Scientific method in the transformation from students to professionals

What Does Science Offer Conservation?

Rarely in conservation do we deal with certainty. It is often uncertain what the best conservation approach is, although it is often a lot easier to be certain what is not a good approach. Science can provide information to conservators about the materials being considered and it offers an understanding of processes especially when variables are limited, but it does not resolve the certainty problem. So what does science offer? Is the biggest contribution that science has to offer conservation scientific method? As this paper is about teaching students, the definition used for the purposes of this paper has been sourced on 'wikipedia'.

> Scientific method: 'systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formulation and testing of hypotheses'
> (Wikipedia 2009)

The original source of this quote preceded the statement by noting that method involved the identification and formulation of a problem. This definition has been adapted to illustrate method in conservation (table 1). The paper will examine this process and how it is taught and learned.

How Do Conservators Make Decisions?

I was recently involved in a debate about whether interpretation or care of objects was the primary action in conservation. This discussion made me think about the way conservation decisions are made. After years in conservation I look at an object and several treatment options come straight to mind. I am not necessarily clear how I know this. Experienced conservators have tried and tested their methods in a range of different contexts, drawing empirical conclusions and making decisions so that over time they become impervious to the process by which they made those decisions. With experience scientific method can become instinctive for many conservators. Is this the definition of expertise? Certainly, this seems to fit with the language of the 'Novice to Expert' scale that ICON has adopted for their accreditation process (table 2). This process spells out the graduations of a developing profession. If an expert conservator 'moves between intuitive and analytical approaches with ease' (ICON 2008), it may be the case that they use a scientific method unconsciously.

If some conservators have honed their abilities to the point where they are no longer explicitly aware of the relationship between intuition and analytical thinking, it is no wonder that when viewed from the outside conservation can appear ritualistic. My experience as a teacher of conservation is that, students attempting to learn conservation hope to replicate this apparently easy insight. However, the desire to jump over the knowledge and skill acquisition stages can only lead to technician level outcomes.

What Decisions Do Conservators Need To Make?

I recently heard a paper at a conservation conference about moving a large mural from a very deprived and drug afflicted area, at the costs of hundreds of thousands of dollars to a much 'nicer' area where it would be at less threat from people around it.

The first question from the audience was ‘what kind of PVA did you use? The question shocked me and has concerned me ever since.

Science can be over simplified in conservation as relating only to the materials that we use and their interactions. Without doubt these relationships are critical; much damage has been done by people claiming to be conservators and failing to understand the relationship of materials added to the objects that they are supposedly caring for. It can be useful to consider the relationship between PVA and a paint layer but conservation is about more. Conservators should ask:

- What was the problem?
- What data do we need to collect?
- What alternatives are there?

The answers to these questions should not just be about facing materials, but about the drug dealers in the park where the mural currently stands, the money available to resolve the problem and the goals and values that informed a decision to save the art by removing it from the people. Conservators need to make decisions in the context of social values. To do this we need data.

Conservation In Context

One criticism that can be made of a discussion of conservation decision making in a wider context may be the lack of scientific method involved and, following from that, the poor quality of data under consideration. There are techniques that can be adopted to attempt to consider a wider context in a formal way, for example stakeholder analysis is useful for considering the need of others (Leadership Champions 2008). However, even this process is challenging. Consider the concept of consulting with stakeholders about the future of an historic site. Who do we define as stakeholders and whose needs are we preoccupied with? My experience in the heritage sector is that we like to consult with spokespeople from faith or ethnic groups, owners, experts, indigenous groups, educated visitors and possibly even well behaved school children. However, I wonder if we selectively eliminate the data we do not want to hear, in this case the undesirable stakeholders, gun firers, vandals, skateboarders, Arthurians, self-styled druids and so on.

To operate a scientific method in conservation that extends beyond the analysis and the selection of materials, it is necessary to consider how to formally collect and work with data such as stakeholders in a rigorous manner. Well established conservators may easily integrate a range of social and environmental factors into their decision making because they have become imbued with the values of their institution (McKenna, 2006). They will be aware of possible future uses of an item, the conditions on display or in storage and the resources for long term care. As before, expertise may make a complex evaluation appear intuitive. This process is also described as ‘unconscious intelligence’ which Gigerenzer defines as judgements which appear quickly in consciousness, that a person is not fully aware of the underlying reasons for but provides sufficient confidence to act (2007:16). However, when operating unconsciously our reasoning is prone to bias (Kahneman *et al* 1982) consequently conservators should question how consistent their methodology is. When faced with conflicting demands from drug dealers who find the mural a convenient point to hide behind, vandals determined to spray paint a marble frieze or a newly formed religious group laying claim to an historic site, do conservators follow any method before they rule out their stake in the artefact? Conservators have not yet developed sufficient mechanisms to collect valid data on the wider context in which they make decisions.

Process Control

Evidently there are dangers in the intuitive approach to conservation. Seamless expertise that goes un-reflected upon can become ritual, as Waller and Michalski describe in their ‘paradigm shift’ paper (2005). The paper argues that the way that conservators carry out tasks could sometimes be described as process control. If a conservator is not able to respond to good quality feedback and make adjustments in response to that, their practice is a little more than ritual. This brings into focus two critical issues for decision making in conservation: the quality of data (feedback) and our ability to attend to it and to take it on board (respond).

Problems of Data

The quality of the data that conservators use to make decisions is critical. Is it enough to argue:

> ‘I have been using Paraloid B72 for the consolidation of poorly fired archaeological ceramics (and the assembly of fragments) for more than 30 years and have not found any problems with items treated this way decades ago’ (Conservation distlist May 09)?

Whilst Paraloid B72 as a consolidant is not necessarily a wrong treatment, if the observations of 30 years is the only data being considered, a significant amount of damage could be done before conservators find out things are not as good as they first appeared. There is much more data on the properties of Paraloid B72 (De Witte 1978, Koob 1986) but how many conservators are researching the literature and how many are relying on the observations of 30 years? Other papers discuss the issues of weaknesses in the literature in more detail (Lambert 2009) but other concerns about the quality of data are discussed here.

Consistency of description

Conservation has many inconsistencies, one of which is in describing the problems we face. Consider the issue of pollution, it is easy to see the damage caused by pollutants, but how do we quantify this for comparison? The problem is obvious but the units of measurement needed to describe and compare the problem are less so. For pollutants we may measure mass, perceivable levels, known safety, known damage, best available technology or limits of detection (Martin 2000, Grzywacz and Tennent 1994, Thomson, 1986). This problem occurs across a multitude of areas and is not easily resolved by standards which often serve to simply add to the range of variables to consider.

Ignoring the data

Too often conservation actions appear to ignore available data. An example is environmental recommendations, especially recommended temperatures. It is not uncommon to see a recommendation of 18ºC (MGC 1992). This figure is based on a fairly outdated understanding of human comfort levels and UK government targets for energy consumption. Most materials are chemically more stable at lower temperatures (Michalski 2000): most people are more comfortable above 18ºC. There is evidence for suitable temperatures for collections but this appears to be ignored as the more familiar but largely irrelevant 18 ºC materialises again and again in recommendations.

Data with limitations

A student recently asked me '*why do we study the Erhardt and Mecklenburg paper on RH fluctuations? Someone told me it was rubbish*.' The critique of the paper offered by the student was that the experiments on the wood were too far from real life problems. Whilst it is true that museums rarely collect small blocks of wood and try to preserve them in fluctuating RH, the experience of those small blocks does tell us something about how wood responds to humidity. The conclusions that conservators draw from the blocks is a matter of what other data they collect. Of greater concern, than the limitations of a well conducted scientific trial, is the question of what other data conservators are collecting that would inform a decision on acceptable humidity fluctuations. The data we need would include information on climate, resources, sustainability, user needs and so on. If these issues should be factors in the decision making process, how do we collect this data?

Responding to Data

Where conservators do access scientific data, how well do they respond to it? There is a very human tendency to selectively ignore data or feedback (Tavris and Aronson 2007). The problem is that at a first level we tend to make a hypothesis and then only seek data that confirms it: very few of us try to disprove our own theories. This means it is easy to find evidence that confirms our perhaps wrong theory but never seek out data that may challenge it (Tavris and Aronson 2007). Additionally, we are also selective in attending to messages that do not conform to what we already believe. In other words we will actively ignore things that conflict with our existing beliefs (Reardon 1991: 46). Finally, evidence shows us that even when we are offered poor quality evidence we are likely to follow it if it conforms with our existing patterns of decision making and that we will conclude that our behaviour, however wrong, is correct (Tavris and Aronson 2007). This is something of a triple whammy. It seems that it is human to collect poor data and selectively ignore any data that conflicts with what we believe. This creates a pattern of behaviour with little or no good quality feedback. Expertise without reflection turns a professional conservator back into a technician.

Having considered the problems in operating a scientific method in conservation, it is necessary to discuss how to pass on the best of our understanding to students. Although they can only become fully formed professionals in the workplace, the foundations are delivered in education (Dardes 2009). How unconscious intelligence can be dissected and discussed with students is a challenge for all those teaching conservation. Another challenge is to require a scientific approach and the selection and use of valid data in a profession where that process is not consistently delivered. Finally although feedback is a natural process of education students need to develop their own reflective skills so that they participate in critical evaluation and develop this as a skill rather than act as passive recipients of grades. My thoughts on how to teach conservation have been stimulated by the recent development of a new two year MSc programme in Conservation Practice at Cardiff University.

Learning Conservation: First The Basics

Before students can begin to develop and apply knowledge, there are some underpinning facts and skills that anyone operating in a conservation environment needs to acquire: looking down a microscope; how to operate an x-ray machine; how to manipulate a scalpel; how to follow a risk assessment and so on. In Cardiff University's three year undergraduate degrees most of this information is taught in the first year. In the two year MSc programme in Conservation practice and this learning will be condensed it into one module. Once this induction period is over the next task is to escalate the level of skills in line with the levels described in the novice to expert scale.

Advancing Knowledge
It is not only skills that need to be developed in students to transform them into conservators. Would-be conservators develop from an entry level of having knowledge and an ability to marshal facts up through an intermediate stage of comprehension where basic knowledge is applied in a limited context.

In the context of conservation, this will mean the students develop from entry level tasks such as cleaning surfaces with a range of solvents or operating several different mechanical cleaning processes on one item, to the intermediate phase of carrying out a process which involves slightly more complex tasks where the application of knowledge is tested. For example, cleaning archaeological waterlogged leather where there is both mechanical and chemical cleaning and the requirement to learn about collagen, hydrogen bonding and materials for the preservation of the leather so that they can select an appropriate approach. Reaching this stage of learning about conservation is comparatively simple. The students may find integrating the theory and the practical elements difficult but, with support, they can usually manage it.

When the learning process progresses to higher levels such as analysis, synthesis and evaluation, the students are more challenged: but what better topic than conservation to present these challenges? Considering a purely academic description of evaluation, this requires: intellectual problem solving, making personal judgements based on available data, and systematically evaluating alternatives to select a solution from those competing alternatives. This description, using purely educational terms clearly applies to conservation processes.

The curricula for the first year of the MSc in Conservation Practice will contain elements which are primarily about skills and some which are primarily about comprehension and application. A substantial section of the course element will be devoted to practical projects where students work on objects that brings both of those sides together. In teaching conservation in Cardiff, one of the critical tools used to encourage the students to formally gather data on their evolving understanding and developing scientific method is their project note books.

The Project Note Book as a Tool
Staff at Cardiff University encourage students to actively reflect on their own experience and learning in a reflective log known as a project note book. Staff try not to be over prescriptive on format of this log which initially presents students with some difficulties, however as the students begin to evolve a formal explanation of their own conservation approach, these notebooks provide an opportunity for the students to record as they learn, allowing reflection which maximises their learning experience (table 3).

Stages in scientific method	Quotes from students in the PNB

Identify problem and collect data	The more I look at the wings the more I see what's wrong with them and the more problems I find to consider
Observation and experimentation	This should take a day or two , maybe longer. I am not sure as I have never done anything like this before, …. So I will probably mess it up and have to do it over'
Formulate hypothesis	.. it became obvious that all the cleaning and stabilization techniques have disadvantages …After deep thought (that took so much time) I decide to trat the object mechanically.
Test hypothesis	The fragments look amazing I am super

Table 3 Examples in students own words of scientific method in practice

Do the students enjoy us encouraging them to develop individual personal solutions? Some students find it hard, to quote from a recent student evaluation form 'I feel like I am teaching myself'. Compared to some learning environments where students are supplied with data and required only to organise and present it, this approach presents a challenge. There are advantages and disadvantages of this method of teaching. The positive qualities are that self-directed learning: encourages independent thought and research; offers no technician way forward; provides room for individuality and in time develops self belief. However students can feel abandoned and have a crisis in confidence. Experience in Cardiff is that the crisis of confidence is a delayed reaction. Initially students are happily ignorant, it is only as their learning develops and they discover the 'known un-knowns'(Rumsfeld 2002) that they realise how big and complex a task conservation is. At that point students realise that nothing is simple and that every phase needs more research. It can seem as the conservation treatment will never be completed and as the magnitude of the task develops some students loose confidence that they will ever complete the task.

Classroom Discussions

In addition to recording their thinking in the PNB students meet with staff to discuss their progress on a particular project. Depending on the student, the project and the staff member, this discussion can fall somewhere between a chat about what level to clean a copper alloy coin to a full grilling about the entire conservation strategy involved. This is not always any student's favourite experience but it does challenge their hypothesis, and whether they are gathering and responding to valid data. Without external stimulus, it is too easy to create over confident assessments of our own certainty.

Conservation in Context

Students at university are automatically isolated from owners and context. At Cardiff University, students are provided with contact information of owners and a requirement to formally consider their needs. Yet in the past students have committed or proposed to commit all of the following apparently silly mistakes:

- Making boxes so big they will never fit on a shelf,

- Treating a research collection with toxic materials
- Providing environmental specifications impossible for the building
- Writing instructions to owners they could never understand let alone follow
- Making packaging so complex it requires a full page of instructions.

All of these examples arose from students who are otherwise intelligent and successful. My belief is that the problem illustrates less a weakness of students and more a challenge for the profession. Seeing students operate out of context makes it clear that the scientific method of conservation in context is significantly under developed compared to materials science itself. As a result the new MSc in conservation will offer a module that is purely about method. The Module 'Method in Conservation' will aim to focus in on how scientific method should underpin every aspect of conservation practice. This will encompass understanding the decay of materials, the analysis of artefacts to inform treatment, devising options for treatment and specifying the future care of conserved materials.

Conclusion

Conservation requires that we understand materials and decay mechanisms and that we research and test treatment options. But we must go further; conservation is more than simply the preservation of materials. Conservation lies in the preservation of significance or value. Choices need to be made that start from defining those values. There are tools to help collect this data, for example developing statements of significance (Clark, 1999, 2001, Walker and Marquis-Kyle 2004) but as a profession we are weak in understanding and applying scientific method to conservation decisions. Yet it is precisely this approach that will help develop the next generation of conservators and will sustain refresh and maintain the current generation of professionals.

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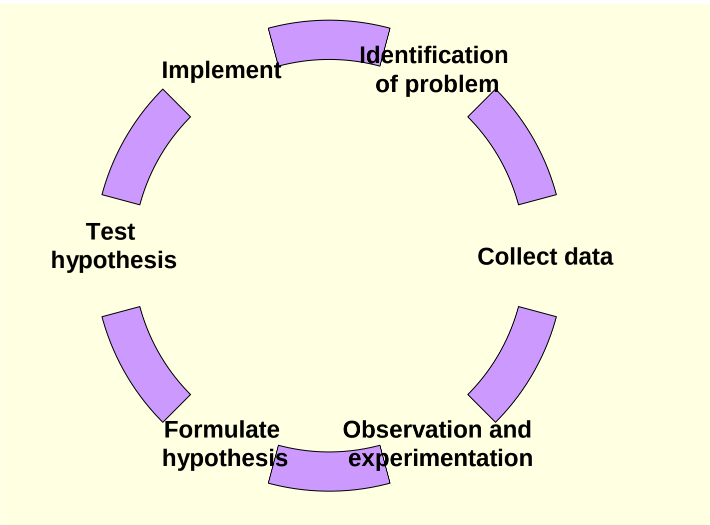

Figure 1 Visual representation of scientific method in conservation

	Knowledge	**Standard of work**	**Autonomy**	**Coping with complexity**	**Perception of context**
1. Novice	Minimal, or 'textbook' knowledge without connecting it to practice	Unlikely to be satisfactory unless closely supervised	Needs close supervision or instruction	Little or no conception of dealing with complexity	Tends to see actions in isolation
2. Beginner	Working knowledge of key aspects of practice	Straightforward tasks likely to be completed to an acceptable standard	Able to achieve some steps using own judgement, but supervision needed for overall task	Appreciates complex situations but only able to achieve partial resolution	Sees actions as a series of steps
3. Competent	Good working and background knowledge of area of practice	Fit for purpose, though may lack refinement	Able to achieve most tasks using own judgement	Copes with complex situations through deliberate analysis and planning	Sees actions at least partly in terms of longer-term goals
4. Proficient	Depth of understanding of discipline and area of practice	Fully acceptable standard achieved routinely	Able to take full responsibility for own work (and that of others where applicable)	Deals with complex situations holistically, decision-making more confident	Sees overall 'picture' and how individual actions fit within it
5. Expert	Authoritative knowledge of discipline and **deep tacit understanding across area of practice**	**Excellence achieved with relative ease**	Able to take responsibility for going beyond existing standards and creating own interpretations	Holistic grasp of complex situations, **moves between intuitive and analytical approaches with ease**	Sees overall 'picture' and alternative approaches; vision of what may be possible

Figure 2 ICON's novice to expert scale ICON 2008