Philosophical reflections on the nature of design & technology

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You need not be a Trekkie to know what "Star Trek" is. In this popular science fiction television series we see how technology enables people in the future to do all sorts of wonderful things that today we can only dream of. You can satisfy your human curiosity by examining life and cultures on different parts of the universe, travel from one place to the other in seconds by using transporter beams (*'beam me up, Scotty'*), get any kind of food you like instantaneously from the food replicator in your room, or have a great time in one of the holodecs by immersing yourself in a virtual reality that makes you think you are on a Caribbean island. The creator of the original series, Gene Roddenberry, has put all his humanistic convictions into the series to show how technology in the hands of humans will be of great benefit. He was, though, realistic enough to include the use of weapons in his creation as well. Phasers and photon torpedoes feature in almost every episode. Not only the good guys (the crew of Federation starships such as Enterprise, Voyager and Deep Space 9) have them, but the bad guys (such as the Romulans) as well. Evidently, technology can be both blessing and curse, depending on who is involved.

> **?** Do you think the question whether technology is a blessing or a curse is only a matter of users, or do developers of technology have a role in that too?
> Or can they claim that their only concern is to 'make it work'?

In the second "Star Trek" series, "The Next Generation" (another 'Next Generation', apart from one in the title of this book), a humanoid called Data features, who is 'used' by the series makers to make us think about other aspects of technology as well. Data namely struggles with his artificiality and wants to become human and have feelings. In several episodes he seems to come quite close to it. In the "Star Trek" fourth series, called "Voyager", there is a hologram, the Doctor, who also displays the desire to be treated as a person, and not as a piece of technology. In one of the last episodes of the series he is even granted copyrights, based on the formal judgement that he ought to be regarded as an author, that is, a person.

> **?** Could technology be developed to such a sophisticated and advanced level that artefacts ('robots') will be able to experience 'feelings' or 'think'?
> Could you give arguments for or against that, so that your judgement goes beyond an opinion only?
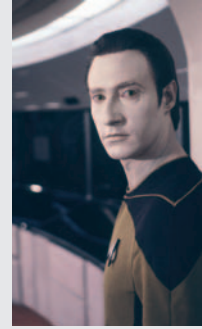
01 02 03

01 "Star Trek" crew with phasers.
02 'Beam me up, Scotty'.
03 Data from "Star Trek - The Next Generation".

(Images 01 & 02 © MPTV/LFI. Image 03 © GENE TRINDL/MPTV/LFI.)

04 05
06 07 08

What is technology?
04 Paintings in a gallery?
05 A stick found in the wood as a cane?
06 A stick used by an ape as a tool?
(Photograph by Kabir Bakie; http://creative commons.org/licenses/by-sa/2.5/)
07 A high-tech laser?
08 The answer to the big question?

Questions like these (is technology good or bad; can technological products get human characteristics?) make us reflect on what technology is like (and also what humans are like!). Such questions can make us deal with technology in a more conscious way. Most of the time, we do not feel much need to do that; we just take technology as it is and use it when needed (and perhaps also when it is not really needed at all). But when we teach about technology, then maybe it is not appropriate to avoid such reflections. Of course it is possible to confine ourselves to teaching the 'tricks' and 'traps' only, and never let pupils think any deeper. But is that good education? Would it not be good to help pupils get a real understanding of how much an important element technology is in our culture and society? Would it not be necessary as a teacher then first to have thought about such questions yourself?

Ways of thinking about technology

Hopefully you are convinced now that it makes sense for a design & technology teacher to think about what technology is. If not, keep re-reading the introduction until you are too exhausted to defend yourself against this claim. Then continue to read here.

Now a second challenge comes up: Where do I start and how do I continue? When you have never systematically reflected on the nature of technology, it seems

like an endless undertaking. Technology is so wide a phenomenon that it is difficult to see how to get grips on what it is. Why do we call some things 'technology' and others not?

> Yes, why actually?
> Can you think of a short definition of your own, or a couple of keywords that characterise technology?

When you try to do this, you will see that it is not easy. Maybe you filled in: 'man-made stuff'. But is all 'man-made stuff' technology? How about paintings and sculptures? Would you call those 'technology'? How about using a stick you found in the wood as a cane? Is that technology, in spite of the fact that it was not man-made? Then, how about certain apes using the same stick to reach the bananas? Do they act technologically? Maybe you wrote: 'application of science'. That certainly holds for a lot of technology, like microchips and lasers, but does it hold for plastic cups and wooden spoons? Or would you say those are not technology?

Fortunately, there are people out there to help you in this troublesome task. They are called 'philosophers'. Now maybe they are not exactly the first type of people that come into your mind for asking about anything that could even remotely be of practical use.

But perhaps you need to revise your ideas about philosophy. Philosophy is not just what you intuitively think it is: seeking the answer to the big *'question of the meaning of life, the universe and everything'*. Thanks to **"The Hitchhikers Guide to the Galaxy"** we know anyway that the answer to that question is: 42.
Still not all philosophers agree on that, but many of them have moved to other questions that may be of equal interest. Philosophers of technology, for instance, have moved on to such questions as: what do we mean by 'technology', by 'technological knowledge' or by 'technological artefacts'? In the past fifty or so years they have found out that there are four different ways of reflecting on the nature of technology. Together those four give you a pretty good impression of what characterises technology.

Those four ways are:
• technology as artefacts;
• technology as knowledge;
• technology as processes;
• technology as a property of humans.

> Have you ever thought of how pupils see technology? Try this: ask them to write or give a short definition of technology or just some keywords. Then check how many keywords they use that

refer to each of the four ways mentioned above. Anything remarkable?

Let us now look more closely at each of those four.

Technology as artefacts

Artefacts are what we often think of first when reflecting on technology. There are lots of them around us: computers, mobile phones, mp3-players, tables, chairs, but also cars, bikes, houses, bridges, you name it. In design & technology they also get ample attention. They are the outcome of design projects. Sometimes we teach how an existing artefact works. We do not seem to pay much attention, though, to the question of why we call them 'technical' artefacts. We deal with each of them separately, but do we ever think of what they have in common? Let us give it a try.

> Write down some keywords that describe what all technical artefacts have in common.

That was by no means a simple question! Artefacts can be so different that you may have thought: do they have anything at all in common? What do a mousepad, an airplane and factory building have

in common? Not much in terms of shape or constituting materials. But wait, they do have in common that they have shape and materials. And once you have realised that, you can take the next step and say that their shape and materials are not random, but chosen deliberately to make them fit for doing what they are supposed to do.

There is a somewhat different way of describing the same observation that can be helpful for teaching about artefacts. Let us take an example: a screwdriver.

? Suppose a Klingon visits you from his planet and tells you that he is trying to learn more about earth, and in doing that
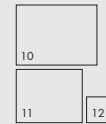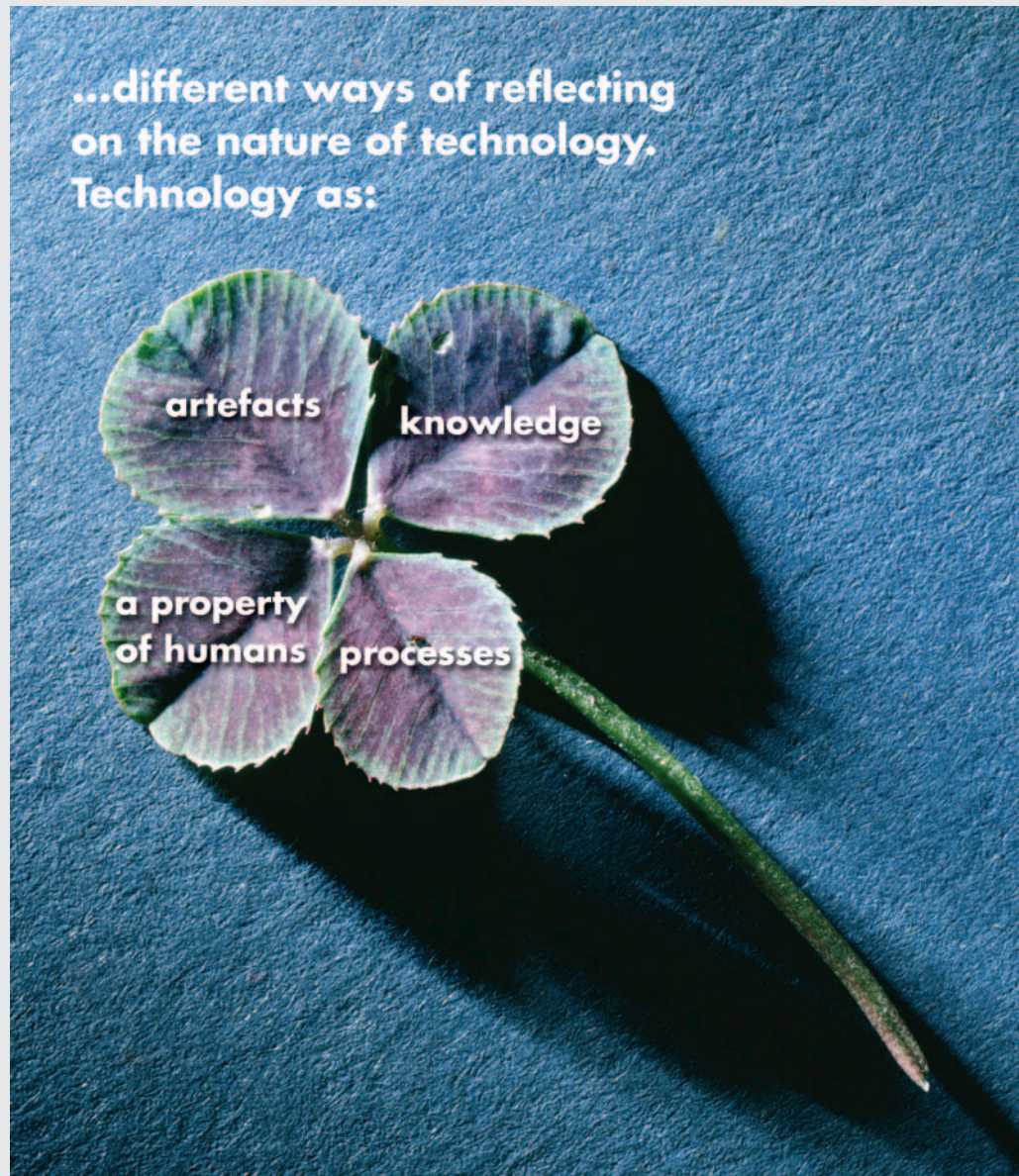
came across the term 'screwdriver'. Could you briefly describe what a screwdriver is?

There are different ways of answering that question. Perhaps you have written something like this: it is a long, thin metal device, with a broader, round ending at one side,

usually covered with a plastic piece, and the other side ends wedge-shaped. The Klingon, warrior as he is, then may think: *'that sounds like a pretty effective weapon; these Earthlings clearly are not as peaceful as they claim to be in Star Trek'*. This misunderstanding is caused by the fact that the description you gave was not complete. You have described in detail the physical and geometrical properties of the screwdriver, but not what it is for.


09 What do we mean by technology?

...different ways of reflecting on the nature of technology. Technology as:

artefacts
knowledge
a property of humans
processes

10 Technology as an artefact - the Humber bridge.
11 An old-fashioned design of screwdriver.
(Photograph © www.oldtools.co.uk)
12 Is this what a Klingon might imagine a screwdriver is used for?
(Photograph © www.deadbodyguy.com)

PHYSICAL NATURE
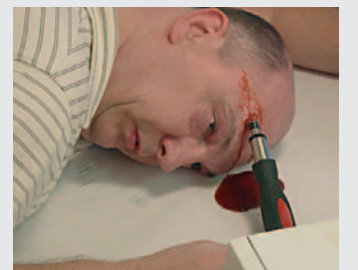
FUNCTIONAL NATURE

13 | 14 15

13 An artefact can be described in terms of its physical AND functional nature.
14 Proper function.
15 Accidental function.
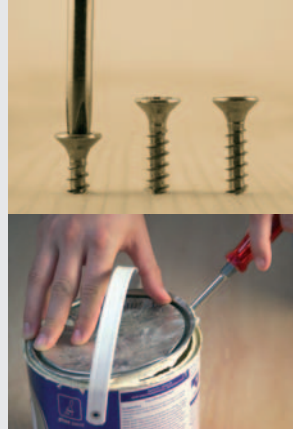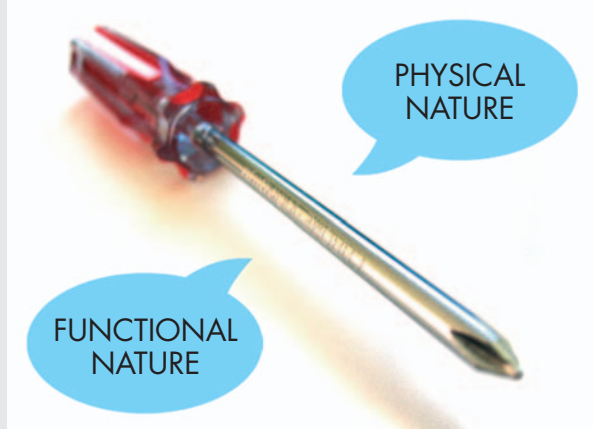
16 17 | 18 19

16 Catweazle's 'electrickery'. (Photograph © ITV/ Rex Features).
17 Wash symbols indicate how a garment should be treated.
18 A door handle to be pushed. (Photograph © NABCO Entrances Inc.)
19 A door handle to be pulled.

Alternatively, you may have written that the screwdriver is a device which you can use to insert screws into pieces of wood and also to extract them from the wood if necessary. If you were able to look into the Klingon's thoughts, you may see a weird-looking device, made of a material you have never seen before (probably available on the Klingon's planet only) with a beak-type of ending that probably can turn. Again you have caused a misunderstanding, now emerging from the fact that you have only described what the screwdriver is for. Apparently a full description of what a screwdriver is requires two stories: one about the physical properties of the device, and one about what you can do with it. In other words: the screwdriver can be described in terms of:
• its physical nature; and
• its functional nature.
And so can every other artefact. The physical nature comprises not only physical (hardness, weight, colour etc.), but also chemical (does it rust? does it smell?) and geometrical (size, shape) properties of the artefact.

Let us focus a bit on the functional nature now. The Klingon's idea that a screwdriver is a weapon is not only understandable, but in a way is also true. There is scarcely any doubt that in the past someone has been murdered by someone using a screwdriver. We, humans, have shown great creativity in using all sorts of devices as weapons. Of course that was not what the screwdriver was intended for.

Intended, though, by whom? Well, by the designer of the screwdriver. That designer purposefully selected the physical properties of the screwdriver in such a way that they would make the device suitable in the first place for driving screws. But once in the hands of users, the same physical properties of the screwdriver may appear to make it suitable for other purposes as well. The sharp ending of the screwdriver makes it fit for stabbing in people's chests or stomachs. More moderately, the length of the screwdriver also allows it to be used as a device to open the lid of a tin can.

So while reflecting on the functional nature of artefacts, we found that there are two types of functions:
• proper functions: that is, what the designer had in mind;
• accidental functions: all the other functions that users ascribe to the artefact.

? The term 'function' is also used to describe what biological artefacts do. A biologist can say: *'the function of a heart is to pump blood'*. Is that the same way of using the term 'function' as in technology? Can you explain why

or why not? How about, for example, a designer describing a function? Might he need to consider the difference between proper and accidental function?

The designer's challenge is to come up with a physical nature for a new artefact that fits the desired functional nature. The user observes the physical nature of the given artefact and comes up with a functional nature that is enabled by that physical nature. In a way, the user also designs something. We can call that a 'use plan'. The use plan for a screwdriver is: take the screwdriver in your hand by gripping the broad end, then stick the other end in the ridge of the screw's head, and then turn the screwdriver, meanwhile turning your hand clockwise or anticlockwise, depending on whether you screw in or out.

Sometimes that use plan is difficult to imagine. The fun of watching "**Catweazle**" on television is that with his Middle-Age knowledge he constantly makes mistakes in estimating how 20th Century devices with *'electrickery'* like the *'speaking bone'*, should be operated. Thus it gives us a good laugh when we see his great disappointment when pulling the handle of the toilet flush does not switch
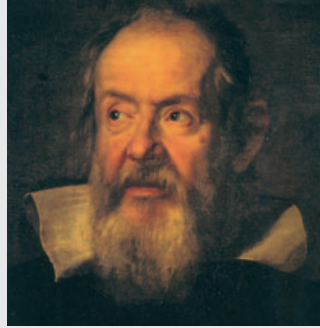
on the light in the bathroom. His use plans are based on wrong assumptions about the relationship between the physical nature of the devices he encounters and their functional nature.

A good designer will also reflect on the use plan. It would be good to design the device in such a way that it contains messages about its use plan. Some door knobs, for example, seem to shout at you: *'pull me!'*, while others are clearly meant to be pushed. Those are examples of how physical properties are used to suggest what the proper function is, and with what use plan to realise it. The designer may also want to reflect on possible accidental function. An important reason for that is that not all accidental functions match with what the physical nature allows for. Dangerous situations may occur when users start using the device in ways that are not allowed for by the physical properties, or when the device is used under circumstances that deviate too much from the ones under which the device ought to be used (too high temperatures, for example, or in water instead of air).

Designers may want to prevent those accidental functions, either by making further decisions about the physical nature to disable those functions, or by including warnings in the manual.
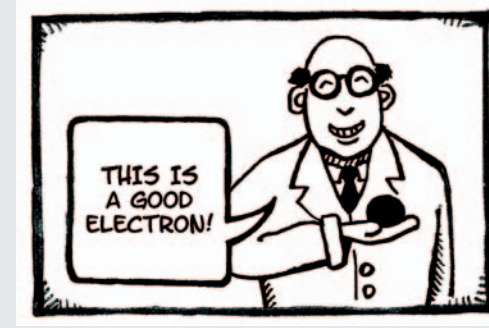
Technology as knowledge

Now let us move on to the second way of reflecting on technology. Technology is not only artefacts, but it also entails knowledge. It is something you can study. It is something you can be an expert in. Now what is characteristic of knowledge in technology, as compared to other fields in which you can become an expert?

Can you first think of some characteristics yourself? Could you, for example, think of some differences between knowledge in science and knowledge in technology?

Perhaps you wrote that science deals with natural objects and technology deals with technical artefacts. But probably you soon realised that scientists may also study technical artefacts. In order to study falling objects, Galileo used heavy and light artificial balls and not natural objects. Yet he did acquire scientific and not technological knowledge with his experiments. What, then, is a real difference between scientific and technological knowledge? Perhaps the following question can trigger us. Before reading on, try to give your own answer.

Why can an engineer use the term 'good' in knowledge claims, while a scientist can not? For instance, why do we consider it a completely normal knowledge claim when an engineer states that based on expertise she 'knows' that *'this is a good type of drilling machine'* while we consider it absurd when a scientist based on his expertise claims to *'know'* that *'this is a good electron'*?

You might object that a scientist does sometimes use the term 'good' in knowledge claims. For instance, he might state things like: *'I know that this is a good bubble chamber'*. But is that really evidence of scientific knowledge? Is not it a judgment about whether or not the engineers who developed the device have done a good job?

The use of the term 'good' is related to 'fitness for purpose'. And purpose has to do with how we would like things to be rather than how they actually are. Scientists are not interested in how things should be; they focus on how things actually are. They study the behaviour of electrons, falling balls, or drilling machines, but they do not make normative judgements

about those. That is what engineers do. The engineer may say that the electron is 'good' for carrying around energy for use in lightbulbs and other devices with *'electrickery'*.

There is a second feature of engineering knowledge that seems to be different from scientific knowledge. That feature is related again to the fact that engineers deal with how things ought to be rather than how they are. What 'ought to be' is something that is not a matter of discovery, but of agreement. When the engineers as a profession decide that devices based on *'electrickery'* must fulfil certain safety requirements, that is mostly decided after a lot of experimentation, but it is not really something that is a necessary conclusion of the experiment. Experiments show when a dangerous situation occurs; that still leaves it as a matter of choice to decide what safety margin to prescribe in order to avoid such situations. Such decisions require collective acceptance of what then becomes an element in the engineers' knowledge baggage.

So we have seen two characteristics of technological knowledge:
• normativity; and
• collective acceptance.

But is scientific knowledge not also a matter of collective acceptance? In a way it is, but in a different way than for engineers. It is not entirely up to scientists to decide what the laws of nature are. Things are the way they are, and scientists can only agree on

whether or not they have followed the correct path to find out how things are. Engineers deal with how things ought to be, and that is really up to them to decide. You may also object that not everything in technology is a matter of decision. Catweazle found that out when he pulled the toilet's handle to switch on the light. Once an artefact exists it is fixed what happens when you exert a certain act on it. That is not a matter of collective agreement. Catweazle can find that out by himself. So at least part of what engineers know is non-normative and non-collective.

One more characteristic of technological knowledge wants our attention. You can find that when you try the following.

Write down in a sequence of sentences how to make a text on a computer and store it on a USB-stick. Give it to a young child who never did that before. Do you think that could work? Now write in a sequence of sentences how to ride a bike and give it to a young child who never rode a bike before. Do you think that will work? What then is the difference?

24 Designers working. (Photograph © Gokhan Okur)

In both cases you have written down what you yourself know to transfer your knowledge to someone else. In one case this works, even though it may require quite a few sentences, but in the other case evidently there is more in your knowledge than you had written down in sentences. In both cases the knowledge concerned the use of a technical artefact. In one case the knowledge could effectively be expressed in sentences, while in the other case it could not. Philosophers use the term 'proposition' to indicate the content of a sentence. In their terms you could say that in technology you can distinguish between:
• knowledge than can be expressed in sentences: propositional knowledge, or knowing-that; and
• knowledge that can not be expressed in sentences, or knowing-how.
Note that both can refer to skills (in one case using a computer and in the other case riding a bike). Apart from that you can also have propositional knowledge in technology about facts (for instance about material properties).

Technology as processes

The third way of reflecting on technology is by seeing it as a way of acting. Technology is about doing things. It is in particular about designing, making and using things. Those three types of processes form the basis of technological innovations. In design & technology traditionally there is a specific

interest in design (which is already expressed in the name of the subject, which in other countries is often called just 'technology'). This interest can be justified by pointing out that the design process is really where the new ideas are born, and that is what triggers all technological innovations. Besides that, the design process is also where you can fully exploit your creativity, and that makes it very appealing as an educational activity.

? Write down in what sequence of steps you think a design process normally runs, or even nicer, make it a flowchart that you can use in class.

Well done. Now, throw away the flowchart immediately, because this is not how things work in reality. Irrespective of what sequence you wrote down, it is wrong. There is no such thing as a 'normal design process'. There are at least three wrong assumptions floating around in design & technology classroom practice about design processes: **1.** all design processes are essentially the same; **2.** they are linear; and **3.** they all have problem analysis first and only later concrete ideas for solutions come. Deliberately these three have not been printed as bullets, because there is already so much misunderstanding about this, that readers could easily think they should learn them by heart as proper descriptions of design processes.

Systematic reflection on real design processes has indicated that we need to think about design processes as much more complicated than as the execution of a pre-fixed sequence of actions. In the field of design methodology people have discovered the following about how real designers go about designing (note: bullets now!):
• designers throughout the design process keep learning about both the problem itself and about its possible solutions;
• designers constantly jump from one level in the design to another (from the overall systems level to lower levels of sub-systems and vice versa);
• designers use different strategies for designing different artefacts, and different designers have different design styles.

But, you might object, these are experienced designers. They have learnt to be flexible without making all sorts of mistakes. That does not necessarily hold for novice designers, such as pupils. Okay, granted you are right in that; get back your flowchart from the bin.

? How can you adapt your flowchart or description of a sequence of actions, so that it does justice to the findings of design methodology?

In other words, how can you give guidance to novice designers without forcing them into a framework that they need the rest of their lives to be liberated from?

Technology as a property of humans

Finally we have technology as a property of humans to reflect on. Here we can treat this briefly as there is much readable material readily available elsewhere. This is really the 'big question' type of domain you had in mind originally when thinking about 'philosophy'. In the introduction some issues about that have already been raised. Perhaps what is most important to emphasise is that this is where values come in.

? Some people say: no explicit values in education! That leads to indoctrination. What do you think about that? Can you imagine proper ways of dealing with values in (design & technology) education?

25 Immanuel Kant.
26 Waste plastic.
(Photograph ©
Centriforce Products Ltd.)

27 Interior of
Exeter cathedral -
Gothic architecture
in the UK.

In technology there are two areas in which values play a vital role: ethics and aesthetics. Ethics deals with questions of 'right or wrong', while aesthetics deals with questions of 'beautiful or ugly'. The philosopher Immanuel Kant wrote about both areas, and his main message was that values can be debated, contrary to the popular saying that they can not because they are just a matter of taste. Of course values are not something you have to accept on the basis of proof. Yet, reasoning does play an important role in ethics and aesthetics. Reasoning can help you investigate what consequences the values you have chosen to hold should have for the way you will appreciate technology. Lots of debates about how technology should develop suffer from all sorts of mistakes in popular argumentation. Let us look at an argument in perhaps its shortest form:

1. plastic bags pollute the environment;
2. you should never pollute the environment;
3. therefore you should never use plastic bags.

Propositions 1 and 2 are called the premises in the argument, and 3 is called the conclusion. Mark that 2 is often left out: plastic bags pollute the environment, so you should never use them. That is striking, because 2 is where the value is. You can tell, because it has an 'ought' in it. It is a normative statement. That makes it different from 1 that states a factual statement. By leaving out 2 it is suggested that you can conclude a normative statement 3 from a factual statement 1. In logic, that is called a natural fallacy.

You find lots of them in newspaper writings about technology. They pollute discussions. Suppose you find it much more important that bags are produced in a cheap way, then you will not conclude 3 from 2. But the nature of your disagreement with the person holding 2 only becomes clear once the two of you have made your values explicit. Doing that can prevent useless debates. Other mistakes in argumentation can be that your factual claim 1 is wrong. In this case that is partially the case. Of course plastic bags put a burden on the environment because they stay around for a long time once thrown away. But many types of plastics can be recycled, and often in easier ways than some other materials. So 1 is true only in a narrow view.

? The argument presented above is complex but important.
How might you involve your pupils in understanding the importance of such arguments and become involved in carrying them out for themselves?

In aesthetics similar arguments can be set up. Looking at the impressive height of a Gothic cathedral, you may reason as follows:

1. Beautiful buildings are those that use space to express certain values;
2. A Gothic cathedral uses height (a spatial aspect of that building) to express the value that its visitors should look upward, to heaven where God is;
3. A Gothic cathedral is a beautiful building.

Note that proposition 1 and 3 are now the normative statements, and 2 is a factual statement. Also note that 1 is stated as if it were a fact. But that is only a matter of language. Do not be misled, because it does express a value. What is beautiful and what is not, depends on your aesthetic convictions. This one is a widely shared one among architects, not only today but throughout the centuries. The fact that such values survive time indicates that not all values are bound to time. Some do seem to be shared by people in all times.

? Now think of a building that you yourself like very much, and try to set up a similar reason through which you can explain why you like it.
You might also consider asking your pupils to justify their aesthetic preferences.

Further reading

For those who have now become infected by the 'philosophy of technology' virus, here are some titles that you may want to consider.

Dakers, J. R. (Ed.), (2006). "Defining Technological Literacy: Towards an Epistemological Framework". New York: Palgrave Macmillan.

Kaplan, D. M. (2004). "Readings in the Philosophy of Technology". Oxford: Rowman & Littlefield Publishers.

Mitcham, C. (1994). "Thinking Through Technology". Chicago:University of Chicago Press.

Scharff, R. C. & Dusek, V. (2003). "Philosophy of Technology: The Technological Condition. An Anthology". Malden, MA: Blackwell Publications.

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