutorial activities, ongoing evaluation and a final exam and has proved to produce significant results in the students’ learning process.

Tutorial activities/ monitoring the learning process

In this pilot program teacher mentoring (both individual and in groups) becomes a learning orientation to guide students. Here is again the idea of the teacher (as faculty mentor) who will be a companion in the process of teaching and learning, a facilitator, the one to encourage and propose autonomous learning. Individual mentoring consists of structured interviews in different planned sessions with a well-defined script and structure. Group mentoring consists of group interview techniques and small group dynamics. Both complement each other and are intended to monitor autonomous learning, gather information to identify special needs, design custom actions, promote good atmosphere in the classroom, etc.

Ongoing evaluation

In this pilot program -and according to current standards-, evaluation is not understood as the result of a process (based on a final exam) but as the evidence of students’ acquisition of competences, skills and abilities initially planned in the program. Such assessment should be considered an integral part of the teaching-learning process, not just at the end of the process but as a tool at the beginning and during the learning process. From an integrative approach, this helps detect where exactly each student is in relation to the group. By doing this, and with the intention of promoting the integration and involvement of all students, the objectives of the program can be redefined according to the evidences collected during the whole process and it is possible to create and promote the conditions and tools necessary to meet the specific needs of each student.

Exam

An exam in materials science can have different forms. Here three different scenarios are suggested, which can be combined or stand alone. Oral exams have in our experience worked well, but they can be combined with a written exam too:

- **Oral exam.** Two photos of damaged cultural heritage objects are chosen among four given possibilities. On the first photo the student is asked to describe the damage and identify what caused it. This includes a description of failure mechanisms and relating to a stress-strain curve, which they choose from the course material in the same way they have been doing in groups during the course. On the other photo the students can be asked to describe the behavior of the given material(s) and correlate it to chemical and structural issues.

- **Posters.** Two posters are produced and presented to teachers and fellow students during the course. Students are divided into small groups that will have some days to prepare and print a poster. 1st poster, which is produced midway in the course, is presenting a simple cultural heritage object from a materials science point of view. The students are asked to identify the
materials included in the object and describe the structure and the expected mechanical behavior as well as adhesion/cohesion. The second poster at the end of the program is dealing with the same or a similar object but concentrating on damage and conservation scenarios – why has the damage occurred and what could be a proposal for the conservation treatment.

• **Written exam** with specific questions on materials and simple calculation tasks.

**Conclusions**

Materials science has long been poorly prioritized in many conservation - restoration programs even though it provides solid background knowledge needed to meet the demands that the students face in their future career. The pilot program presented here includes scenarios that are close to the specific work situations of conservator-restorers because it focuses on solid knowledge on materials behavior and seeks to enable students to understand, deduct and communicate this knowledge for the benefit of cultural heritage objects.

The competences that conservators-restorers need have changed significantly over the last decades and, apart from knowledge and hands-on skills, competences like communication, deduction, risk analysis and decision making are equally required. Apart from the contents indicated above, the aims of the proposed pilot program are to contribute to the development of such competences and match the recommendations formulated in reference documents such as the ones formulated in the last years by ENCoRE and E.C.C.O.. Programs like this can therefore be recommended for any conservation training program since they embrace the multidisciplinary and communicative nature of the conservation profession and stress the importance of the materials science approach to decision making within the conservation-restoration field. Apart from attending theory lessons of hard science, students are trained to search for solutions and foresee damage by testing, discussing, consulting and by correlating their experiences to dilemmas found in actual studio cases. Previous experience has shown that this approach is very fruitful in the students’ learning process. Students that have taken part in such a program evidence significant differences in their capability to discuss, argue and build up explanations to specific damage found in artworks, showing a solid knowledge on science but also demonstrating a higher ability to identify and explain complex failure mechanisms.

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NOTES


ABSTRACTS

Mechanical properties and the structure of materials are key elements in understanding how structural interventions in conservation treatments affect cultural heritage objects. In this context, engineering mechanics can help determine the strength and stability found in art objects as it can provide both explanation and prediction of failure in materials. It has therefore shown to be an effective method for developing useful solutions to conservation problems. Since materials science and mechanics can help conservators predict the long term consequences of their treatments and provide them with tools to avoid future problems, it should be present in all conservation-restoration training programs to help promote students’ understanding of the degradation mechanisms in cultural materials (and their correlation with chemical and biological degradation) as well as the implications behind conservation treatments.

Les propriétés mécaniques et la structure des matériaux sont des éléments clés pour comprendre comment les traitements structurels en conservation restauration affectent les objets du patrimoine culturel. Dans ce contexte, l’ingénierie mécanique peut aider à déterminer la résistance et la stabilité pour les objets d’art puisqu’elle peut fournir à la fois des explications et des prédictions d’échec des matériaux. L’ingénierie est donc efficace pour développer des solutions utiles aux problèmes de conservation. Puisque la science des matériaux et de la mécanique peut aider les restaurateurs à prédire les conséquences à long terme de leurs traitements et leur fournir les outils pour éviter des problèmes à l’avenir, elle doit être présente dans tous les programmes de formations en conservation-restauration afin de promouvoir la compréhension des mécanismes de dégradation de matériaux culturels (et leur corrélation avec la dégradation chimique et biologique) ainsi que des incidences de traitements de conservation.
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Mots-clés: enseignement, conservation, science des matériaux, conservation structurelle, didactique, héritage culturel

Keywords: teaching, conservation, materials, science, structural conservation, didactics, cultural heritage

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