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INTERVIEWS

Professor Łukasz Bratasz* talks to Ewa Manikowska**

Heritage Science – The Benefits of an Interdisciplinary Approach in Protecting Cultural Heritage

Ewa Manikowska (EM): With your distinguished curriculum in physics, for several years now you have been conducting research projects in the much broader and quite recent field of heritage science. Could you briefly explain to our readers what heritage science means?

Łukasz Bratasz: Heritage science is a relatively new discipline which tries to answer the questions posed by the humanities using tools and methods offered by natural sciences, engineering,

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or life sciences. It is important to ask the question: why is heritage science a new discipline? Indeed, there was always care for heritage, but we did not have heritage sciences.

This is quite similar to other new disciplines. For example, 70 years ago there was care for the environment but there were no environmental sciences, while nowadays we have environmental science departments at each university. Another and a more recent example is geriatrics. There has always been care for elderly people, but now we also have a discipline which focuses on the aging of people, the burdens of aging, and remediation strategies. Heritage science is no different: there was always care for collections, monuments, and heritage objects but now there is growing need for the development of, or answering to the questions about heritage using the tools offered by the sciences, engineering, and life sciences. So why do we have this new field? I think it is because society has realized that heritage is an important sector of the economy, particularly tourism industry. And if you have a sector you also have resources, services, and institutions. Traditionally, in this sector there were always services like conservation and disciplines like archaeology, art history, and art conservation. Each sector important for the economy needs its sciences as well, simply because cultural heritage resources are limited and not recoverable.

EM: Could you give us more insights into heritage science methodologies, research questions, and tasks?

I'll start with a broad overview. I would divide heritage science into two streams. One is the development of new knowledge and new information that did not exist before. For example, we can imagine that we have a DNA code in some archaeological remains and we generate completely new knowledge by investigating this code and relating it to the geographical area or time of origin of these remains. Similarly, in the history of art based on the analysis of the isotopes of pigments we can understand better when and where a given painting or artifact was created. Again, we will produce information that did not exist before. The second main path of heritage science relates to the preservation of the information or more broadly – preservation of values (aesthetic, historic, scientific, economic etc.) related to natural and cultural heritage. I am working mainly in this second area.

EM: Could you give us some examples based on your research projects and experience?

Many of my projects are related to the analysis of deterioration mechanisms, for example development of mechanical damage in artworks induced by an unstable environment, like cracking of the paint layer of wooden sculptures, delamination of

the paint layers in panel paintings etc. Most recently I have received funding from Norway Grant operated by Polish National Science Centre, implemented in collaboration with the Norwegian University of Science and Technology in Trondheim and the Academy of Fine Arts in Kraków focusing on elucidation of mechanism of the craquelure pattern – the network of cracks – formation in paintings. When you listen to an art historian or a conservator speaking about paintings you hear about colour, shape, composition but never about craquelures which always are there because there is no adequate language to describe it. The project aims at understanding the craquelure formation and impact on object vulnerability to environmental variations. For many years such research was just a matter of academic curiosity important for few specialists, however recently this topic is gaining in importance because there is a push to preserve heritage without harming the environment or minimizing environmental impact. This new trend is called sustainable conservation and defined as measures to minimize loss of heritage value at given financial, social, or environmental costs. I have spent four years at Yale University as head of the Sustainable Conservation Lab and I have noticed how difficult it is to explain to young generations, students why museums preserve values related to heritage, but doing that frequently we do not care about other values like equity or values represented by the environment. Finding the right balance between the preservation of cultural heritage at given environmental costs is one of our greatest challenges and it is not an easy task. Sustainability is not about preserving one's way of life or about producing a "green" building or even about ensuring that a historic site survives into the next century. Sustainability is not about the conservation, preservation, restoration, or sustenance of artifacts or practices, even insofar as many of those actions are of critical importance; rather it is about weighing the consequences of such actions on the most disenfranchised members of society and on the global environment at large. In order to preserve heritage from mechanical damage induced by a fluctuating environment, many memory institutions are using huge air conditioning systems. The energy used by such machines is tremendous. When I was working at the National Museum in Kraków the yearly cost of climate control was equivalent to the employment costs of all 65 conservators. The same proportion was at the Yale University Art Gallery, where I worked on the optimization of the energy costs. For us it was not only a question of how to preserve heritage while reducing the impact on the environment, but also how to use most effectively the limited financial resources for preservation. This leads to the new field of heritage science called risk management, which aims at understanding what are the most important processes and the main risks leading to the loss of value of a given collection/heritage site, and addressing such risks. If we are spending institutional resources addressing risks which are not on the priority list, we are

just losing money. Unfortunately, this is very frequently the case in many museums worldwide. The effective preservation policy must identify main risks and address them. Thus, risk assessment is the second area of my research.

EM: Could you give us an example of a big research question in heritage science you want to answer?

An important and still unresolved research question in heritage science is the soiling of architectural or painted surfaces caused by the deposition of particles. We still have no answer on a global scale on how to prevent these changes, which cause accelerated aging, and in consequence loss of value of heritage that gives rise to a need for complex and expensive conservation projects. A good example of the scientific debates of this kind is the controversy between American and Italian scientists following the conservation of frescoes in the Sistine Chapel. They argued over whether the heating of the surface of the Last Judgement would help to preserve it. While the American researchers postulated the heating of the fresco by 1-2 degrees which would limit the process of particle deposition due to attraction of particles to cold surfaces, the Italian ones argued that heating would increase convection of air along the wall causing accelerated deposition due to turbulences in the air. Thus, given that there was no clear answer how to preserve the frescos, it was decided not to take any action.

EM: Is heritage science already an established research field?

In some countries the field is well established. There are already university heritage science departments, conferences, and journals of heritage science. Thus the field, with the exception of its literary canon, fills all the requirements of a new discipline.

EM: How does the recent redefinition and extension of the meaning of cultural heritage affect heritage science research?

I have no problem with this extension. Heritage value is preserved by different means. Heritage science is active in the field of intangible heritage, too. I can recall here the projects which aimed at reconstructing the ancient voices and singing in the Byzantine era in the Hagia Sophia, which among other things took into account the acoustics of this building. Another, albeit failed, heritage science project aimed at revealing, with the means of the atomic force microscope and advancement of IT technology, the modifications in the surfaces of Greek vases generated by the voices of the ancient artisans during their making, a process similar to production of early records. The same refers to the digital world: heritage science is well equipped to answer many fundamental questions related to this new field of heritage. However, heritage science is always a tool to support the decision-making

processes of heritage managers, art historians, and conservators. We can observe an analogous situation in medicine. It is the doctor who makes the final decision based on the work of the physicist, chemist, or biologist, who tries to understand the processes leading to certain types of disease and tries to develop ways to cure them. I never look at myself as a person who can decide and order what should be done; I can only assist in evidence-based decision-making.

EM: The impact of heritage science and its research questions should go well beyond science and engineering. They seem fundamental for the management of memory institutions and cultural heritage sites, and their implementation requires cross-field collaboration and understanding. Could you briefly comment – based on your year-long practical experience as head of two important labs (the National Museum in Kraków and at Yale University) – how heritage science challenges and changes the traditional ideas underlying the understanding, management, and conservation of cultural heritage?

Indeed, heritage science is one of the most multidisciplinary fields, and it requires the collaboration of people working in the field of art with physicists, chemists, and engineers. I can think of just one area more extreme: the application of physics and other sciences to poetry. Still, we should look more at the challenges and opportunities created by such collaboration. One of such areas is certainly education. In times when many humanists are unemployed, work without wages, or are underpaid, by incorporating heritage science into the traditional university curriculum of heritage managers or art historians we could reduce the gap between education and future remuneration. On the other hand, members of traditional scientific disciplines also have some limitations and imperfections in their communication with people who did not study physics, math, or biology. Thus, it would be fundamentally important to equip them with such skills.

EM: In the CollectionCare Horizon2020 research project, you are creating a Preventive Conservation decision support system for small and medium-size museums, based among other things on advanced computer and internet technologies. The outcome Noah's Ark, the Europa Nostra awarded research project in which you were involved, was an innovative telematic mechanism: The Flood Information Warning System. Could you tell us more about the impact of heritage science projects and tasks on the advancement of innovative technologies in heritage management and institutions?

Maybe I will disappoint you. Frequently heritage science does not use extremely innovative technologies. We are adopting the tools that exist and are used by other disciplines, very often just standard tools. What is innovative is not the

technology itself but the questions that we pose. Of course, there is a lot of innovation in this field because we are adopting the most recent developments. The CollectionCare and IPERION-HS projects, which I am currently implementing, focus on an approach in the management of cultural heritage based on the risk assessment method. It is not enough to establish a system of blank standards for the preservation of cultural heritage and rules based on preventive conservation measures, as it is impossible to implement them all. We are living in difficult times and we have to choose what to preserve, what method to apply, and which risk we need to address. The platform we are developing aims at supporting decision-making and at identifying the preservation priorities. For example, I have frequently encountered the situation of museums with very poor fire safety measures, focusing mainly on issues of secondary importance as stabilization of the environment, changing old boxes to a new one. This may lead, like in the case of the National Museum of Brazil, to the total and irreparable destruction of the collection. If you do not preserve your collection against fire at adequate level, which should be a priority for most collections, you should not spend money on anything else. In the ring of fire, dominant risk is related to earthquakes. Fortunately, the conflicts between the preservation of heritage and the preservation of the environment are not as dramatic and we can find a very good balance between them. A good example here involves the recent developments in the preservation of collections in passive storages, which while not consuming energy ensure a better environment for the collection than the solutions offered in traditional museums, where the temperature is adapted to the comfort of people and not to the needs of the artifacts. Interestingly, this is a solution based on historic examples of libraries stored in unheated buildings with large buffering capacities, which survived centuries in a relatively good state of preservation. Among the first projects I was involved in is Noah's Ark, which focused on understanding the impact of global climate change on outdoor heritage objects. One of the few critical findings of this project, particularly important to my home country (which is Poland), relates to the preservation of wooden heritage. We've predicted – and this is one of the huge risks brought about by climate change – the movement of termites from the South to the North, and of course our wooden historic buildings were never exposed to such a threat. Heritage managers should develop adequate policy to mitigate this risk. The climate model shows the we can expect increase of number and intensity of extreme climatic events. Another type of risk which is frequently underestimated is related to slow and gradual degradation processes affecting significant part of the collection. The risk assessment I carried out together with friends from Yale Peabody Museum of Natural History indicated that risk of slow chemical degradation of polymers has two orders of magnitude larger impact on collection value

than pest and four orders of magnitude larger impact than mechanical damage generated by unstable environment.

EM: What are the main challenges of heritage science?

That is a difficult question and I do not know if my answer will be universal for each country. From the point of view of my research group I would point to the problems – given that this field does not have such resources as nanotechnology, health, or biotechnology – with attracting and competing for young enthusiastic researchers who would like to invest their time and build a career in the heritage science field. Of course, it sometimes happens, because not everyone wants to be a super-physicist working on Black Holes, and not everyone wants to work and make money in Google. I think that funding agencies and policy makers need to create the same incentives as other fields have.

EM: Let's diversify the previous question: What are the main contemporary challenges that heritage science should approach?

I am not sure if I am in a position to answer what we should do, but I can tell you about the directions in which heritage science is going, and which areas are extremely innovative, important, and fascinating. I could only wish to have the appropriate skills to work in them. As I have already mentioned, heritage science may be divided into the preservation of values and the creation of new knowledge. In the latter field I see two extremely interesting areas. One is heritage computing, which is the application of the new technologies and tools offered by the IT sector to heritage. For example, you can look at the Google website (https://artsexperiments.withgoogle.com/tsnemap/) and learn how they use the mathematical algorithms to find similarities between the art objects. These algorithms are trained on huge database of pictures supplied by the people. Google applied them to search the collection of heritage objects' images, find similarities between them, and express them as physical distance on a 3D map. Sometimes similarities are obvious for art historians, but sometimes they are not. The most advanced institution in this field is the Rijksmuseum – my jaw always drops when I look at their presentations. The second cutting edge institution in this area is the Frick Collection in New York, which uses, among others, machine learning and image processing. This institution is collaborating with mathematicians from Stanford University on applying machine learning to catalogue the Frick Gallery collection. The implementation of this technology has accelerated the cataloguing process four times. Now curators, after correcting the work done by the computers, can focus on more creative activities. Thus, we are speaking here not only about the acceleration of cataloguing but also of shifting the curators' work to focus on challenges and tasks which cannot be done by

computers. The second area is neuroscience. The Massachusetts Peabody Essex Museum is the first museum in the world to employ a neuroscientist. There are two directions in this area. One is driven by academic interest – we want to understand how the physical parameters of the objects, for example of photography, produce esthetic impressions. Why do we consider one object more "ideal" than another? Without understanding how the change of physical parameters impacts the perception of value we cannot honestly speak about damage and degradation. The second is more applied direction: using oculometry we can trace the human sight and optimize the museum exhibition to deliver more esthetic values and make it more pleasant to the viewer. There is also research which has tried to demystify why certain objects are considered masterpieces: some of this might be explained using neuroscience methods. As for the preservation of cultural heritage, a huge challenge is sustainable preservation, i.e. methods and measures of preservation which do not harm the environment and do not impact the communities, and generally balance preservation and the social and environmental costs.

EM: In conclusion I ask a very timely question. Can you predict what will be the impact of the current pandemics on heritage science?

For me the current pandemic first of all helps in teaching students about risk assessment, because people understand better the risks which they experience in their lives but not those which they can only imagine. Of course, nature of humans is that we focus on these kinds of risks. However, I am teaching that most important risks are usually those which impact is difficult to spot, i.e. the very slow process of degradation, which happens on the scale of centuries but leads to the unavoidable loss of heritage in one, two, or three hundred years, or rare catastrophic events. So, with the current pandemics students and heritage managers are starting to understand risks better and they see that risk assessment is needed to be better prepared for the unexpected. Secondly, and this is more general, I think that the pandemics will impact on the patterns of viewing, people's behaviours, and so on. This could push neuroscience research in the direction of exploring how to improve experiences using the digital form of interaction with heritage. However, I think I will not go into such research. I do not want to just follow the fashion – I prefer to focus on something that I am expert in. I am certainly not an expert in Sars-Cov-2 but some of my colleagues say that our knowledge on particle transport in churches can help to estimate risk of infections during liturgical services.