

Learning, Technology, and Technique

Apprentissage, technologie et technique

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Abstract

To be human is to be a user, a creator, a participant, and a co-participant in a richly entangled tapestry of technologies – from computers to pedagogical methods - that make us who we are as much as our genes. The uses we make of technologies are themselves, nearly always, *also* technologies, techniques we add to the entangled mix to create new assemblies. The technology of greatest interest is thus not any of the technologies that form that assembly, but the assembly itself. Designated teachers are never alone in creating the assembly that teaches. The technology of learning almost always involves the co-participation of countless others, notably learners themselves but also the creators of systems, artifacts, tools, and environments with and in which it occurs. Using these foundations, this paper presents a framework for understanding the technological nature of learning and teaching, through which it is possible to explain and predict a wide range of phenomena, from the value of one-to-one tutorials, to the inadequacy of learning style theories as a basis for teaching, and to see education not as a machine made of methods, tools, and systems but as a complex, creative, emergent collective unfolding that both makes us, and is made of us.

Résumé

Être humain, c'est être un utilisateur, un créateur, un participant et un coparticipant dans une tapisserie richement emmêlée de technologies - des ordinateurs aux méthodes pédagogiques - qui font de nous ce que nous sommes autant que nos gènes. Les utilisations que nous faisons des technologies sont elles-mêmes, presque toujours, des technologies, des techniques que nous ajoutons au mélange emmêlé pour créer de nouveaux assemblages. La technologie la plus intéressante n'est donc pas l'une des technologies qui forment cet assemblage, mais l'assemblage lui-même. Les enseignants désignés ne sont jamais seuls à créer l'assemblage qui enseigne. La technologie de l'apprentissage implique presque toujours la coparticipation d'innombrables autres personnes, notamment les apprenants eux-mêmes, mais aussi les créateurs de systèmes, d'artefacts, d'outils et d'environnements avec et dans lesquels elle se produit. À partir de ces fondements, cet article présente un cadre permettant de comprendre la nature

technologique de l'apprentissage et de l'enseignement, grâce auquel il est possible d'expliquer et de prévoir un large éventail de phénomènes, de la valeur des tutoriels individuels à l'inadéquation des théories sur les styles d'apprentissage en tant que base de l'enseignement, et de voir l'éducation non pas comme une machine faite de méthodes, d'outils et de systèmes, mais comme un déploiement collectif complexe, créatif et émergent qui nous fait et qui est fait de nous.

The Nature of Technology

The term *technology* is an ever-evolving fuzzy abstraction with multiple contested meanings. I do not have space to address even a fraction of these here but refer you to Dron (2022) for a fuller discussion. For the sake of clarity, I will, though, distinguish between the subset of technology better described as *tech* (typically the stuff with flashing lights and microchips) and *technology* itself (that includes the desks, legislation, and poetry). This is a paper about learning and *technology*, not just *tech*, though all that is true of technology is also true of tech.

The definition of *technology* used in this paper is 'the orchestration of phenomena to our use' (Arthur, 2009, loc 783-786), because it is more discriminatory and inclusive than most. Simplifying a little, technology is *the organization of stuff to do stuff*.

The stuff that is organized may be anything that exists or that we imagine exists in the world, from fire or metal to beliefs about how people learn or the presumed wishes of gods. It may be physical, conceptual, virtual, organizational, structural, procedural, material, immaterial, real or imaginary. There are as much technologies of prayer as there are of locomotion (Franklin, 1999, pp 8-9). Symphonies are technologies, too (Kelly, 2010, loc 5269). Some technologies, such as thinking in words or doing mental arithmetic are, quite literally, a part of us. They are cognitive gadgets (Heyes, 2019) we can organize to do stuff.

Technology can refer to processes, products of processes, or abstractions. For instance, writing (abstract) is a technology that I am using to write (verb) some writing (noun), that you are reading. I am also using an unimaginably vast number of other technologies to write this – words, transistors, concepts, grammatical rules, a chair, a screen, electricity, theories, screws, books, websites, metaphor, keyboard skills, and so on, all play a role.

Virtually all technologies are made of, are developed from, and exist in essential relation to other technologies (Arthur, 2009). Technologies evolve and take form through the orchestrated assembly of other technologies. *The stuff that is organized to do stuff almost always includes other stuff that is organized to do stuff*.

The boundaries that we choose to place around what we describe as a technology are critical: it is not only the parts of the assembly that matter but, most of all, how those parts are organized to do stuff. It is profoundly mistaken to use the most obvious part of the assembly as a synecdoche for the technology that actually matters. It makes no more sense to inquire into the effectiveness of computers

in learning, say, than to inquire into the effectiveness of their power supplies. To understand the technology, we must look at the whole assembly, not just at its more obvious constituent parts.

Learning Technologies

Fawns (2022) describes pedagogies and technologies as inextricably entangled, while Anderson (2009) calls their relationship a dance. However, pedagogical methods and principles (*pedagogies*, for short) *are* kinds of technology, too, organizing stuff (subject matter, beliefs about learning, media, words, theories, and so forth) to do stuff (helping people to learn). Learning technologies may usefully be described as those that include pedagogies as part of their assembly.

A learning technology assembly is not just the product of those we label as teachers: we are all learning technologists. Whenever we organize stuff with the intent of learning (whether knowingly or not) then we are using pedagogies, so the assembly is a learning technology.

There are nearly always *many* teachers who contribute to the assembly other than those designated as such, from fellow students and textbook authors to timetablers and architects. The most important organizer of stuff is *always* the learner, but no one is a true autodidact: we always learn from, with, and through countless others. Learning technologies are deeply distributed, and every part of their assembly matters to the whole.

We often talk of *using* technologies but, usually, that use is *also* a technology. The stuff we do with the stuff that is organized to do stuff is usually *another* organization of stuff to do stuff. You and I may, for instance, both use the same technology of language, and even most of the same words, but what matters is how we organize the words: the technology we make, not the technologies we use in the making. We don't so much use technologies as *participate* in them, forming a part of the technology itself as it, in a very tangible sense, forms part of us as a physical or cognitive prosthesis.

Sometimes, our participation is pre-determined. For example, when we tell the time from a clock, or solve a quadratic equation, our participation is proscribed, assuming the technology is to serve its designated purpose. I call these **hard** technologies, for the same reasons that subject areas like science or math are typically referred to as *hard* disciplines. Hard technologies can be enacted correctly: we must play our correct roles in order for them to work. Rules and regulations are hard, as much as light switches. The hardness is a description not of the parts of the assembly, but of the rigidity of our roles in being a part of it.

Sometimes, our participation demands creativity or invention. For example, we might use a pencil and paper to produce any of an infinite possible variety of drawings or writing, and there are uncountably vast numbers of ways we could hold the pencil or vary the pressure on the paper. We fill the gaps it leaves for us in endlessly new ways with technique and content that will never, even in an infinite universe, repeat the same way again. This is without even allowing for the fact that a pencil can, like a screwdriver, have infinitely many other unprestatable uses, from a murder weapon to a hair grip, filling a potentially infinite range of adjacent possible empty niches (Kauffman, 2019). I call such

technologies **soft** technologies, for the same reasons that subject areas like arts or humanities are described as *soft* disciplines. Soft technologies can be enacted well, or less well, but never correctly, because there are always unprestatably many ways they could be enacted differently. Again, the word ‘soft’ describes our participant role in the technology’s enactment, not the pencil or paper per se.

It is virtually impossible to find any purely hard or soft technologies because:

1. Almost all technologies are assemblies of other technologies, soft and hard, so almost all fall on a continuous spectrum between the two.
2. All may be assembled with others to become softer or harder, so softness depends greatly upon where we choose to place the boundaries around the assembly.

A clock, used to tell the time, is hard but, if it is used for decorative purposes or as a door prop, then it may be much softer. Equally, a pencil and paper may become harder when assembled with a join-the-dots picture, or for technical drawing. There is no technology that cannot be softened or hardened by assembling it with others, thereby creating a *different* technology.

Some technologies, like the pencil, are inherently needy, useless without further orchestration, and so are inherently soft while others, like the clock used as a timepiece, are hard but can become softer through assembly. Again, it is how we participate that makes them softer or harder, not the innate qualities of the parts. To its author, a multiple-choice quiz may be a soft technology but, to a student, required to select one and only one possible answer, it may be very hard. The boundaries of the assembly, the phenomena that are orchestrated, and the uses to which it is put are very different for the teacher and for the student.

Hard technologies provide replicability, reliability and efficiency, but at a cost of flexibility. Soft technologies afford creativity, flexibility and adaptability, but they demand effort and skill. They are inconsistent, unreliable, and normally inefficient. Hard technologies are essential: they provide scaffolds that can lift us beyond what humans could do unaided, can reduce the need for cognitive or physical effort, and are almost always present to some extent in any assembly. However, they must be assembled with soft technologies if they are to be of any use or value. A learning management system (LMS), say, is built from nothing but hard, deterministic components, including hard pedagogical assumptions embedded in its design (Laanpere et al., 2004), but is useless until assembled with the (potentially softer) content provided by course designers and students. And, like all technologies, it can be and almost always is part of a larger assembly, including components like academic regulations, management procedures, or professional body requirements that may harden, as well as pedagogies and opportunities for dialogue that may soften.

Harder technologies tend to play a more structural and dominant (but, except in dominative technologies like rules, rarely deterministic) role in assemblies than softer technologies, which must adapt and conform to the constraints of what are, by definition, more rigid parts. This means that, while pedagogies are (to teachers) usually very soft technologies, they must be designed to fit into harder, more rigid technologies like timetables, fixed course lengths, curricula, assessment regulations, and so on. Pedagogies never, *ever* come first. Often, they are already built into harder elements of the learning

process, from the design assumptions of LMSs, to textbook sequences, to scripted lesson plans. Although these may be assembled in ways that make them softer, it is usually simpler to be part of the existing machine than it is to create a new one. Strict assignment deadlines coded into an LMS can easily be subverted by allowing submissions using email, for example, but demand more cognitive effort and time from all involved and lose the reliability and consistency of the harder system.

Technologies and Technique

Soft technologies demand technique. By *technique* I mean the idiosyncratic, ever-varying, often creative ways in which we may organize stuff to do stuff. For example, there is hardness in handwriting, insofar as the letters and words must follow recognized patterns sufficiently well to be understood by others, and (for any given style) it is possible to attain something close to perfection in its execution. However, no two people ever have identical handwriting, and there are many acceptable styles of handwriting from which to choose.

Techniques are technologies, too, are as much a part of the assembly as any other. They can always be developed, practiced, and refined in the process becoming harder. The harder technologies we create can then become parts in a further assembly. For example, a musician practicing scales rarely does so to play scales well, but to play other music better.

‘Perfect’ technique is typically difficult or impossible to attain because there are unknowably limitless ways it could be enacted. Objectively poor technique (in the sense of not implementing or using harder technologies correctly) may still provide plenty of room for expression, communication, and meaning-making, as well as interpretation by other co-participants. As always, it is the assembly that matters, not the parts. Whether through their own technique or how they inspire their students to use their own, an untrained teacher with passion who cares about *what* they are teaching and *who* they are teaching can often teach better with poorer methods than a well-trained teacher who does not care. Technique fills the gaps between us as much as it fills the gaps left by hard technologies.

There is little or no correlation between effective learning and either the number of technologies we use or the technical precision with which they are orchestrated. However, having a larger range of tools (including more refined technique) affords more opportunities to do more. Every technology we create provides new adjacent possible empty niches (Kauffman, 2019) that can be filled with new ways of doing and being. Also, using harder technologies that do some of the work for us, be they pedagogical, digital, organizational, or whatever, frees us to do more, at a greater scale, with less cognitive effort.

Implications and Consequences

There are many consequences of seeing learning, teaching, and education as co-participative technological phenomena. This section provides some examples of a few of the more striking of these.

‘Good’ Ways of Teaching are Not that Good

Because around half of all teachers are, statistically, average or below average, softer pedagogies such as those in the constructivist or complexivist traditions that demand skillful technique are, on average, likely to be less successful in achieving hard, pre-stated outcomes than harder pedagogies such as those from objectivist traditions, that may provide stronger guidelines and prescriptive methods for teaching. This is indeed, on average, what we find (Hattie, 2013; de Bruyckere et al., 2015) and, for a skilled and talented teacher, active learning approaches are superior (Andrews et al., 2011). Equally, because all learning technologies are at least a little soft, it is quite possible to use weak methods well. There are countless great teachers using apparently terrible methods whose technique more than compensates. In fact, because designated teachers are only a fraction of the teachers involved in any learning transaction, successful learning may often occur even when they fail to turn up at all (Dron, in-press).

Bad Teaching Can be Successful

In-person universities are often able to employ many teachers who have never learned how to teach because much of the teaching is done by the institution itself. Selection procedures help to ensure competent self-teaching students, almost regardless of what kind of formal teaching occurs. Students are pulled from their own environments into an environment that broadcasts that its purpose is learning in every corner. They are surrounded by other students who provide role models, who share ideas, who discuss and debate. They have libraries, common rooms, curricula, credentials to aim for, timetables to follow, syllabi, and textbooks. Regulations determine norms, expectations, and constraints. Even the act of travelling to a lecture theatre for the purposes of learning a specific topic creates salience and value that may matter as much as the lecture itself. Teaching is profoundly distributed, and deeply embedded in the technologies of the institution.

The No-Significant-Difference Phenomenon is Inevitable

It is not at all surprising that a small subset of the technologies used to support learning make no significant difference to the learning outcomes (Pei & Wu, 2019), because 1) it is how the parts are assembled that makes the technology, not the parts themselves and 2) this can be done better or worse, no matter what components are involved. The skill (of all participants, especially including students) with which it is accomplished matters far more than the pieces that are assembled to accomplish it.

The Two-Sigma Problem Cannot be Solved

Few, if any, methods of teaching are as effective as one-to-one tutoring (Bloom, 1982), because one-to-one tutoring is not a method: it is a situation, in which any method at all could be used. The close relationship between student and tutor means that tutors can adapt their methods as needed to the individual. Even if better methods were devised that would meet Bloom’s challenge, tutors could use them too.

Learning Styles Have No Value in Teaching

There is virtually no evidence that teaching to an individual's learning style has any value at all (Husmann & O'Loughlin, 2019). While it is clear that people do learn more effectively in different ways, it is likely because we learn methods of learning early in life, and we tend to prefer those that have (for whatever reason) previously been successful. We therefore preferentially practice them, improving our technique in using them. These are not learning styles but being-taught habits. But, even if there were any truth to any of the scores of contradictory learning styles theories, there are two big reasons it would have little value. Firstly, if it were true then it would also be true of teachers, and the chances that a teacher could teach using methods intended to cater for different learning styles with equal skill are close to zero: technique matters. Secondly, there will invariably be many other parts of the assembly that will have an equal or greater effect than methodical alignment with a learning style. But, even if it were effective, it would be unethical to act on it because we would be failing to teach students to learn using different methods, and the world in which they will become lifelong learners is not packaged to meet their learning styles. Being labelled as, say, an auditory learner would be little help if the objective were to learn to paint.

There is an Almost Total Absence of Replication Studies in Education

Only 0.13% of studies in top education journals are replication studies, most by the original researchers (Makel & Plucker, 2014). There is no need to despair of this because teaching is not a generalizable phenomenon that is susceptible to reductive research methods: it is a technology. Scientific theories and discoveries *may* certainly be parts of a technology assembly used for learning – they can be useful tools or phenomena in the orchestration - but only in orchestration with vastly many more parts that are not, any of which are likely to matter as much or more. Many of these are soft, so are dependent on the skills of the co-participants and never replicate. Replication is, for any non-trivial learning, therefore impossible. Moreover, the many co-participants involved are mutually affective, leading to unfathomably vast combinatorial complexity, rich in emergence and recursion, prone to chaotic chains of inter-reaction, so what we learn in trivial cases cannot be extrapolated to the non-trivial (Kauffman, 2019). Reductive scientific methods *may* be used to investigate behaviours of specific, well-defined hard technologies: the effects of changing the content of a SAT, for example. This may be useful in improving SATs, but that is all. In most cases, replication studies have no more value than any other story. Though methods, theories, models, and tools can provide vital scaffolds to support the process, teaching is a fundamentally human activity that cannot be reduced just to its technological parts. If we can better understand the technologies in which we co-participate, that we assemble with, through, and for others, if we can tell stories about them and share our discoveries, then we can create new adjacent possible empty niches for ourselves and others to build on. We and our co-participants will never assemble them in the same way twice, but we will all become better at doing so next time. This is the nature of education and the purpose of educational research. It is not just an inexact science. It is not a science at all. It is how we, collectively and individually, improve our toolset and our skills at using it.

Conclusion

Though technological in nature, education is not a machine. It is a process of learning to be part of a human society; of developing skills, values, and attitudes that help us to live, work, and play well with others; of being more capable of leading a rich and fulfilling life; of being useful contributors to our communities; of enabling us to learn continually and effectively throughout our lives. To achieve that we *do* need to learn hard skills, to engage with hard technologies, and to be parts of hard machines. Much of what we learn is concerned with attempting to create hard technologies within us, that we can assemble with others in order to achieve our purposes. Also, there is often much pleasure to be found in using even the most mechanical and mindless of technologies well, from sawing wood to doing the dishes. These are essential parts of the whole, without which education has no substance at all. However, these are means, not ends in themselves: parts of the assembly, not the reason for doing it. Soft technologies are what make the hard technologies matter, that lift the mechanical into spheres of imagination, value, engagement, and meaning. These are difficult to research, and impossible to define in terms of quantifiable objectives and outcomes, because they are always situated, always unique. Every assembly differs profoundly from every other that ever has been or will be.

The technologies around us are part of that cognition, too. From door handles that communicate their purpose (Norman, 1993) to smart systems that embed decision-making processes within their software or hardware, to all acts of communication with others through language, dance, music, and, indeed, every technology ever made, we share our cognition and discoveries with others. Our minds are extended through people and technologies in which we and others may participate (Clark, 2008), including those that are soft and unrepeatable.

Our technologies are what make human intelligence possible and are part of a fundamentally collective intelligence in which all of us (including the dead) may play a role. Learning is not just a phenomenon of the brain or body, but a means through which we and what we organize to do stuff become entangled with the stuff that *others* organize to do stuff. Our individual minds are made (in part) with technologies, and our technologies are embodiments (in part) of our minds. Technologies are not just extensions of our own minds, but they are how our minds become entangled in the minds of others. The educational process is thus not just an individual but a collective endeavour, a ratchet that lifts us all to greater heights, that connects us, that makes us who we are, and makes us more than we are.

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