Les musées de sciences et la formation du citoyen expert : science participative et

gamification de la technè

When Museums of Science Create Citizen Expertise: Participatory science and the

gamification of techne

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WHEN MUSEUMS OF SCIENCE CREATE CITIZEN EXPERTISE: PARTICIPATORY SCIENCE AND THE GAMIFICATION OF TECHNE

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Translated from French by Margaret Whyte

Abstract

What do video games and basic scientific research have in common? While the question may, upon first thought, seem utterly absurd, it has in fact in the course of the past several years become central to a fascinating extension of epistemological boundaries. With the advent of the Internet, participatory science – most often now called citizen science – means that anyone who wishes can contribute to the development of knowledge, so breaching previously immutable barriers between lay people and scientists. The most effective technological interface and one which allows for flexible scientific practice adapted to the greatest number of people, is that of the video game – a choice that is fully in line with changing consumer habits. Hence the concept of the gamification of techne. In museums of science and technology, where game-playing is already an integral part of their pedagogical and didactic practices, the introduction of game-based interfaces with real scientific impact is a way to give visitors opportunities to themselves become citizen experts, knowledgeable not only about the latest advances in scientific research, but also about the ethical, social and environmental issues that this research inevitably raises.

Keywords: video games; gamification; participatory science; citizen science; science museums; epistemology; crowdsourcing

Participatory or citizen science is all the rage today both in Europe and in North and South America, with countless projects of this kind to be found in the majority of university science disciplines. What they all have in common is the degree of collaboration – sometimes close, sometimes not – that occurs between practising scientists and members of civil society. Furthermore, in today’s context where the historical bases of citizen science are all too often poorly known, it should perhaps be stressed that, rather than being a new phenomenon, this situation really represents a return to the past. We need only think of how climate studies in the 18th century were totally dependent on an extensive network of expert observers, adventurers, physicians, sailors and travellers, all, wherever possible, equipped with “standard” thermometers and barometers. The same was true for the natural sciences (we need only to think of the exchanges of letters and specimens to and from Linnaeus in the 18th century and Darwin in the 19th century). The learned societies, the salons and even the coffeehouses of the 17th, 18th and 19th centuries were vitally important forums for intellectual contact and exchange where scholars and

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amateur scientists alike could rub shoulders. Rarely was the production of scientific knowledge seen as being the sole preserve of philosophers of nature hidden away in their studies.

Like the practice of science in those past centuries, citizen science today also leads to the production of original scientific knowledge – which still obviously requires validation by the scientific community, not by civil society. The kind of participatory scientific research, often made necessary by the huge volumes of raw data, or big data sets, to be dealt with, are processed using IT tools designed especially for use by the general public and for the Internet. Some of these tools are recognized, others less so. Games, often genuine video games, figure among the most popular tools used in citizen science. If the goal of participatory science is both to create new scientific knowledge and to promote the establishment of a new class of “citizen experts”, it is fascinating to observe that this highly praiseworthy goal is increasingly being achieved through the use of a new form of techne: video games. We are witnessing what can be described as the gamification of scientific techne, now targeting the general public. Techne, as opposed to its Greek antonym, episteme, which is based on the concepts of logic and geometrical demonstration, instead focuses attention on the creation of material elements and on the practice of a tangible physical activity. In the context discussed here, that activity consists of the increasingly widespread physical and social practices and gestures now commonplace around video games. Seen in this light, games can become tools for scientific research through what we would describe as the gamification of scientific techne for the general public.

My article approaches the question of citizen science and the production of scientific knowledge from three different perspectives. In the first section, I examine examples from the history of science that illustrate the changing dynamic of participatory, citizen-based scientific knowledge. I then go on to analyze what it is that has prompted the recent resurgence in the so-called participatory sciences and consider the intrinsic epistemological values they convey – including the concept of the gamification of scientific techne. Lastly, I want to try and tie this reflection in with the modus operandi (and questionings) particular to museums of science and technology. The past several decades have seen these institutions gamify the way sciences can be learned, through a range of play-based activities designed for school-age children. At the same time, this kind of learning carries with it the inherent risk of falling victim to its own passivity: visitors (be they young or old) are spectators of accepted knowledge, rather than active participants in the production of knowledge. What would be the best way to integrate this recent trend toward gamification of knowledge-based techne into a museum context? Can it be used as a tool in the education of citizens for the 21st century? What a project that would be! And one that would call for wide-ranging (but stimulating!) reflection.

PARTICIPATORY SCIENCE: SOME HISTORICAL BENCHMARKS

Can we reasonably talk about participatory science in historical terms? We would certainly all agree that, since ancient Greece or even well before that era, societies have constantly been enriched through new contributions to scientific knowledge made by communities of individuals, a phenomenon we call the collective dimension of knowledge (Plato’s Academy being one such example). But what about the shift toward participation by the greatest possible number, including non-specialists? Is this a purely contemporary concept? We learn, for example, in the 6th part of the Discourse on the Method (1637) that René Descartes’ (1596-1650) project of self-instruction was “suffering because of the need for innumerable observations which I cannot possibly make without the help of others” (Cottingham et al. 1984-1991, Vol.1:149). Modern science, what we consider to be the result of the scientific revolution, is essentially based on observed facts – or what Descartes calls “innumerable observations”. While he hopes that the public “take an interest in my endeavor”, who is it that he will ultimately need to draw upon to collect his data? Where is he going to get his much-desired “help of others”? It can come only from artisans “or such persons as he could pay, who would be led by the hope of gain (a most effective motive)
to do precisely what he ordered them to do”. There also exists another class of individuals, those he calls “voluntary helpers”, who offer their services free of charge:

… who might offer to help him from curiosity or a desire to learn, usually promise more than they achieve and make fine proposals which never come to anything. In addition, they would inevitably wish to be rewarded by having certain difficulties explained to them, or at any rate by compliments and useless conversation, which could not but waste a lot of [the natural philosopher’s] time. (Cottingham et al. 1984-1991, Vol.1:149).

While artisans constitute a biddable workforce motivated by monetary gain, the “voluntary helpers” are considered downright harmful to the projects dear to the heart of our philosopher of nature (Gauvin 2006). For Descartes, there exists no a priori assumption as to “participatory science”. On the other hand, through the acquisition of "a few general notions of natural philosophy”, Descartes argues:

…it opened my eyes to the possibility of gaining knowledge which would be very useful in life, and of discovering a practical philosophy which might replace the speculative philosophy taught in the schools. Through this philosophy we could know the power and action of fire, water, air, the stars, the heavens and all the other bodies in our environment, as distinctly as we know the various crafts or our artisans; and we could use this knowledge— as the artisans use theirs—for all the purposes for which it is appropriate, and thus make ourselves, as it were, the lords and masters of nature. (Cottingham et al. 1984-1991, Vol.1:142-143)

Descartes’ epistemological rhetoric is based on a universal method which allows anyone who has acquired and mastered it to contribute to the advancement of knowledge. The Cartesian method, at once unique and rational, would thereby open the door to opportunities for “participatory science” where all people—theoretically—would be equal with regard to science. However, there is a conspicuous gap between theory and reality.

A number of studies, including research by Steven Shapin and Simon Schaffer (1985), have demonstrated the role of social status and the concept of trust in the validation of scientific knowledge. The establishment of a consensus around a matter of fact is fundamentally a social exercise, generally requiring the supportive endorsement of “distinguished gentlemen”, seen as being credible witnesses—since simple artisans and technicians are entirely invisible—and buttressed by substantial doses of communication and persuasion. In the decades that followed Descartes, the importance attached to the construction of rational systems was replaced by the observation of natural phenomena, increasingly through the use of scientific instruments. The authenticity of these phenomena was contingent on their replicability, on the accuracy and precision of the scientific instruments used to obtain them, and ultimately on the credibility of the person (or group) presenting them. The issue was no longer that of building a body of knowledge based on the absolute authority of the philosopher; it hinged instead on the social consensus established among a significant number of contributing participants. And these participants were only rarely trained scientists. The majority made their contribution to science simply by virtue of their presence at the meetings of the Royal Society of London, to give one example. Science had indeed become participatory, but only when those contributing participants were endowed with recognized social status that could support the cause of the search for truth (Shapin 1994).

With the advent of the modern era, science was transformed into a highly social activity—a situation that holds true to this day. For many scientists and European gentlemen, public markets, shipping ports, piazzas, fishing villages, even startup cafés were the best possible locations for exchanging useful information, special observations and rare objects (Eamon 2006; Johns 2006). International networks for exchanges developed around recognized scientific figures who could lend their weight to the knowledge shared in these forums. One such scientific heavyweight in the 18th century was René Antoine Ferchault
de Réaumur (1683-1757). Réaumur was a member of the Royal Academy of Sciences in Paris, a man interested in natural history in general, and in insects in particular. People contributing to his research came from all over France and even from elsewhere in Europe and the rest of the world (including New France). Recognizing the importance of obtaining the greatest possible number of observer reports, sketches, even living insect specimens for his own collection, Réaumur rallied to his cause a highly placed State official – someone we would not normally associate with the successful conduct of a scientific endeavour:

I will gratefully accept presents from all those who take an interest in the progress of natural philosophy ... and will gladly make my thanks public, if they will be so kind as to send me insects that they judge to be unusual. [...] They have only to enclose them in little boxes with the necessary food for the journey, and to address them to the Count d’Onsenbray, postmaster general of the French Post; inside the first envelope, they should put a second one addressed to me: they may be sure that the package will be faithfully and promptly delivered. (Réaumur cited in Terrall 2014:79)

Réaumur’s correspondence was in no way limited to communications on the subject of natural history. The archives for him which are housed at the Academy of Sciences in Paris contain a prodigious number of letters he exchanged, from as early as the 1730s, on the subject of the climate in France and in Europe, as well as in the Middle East, in Africa, in North and South America, and over the Indian Ocean. The people sending him thermometric data from all these different regions of the world were naval officers, diplomats, businessmen, scientists, clergymen and physicians. They were all taking readings from thermometers invented by Réaumur himself, supplied by him and, in the majority of cases, constructed by his close associate, Abbé Jean-Antoine Nollet (Gauvin 2012a). This data was intended primarily to contribute to the production of a world temperatures and weather map designed to enable natural historians to identify optimum conditions for the acclimatization of exotic plants and trees in France. Most of the numerical data collected in this way was published in the Mémoires of the Academy of Sciences until 1740; Réaumur himself continued to take daily thermometric readings until his death in 1757.

Historical climatology has generated increasing interest in recent years. In an upcoming publication on the subject, historians Jean-Baptiste Fressoz and Fabien Locher shed considerable light on the magnitude of the communications networks established between scientists and amateurs between the 16th and the 19th centuries, when scientists were endeavouring to create a model to represent climactic phenomena around the world. How fascinating it is to realize that this view that there can be a global climate model is reflected even today in the scientific consensus on global warming, which many consider to be a phenomenon resulting from recent human activity (Bonneuil and Fressoz 2013). There exist many other examples of coordinated participatory science in the field of natural history; we need only think of the collection work done in the 18th century by Hans Sloane – whose bequest of his considerable personal collection led to the founding of the British Museum (Macgregor 1994) and that of Charles Darwin (originator of the theory of evolution) in the 19th century (Browne 2003). Even Isaac Newton’s famous *Principia Mathematica* (1687), the ultimate in math theory treatises, if ever there was one, could not possibly have been written without the existence of the worldwide system of the exchanges of information used to support trading practices and diplomatic missions in the 17th century (Schaffer 2009). The professionalization of science as a field of university studies from the mid-19th century onward, together with the ultra-specialization of science disciplines in recent decades, has left little room for curious amateurs. Even if the founders of Google, Apple, Microsoft, Facebook, Twitter and other IT pioneers have managed to stand out among the crowd – and dominate the new media environment – without advanced academic credentials, the same cannot be said for the field of research science. At the same time, there is growing recognition of the value of being able to draw on an extensive amateur workforce, and the corresponding emergence of a form of genuine participatory science in basic research.
in fields that require an unimaginable quantity of what are known as big data sets. Even so, for 21st century “voluntary helpers” to become active participants in the production of new scientific knowledge, they need to be given the best tools for the job, tools they are familiar with. And in today’s world, what can be more familiar than video games!

**THE GAMIFICATION OF TECHNE: SCIENCE’S NEW EPISTEMOLOGICAL DEVICES**

Before turning to the question of video games, it could be useful to look briefly at two projects (among dozens) that use citizen engagement strategies not unlike those employed by Réaumur in the 18th century. *Galaxy zoo* ([http://www.galaxyzoo.org](http://www.galaxyzoo.org)) is one of 22 projects included in *Zooniverse*, an online platform devoted entirely to the development of scientific research. Internet users who connect to *Galaxy zoo* are asked to identify galaxies – hundreds of thousands of galaxies. Reference to a very precise classification nomenclature allows astronomers to determine where galaxies are located in the universe and develop hypotheses as to their formation. For the classification of any given galaxy to be accepted by astronomers, it needs to be recognized by at least 30 different “volunteers”. It is the very high number of these “volunteers” which means the veracity of the observations made can be accepted, even though the “volunteers” are not themselves specialists. This collective effort on the part of amateur astronomers and internet users has led to the publication of more than 40 scientific articles in scholarly journals in recent years.

Closer to home – for some of us at least – and in an entirely different field, eBird Québec (the *Regroupement QuébecOiseaux*) officially launched on March 1, 2014 a new web portal for recording observations of birds in Québec. This portal ([http://ebird-qc.ca](http://ebird-qc.ca)) replaces the Regroupement’s ornithological database, ÉPOQ, which has served for over 40 years and to date contains records of over 6 million sightings made by amateur birdwatchers. eBird is an international database which collects millions of reports of sightings every year, all available for viewing by experts and birdwatchers all over the world. In just ten years, this database has become an indispensable reference tool for studying changes in bird populations and the effect of climate change on the migratory habits of certain species. Making full use of the growing community of birdwatchers and Web 2.0, “fledgling” birdwatchers have already published over 40 articles in scientific research journals (Desrochers 2013).

Unlike SETI (Search for Extraterrestrial Intelligence) which, by linking thousands of computers on standby around the world, uses grid computing to analyze an astronomical quantity of data collected by radio telescopes, the two examples described above place prime emphasis on the need for active, not passive, involvement in their particular form of participatory science. The volunteers involved have a vital role to play, as they must carry out specific tasks at different degrees of difficulty or detail. Most of us would wonder what pleasure they can possibly find in such narrowly defined requirements. Unless someone is an out and out astronomy buff, they are unlikely to really enjoy spending hours classifying galaxies. Would it be different if the activity took the form of a game? Worldwide revenues from video games of all kinds are projected to represent over 100 billion dollars in 2014, a phenomenal figure which clearly reflects the enthusiasm created by this kind of entertainment. By certain estimates, up to 70% of Americans play video games on a regular basis (on computers, game consoles or their telephones). We are observing a modern-day habitus which scientists are only now beginning to take advantage of for purposes other than game-playing. And by using competition (through the accumulation of points), together with collaboration between players, this new approach to epistemological games blurs the lines between scientific research and mass entertainment. A few examples taken from a list compiled by Chandra Clarke (2014) will serve to illustrate the point:

*Designing new proteins* ([http://fold.it](http://fold.it)): All proteins possesses the special characteristic of being able to fold in on themselves in their own particular way – a property that gives them their stability. It is this attribute that has led to the creation of an online multiplayer...
collaborative game (Foldit) whose purpose is to identify new stable structures from among an incredible number of possibilities (a protein can consist of between 100 and 1,000 chains of amino acids). Two reasons explain the particular importance of this game for science: in the first place, the design of new proteins will help medical researchers find remedies for diseases like AIDS, cancer and Alzheimer’s; secondly, although computers have been programmed to carry out thousands and thousands of random protein folds, the designers of the game want to determine whether the natural ability of humans to recognize forms and resolve problems might not prove more effective. If so, researchers could then “teach” these strategies to computers and thereby fold proteins still more rapidly. Over half a million players are active participants in this research project – the vast majority of them having no previous background in biochemistry.\(^5\) Foldit constitutes a blueprint for this new trend in research.

**Piloting a spacecraft** ([http://www.esa.int/gsp/ACT/ai/projects/astrodrone.html](http://www.esa.int/gsp/ACT/ai/projects/astrodrone.html)): It’s hard to find anything more timely than this game, an application for smartphones and laptops (Apple and Google) that puts players at the centre of a virtual environment where they must control an astro drone. For the first level, players must dock their drone at the international space station. For the second level, have to set off in pursuit of a comet (67P/Churyumov-Gérasimenko — or “Tchouri”) on board the Rosetta probe, launched in 2004 by the European Space Agency. The probe, after a voyage of 6 billion kilometres, finally reached the comet in 2014. The goal of the game – and of the actual space mission – is to land the robotic laboratory, Philae, on the comet, in order to better explore it; this unprecedented manoeuvre was successfully carried out on November 12, 2014. The data amassed while participants are playing the spacecraft piloting game (if players agree to their being used) help improve the autonomy of robots sent into space, through reviews and complex analyses by scientists of the formation of the images captured by the virtual game capsules. In this case, data are not given in advance to players but are instead created by them – and subsequently analyzed by the scientists.\(^6\)

**Mapping the 3D structure of neurons** ([http://blog.eyewire.org/about/](http://blog.eyewire.org/about/)): Created in the research lab of Sebastien Seung at MIT, the purpose of this game is to try to map the network of neurons and synapses in the human brain: the *connectome*. Hardly an easy task when we remind ourselves that the brain contains around 100 billion neurons! Players, assisted by an artificial intelligence algorithm, are given the challenge of solving 3D puzzles. Advanced players can even take part in “Hunts” where they scour completed cells to track down and “scythe away” neuron branch errors, what are called “mistake branches”. The more mistakes players can find, the higher up in rank they move, until they attain the “Order of the Scythe”. The game also provides stunning graphic representations where art and science are blended together in a highly natural way. *Eyewire* is a construct that enables more than 130,000 people in 145 countries to contribute together to the advancement of the neurosciences.

**Saving Britain’s Ash trees** ([http://apps.facebook.com/fraxinusgame/](http://apps.facebook.com/fraxinusgame/)): While in Montreal, an insect from South East Asia, the Emerald Ash Borer, is threatening the survival of our Ash trees, in Great Britain, these trees are being by attacked by a strain of pathogenic fungi that cause a disease known as *chalarose*, or Ash dieback. Facebook users, between two “Like” clicks, are now being asked to analyze DNA samples collected by scientists, to try and find a way to counter the effects of this disease, one which could lead to the loss of 90 to 95% of the Ashes in the British Isles. The goal of the game is to collect points by associating series of colours representing those same DNA samples. With Facebook’s international reach, the potential for crowdsourcing is obviously of major significance.
Crowdsourcing is the principal characteristic of all these different epistemological games. The games also draw on players’ powers of observation and on the human brain’s extraordinary capacity for pattern recognition and problem-solving. Epistemological games could potentially significantly impact on basic scientific research, even if one were to consider only a fraction of the 3 billion hours per week people around the world spend on video games. With these games now all available online, we need to ask ourselves whether they are relevant and appropriate to museum environments. What could science and technology museums be doing to improve upon these highly original, and in many cases, already highly popular, invitations to play with science? And, finally, do museums and epistemological games have a role to play in the education of the “citizen expert”?

SIMPLY ACQUIRING KNOWLEDGE … OR LEARNING HOW: CITIZEN EXPERTS AND APPROACHES TO GAMIFICATION IN MUSEUMS OF SCIENCE AND TECHNOLOGY

If we could rid ourselves of all pride, if, to define our species, we kept strictly to what the historic and the prehistoric periods show us to be the constant characteristic of man and of intelligence, we should say not Homo sapiens, but Homo faber. In short, intelligence, considered in what seems to be its original feature, is the faculty of manufacturing artificial objects, especially tools to make tools, and of indefinitely varying the manufacture.

(Bergson 2008 [1907]: 151, our translation)

Educational games have become a sine qua non of education in the museum context, often to the detriment of real objects (from art, history or science) (Gauvin 2012b; see also Conn 2010). So much so that museums of science and technology are often considered by many adults to just be children’s museums. Is this an inescapable paradox? In a recent study, two of my Harvard colleagues, Peter Galison and Jeffrey Schnapp (2012), question the over-emphasis museums put on educating school-age clienteles—“Talk as if to twelve-year-olds”—was the maxim they used to make their point. These two scholars argue that museums should not confine themselves to using traditional or virtual media for conveying knowledge; they need to completely revamp the learning strategies they adopt for exhibitions, using a three-pronged approach based on depth, process and participation. These crucial concepts can be summarized as follows:

**Depth**: We need to excavate below the surface of specific objects to discover the archeology of knowledge and the multiple dimensions, both epistemological and technical, of the depth of knowledge and how that explain those objects.

**Process**: The concepts that fascinate us are not the fundamental building blocks of science, but rather the processes and practices that produce them— including the epistemological contribution made by failures and dead ends— together with the crucial sociological role played by the institutions that fund research.

**Participation**: Why be satisfied simply with the dissemination of knowledge when it is becoming increasingly easy to participate actively in, and contribute to, basic research?

This three-fold strategy, focusing both on scientific objects and the related practice of science, is an ambitious challenge to take on and would call for a major reconfiguration of the educational apparatus and strategies of museums of science and technology.

In my own personal case, it is the third facet of this strategy, active participation in basic research, which particularly resonates with me. I strongly believe that participatory science goes far beyond the simple forms of communication of knowledge we commonly encounter in museums of science and technology.
We need only actively capitalize on a range of epistemological games like those described above, and we could open up a unique dynamic window on the world of scientific research. The function of such games is not so much to contribute to the acquisition of theoretical knowledge (*homo sapiens*) as to increase practical and epistemological skills (*homo faber*). To adopt the terminological distinctions made by Michel de Certeau (1990), epistemological games enable players to develop tactics that are not limited to particular environments or skills; they are the very antithesis of strategies, which are predicated on an assessment of balances of power for a subject with a separate and identifiable capacity to choose and to act. More to the point, tactics are not tied to any particular environment (very often a pre-defined one). As a result, players can seize opportunities, and opt for the unexpected, for tricky moves and crafty schemes which can almost always be learned only by carrying out actions and discovering them by chance or of necessity. In other words, the art of adopting successful tactics means being able to act in the absence of a defined and dominant power. It should therefore not be at all surprising to learn, as I pointed out earlier, that designers of games of this kind draw primarily on the human brain’s capacity for pattern recognition and problem-solving. Pride of place is given to players’ intellectual savoir faire and epistemological resourcefulness – and that is what creates the bases for scientific discovery.

In a museum context, the gamification of science can become a natural extension of conventional exploration and learning games. What is different is that it provides opportunities for introducing innovative, but still familiar, epistemological dimensions in museology and, at the same time, real opportunities for citizens to become active participants in the creation of scientific knowledge. If judiciously adapted to meet the needs of an exhibition on biotechnology, astronomy or botany, the gamification of science can provide visitors with opportunities to get a glimpse of what laboratory research really entails – by themselves becoming active and involved participants in it. At the same time, it is up to museums to help their visitors better understand the historical context and sociological dynamic underlying any scientific enterprise. Museums also need to facilitate visitor interface with actual objects and, above all, encourage those visitors to rethink issues raised by scientific discovery, something that does not necessarily happen when they are sitting comfortably at their home computers. Yet it is precisely this very same desire to rethink issues that constitutes the driving force behind the recent trend toward citizen participation in professional scientific activity. In his recently published book, Yves Gingras (2013: 21-24) presents a brief analysis of the modern concept of “citizen experts”, militants from pressure groups who sometimes “dare” to challenge results produced by professional scientists or researchers, in fields as diverse as medicine, technology or the environment. As Gingras points out, “this revolution in citizen-scientist relations stems clearly from the overall increase in people’s levels of education but it is also the result of how easy it has become, and fast, and free of charge – mainly due to the Internet – to gain access to research results that were previously difficult or impossible to obtain and assimilate” (*our translation*). Here again, the general public can use information and communication technologies to examine research carried out by scientists and, even more importantly, thereby contribute to the growth of a scientific ethos. After all, shouldn’t we all agree that the state of a nation’s democratic health rests today not only on healthy political debate, but also on an increased awareness of current issues surrounding science and technology?

Certainly, there are groups like the Citizen Sciences Foundation which are working to help educate the broader public on how to recognize the often undue influence of lobby groups on governments, challenge the increasingly widespread commercialization of scientific knowledge at the expense of both the public good and the environment, and develop effective ways to protest against the lack of any public regulatory framework for risk management. The Foundation states:

> Given this situation, we recognize that we assuredly need to carry the fight into institutions with responsibilities in research and expertise-development, but we must also build up citizen and public-interest research grounded in each person’s needs and knowledge, at the same time building on the strengths of civil society and the new forms
of personal involvement and appropriation of science we have seen develop in the past few years. We believe that fully exercised citizenship in today’s world calls for a redistribution toward society of the means of production of knowledge and for collaboration between research scientists and laypersons.

In Québec, an agency known as the BAPE or Bureau d’audiences publiques sur l’environnement (Environmental Public Hearings Bureau), established in 1978, has played a pioneering role in recognizing the rights of citizens to information and consultation on environmental quality. The “value and relevance of contributions by the people of Québec to environmental quality” was specifically recognized when the BAPE was set up. I firmly believe that museums of science and technology are ideal venues for exploring, encouraging and contextualizing this new kind of citizen activity and the critical 21st-century social, political and environmental issues to which it is responding. If epistemological games have already shown that they can contribute to the advancement of scientific knowledge, their integration into the museum world could make a significant contribution to the education of citizen experts, citizens with their own role to play, actively aware of the dangers and benefits resulting from technoscience (Bensaude-Vincent 2009).

CONCLUSION

Citizen or participatory science is not a new phenomenon. Nonetheless, the widespread availability of information and communication technologies, Web 2.0 and crowdsourcing has meant it is now reaching a far broader public than ever before. Even so, the form of citizen science that is still garnering the most attention is based on the acquisition of individual knowledge and players’ game-based entertainment. Video games are today an inescapable part of the “collective tacit knowledge” which Harry Collins (2010) argues can only be learned when you are an active member of your society. If we could make this game-based tacit knowledge an integral part of the essence of our museums of science and technology by gamifying techne and actively implementing Galison and Schnapp’s depth, process and participation-based approach, we would be able to give our visitors opportunities to themselves develop scientific techniques that produce authentic research results, while at the same time contributing to developing in these same visitors, the counterparts of Descartes’ “volunteer helpers”, a heightened awareness of their own role as citizen experts and advocates of solidly-grounded, compassionate ethical values.

NOTES

1 The source article in French cites extracts from the French original of Descartes’ document (1996 [1637]) and provides the corresponding references. The quotations given in English for this translation come from The Philosophical Writings of Descartes, transl. by J. Cottingham, R. Stoothoff, and D. Murdoch (3 vols, Cambridge and New York: Cambridge University Press, 1984–1991).

2 For a list of the most significant projects of this kind (primarily American), see the website maintained by the Scientific American: http://www.scientificamerican.com/citizen-science/ (accessed June 22, 2014).

3 The introduction to the site says: “We make citizen science websites so that everyone can be part of real research online.” Zooniverse is part of the Citizen Science Alliance. With partners from all over the world, it was set up “to produce projects that use the efforts and ability of volunteers to help scientists and researchers deal with the flood of data that confronts them”. See: www.zooniverse.org/about (accessed June 20, 2014). More than 1.1 million people worldwide participate in its different projects.


5 The Foldit website lists publications recognizing discoveries that have contributed to new scientific knowledge. One example is the form of a protein which biologists had been working on for more than 13 years and which was identified by the Foldit community just 10 days!

6 This is standard practice in the video game industry. Recently, between July 17 and 31, 2014, a beta version of the game Destiny (produced by Activision and Bungie) was launched on the Internet for users of PS3, PS4, Xbox 360 et Xbox One game consoles. More than 4.6 million players downloaded the game free of charge, so creating an enormous storehouse of data and comments that could be used for the commercial version. The game was officially launched on September 9, 2014: http://www.destinythegame.com

7 See, for example, Kehl (2013). I use the term “museums of science and technology” in its broadest sense, so as to encompass both museums which have real collections of historical objects and science centres which usually have few or none.
Their original document uses appositions to clarify their ideas: “Depth (not Anthology)”, “Process (not Product)” and “Participation (not Dissemination)”.

From the Foundation’s website: http://sciencescitoyennes.org/comment-integrer-les-sciences-a-la-democratie/ (accessed July 22, 2014). To learn more about the issue of global warming and the huge smear campaign organized to fight the broad scientific consensus on the subject, see the excellent analysis published by Oreskes and Conway (2011).

For further information, consult the BAPE’s website: http://www.bapecouv.qc.ca (accessed July 5, 2014).

There is beginning to be a growing awareness of this role in the social sciences field as well. See Citizen Social Science’s crowdsourcing project at: http://citizensocialscience.org.uk/ (accessed July 15, 2014).


