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PHILOSOPHY OF TECHNOLOGY

The social nature of technology fixes

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Abstract. In this paper we argue that concerns about 'technological fixes' are often misguided because people misunderstand the basic concept, which is both value neutral and fundamentally about social issues rather than properly technical ones. After analysing and expanding the concept of a technological fix, these insights are applied to several cases, including an example from software engineering. We contend that decision-making processes involved with technological solutions and innovations need to build in more reflective components sensitive to basic human behaviour in order to be more successful.

Key words: philosophy of technology, philosophy of engineering, technology fixes, software engineering.

1. INTRODUCTION

The concept of a 'technology fix' is a twentieth-century notion. Believed to have been first used by Alvin Weinberg in the 1960s, the idea was that a variety of the problems facing humanity could be resolved through careful applications of technology.

> *In view of the simplicity of technological engineering, and the complexity of social engineering, to what extent can social problems be circumvented by reducing them to technological problems? Can we identify Quick Technological Fixes for profound and almost infinitely complicated social problem, 'fixes' that are within the grasp of modern technology, and which would either eliminate the original social problem without requiring a change in the individual's social attitudes, or would so alter the problem as to make its resolution more feasible? (Weinberg, 1966, 1967).*

Weinberg was a nuclear scientist who optimistically believed that the electricity requirements of humanity could easily be met through the proliferation of nuclear power, and done so with a minimal impact on the biosphere. He expanded his optimism, however, beyond electricity. One of his fixes was the intrauterine device (IUD), whose invention he believed could solve humanity's looming population crisis. The device "provides a promising technological path to the achievement of birth control without having first to solve the infinitely more difficult problem of strongly motivating people to have fewer children" (Weinberg, 1994). The IUD case is illustrative of the point we wish to highlight: technology fixes are ultimately about addressing human problems and human behaviour. For our purposes, we restrict the notion of a technology fix to this class of proposed solutions. A technological fix is a technical solution to resolve what is fundamentally a social problem (Etzioni and Remp, 1973).

Technological fixes have started to acquire a rather bad reputation. As Lisa Rosner writes, the term 'technological fix' "has become a dismissive phrase, most often used to describe a quick, cheap fix using inappropriate technology that creates more problems than it solves" (Rosner, 2004). One has moved, it seems, from the optimism of Weinberg to a contemporary pessimism. There are, to be sure, plenty of advocates for technological and engineering "fixes", but a troublesome cloud of doom and doubt remains attached

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to them, especially in the mainstream consciousness. These range from dire warnings about technological approaches, such as Bill McKibben's *Enough: Staying Human in an Engineering Age* (McKibben, 2004) or his more recent *Falter* (McKibben, 2019), to headlines such as "The Dangerous Belief That Extreme Technology Will Fix Climate Change" (Bajak, 2018).

We contend, however, that part of the reason for this shift in connotation may be attributed to a basic misunderstanding of the nature of technological fixes. Fixes are normatively neutral, neither good nor bad. But if one misunderstands their underlying nature, then one is more likely to run afoul of the types of problems that have given 'tech fixes' such a bad name. Part of the problem is that technological fixes bring to mind a certain class of phenomena that are relatively narrow, emphasize the technological in a manner that overshadows the social, and hence are potentially misleading. We argue that the concept of a technology fix must be broadened to highlight the need to address a more reflective component in such alleged fixes while focusing on the underlying human factors that ultimately ground them. What have been traditionally labelled as examples of tech fixes are actually a small part of a larger class of human phenomena. Once this recognition is in place, we argue that the concerns of technology fixes are actually problems of human behaviour and not problems of (the use of) technology, strictly speaking, at all.

We thus argue for two primary conclusions in this paper. First, technology fixes include a range of phenomena much wider in scope than generally believed. Technology fixes are unified as a particular kind of *social* phenomena that underlie the application of a technology. It means that technology fixes need to be seen from the perspective of motivating human behaviour in a particular context rather than solely from the perspective of the technical issue to be addressed. Second, technological fixes – like technology itself generally – are value neutral. It is doubtful that anyone would seriously argue that automobiles, when first introduced, constituted a deep social harm. Their introduction helped further industrialization and fuelled a general increase in human well-being. Yet today automobiles and the pollutants they produce arguably do present pressing harms. It is thus not the *automobiles* that are strictly the problem, but how (and how much) we *use* them in our contemporary context.

2. CLASSICALLY UNDERSTOOD TECHNOLOGY FIXES

We first need to establish that our expanded concept of a technology fix is appropriate. Let us start by discussing some 'classic' cases of technology fixes and then abstract away from those cases to identify the critical components of the fixes and argue towards the inclusion of cases less traditionally associated with tech fixes. All of this analysis is aimed at establishing the claim that technology fixes should be evaluated in terms of human behavioural upshots.

The clearest and arguably most invoked examples of tech fixes appear in the area of environmental problems. Contemporary ecologically informed scholars can point to a host of past examples where technological fixes went awry, whether causing new and often more pressing concerns, or simply shifting the issues to other, typically less visible, areas. Modern industrial mining presents a relatively clear case of moving pollutants from one environment to another without really addressing the core problem (the deleterious effects of the pollution) at all. Consider the case of the Anaconda Copper Mining Company and the Washoe copper smelter in Montana, USA. (For a more detailed discussion of the Anaconda Copper Mining Company case, see [LeCain, 2004]).

Copper smelting produces significant amounts of sulfur dioxide and arsenic that were historically released into the air. Such was the case at the Washoe smelter in the Deer Lodge Valley of southwestern Montana. Ore processing and smelting operations began at the site in 1902, and in 1918 the Anaconda Company built "The Big Stack" – a 585-foot brick chimney for releasing byproducts from the smelting process. When built, the area was rural and sparsely populated. As a result, the company made no effort to control the smelter's emissions. Within months of the opening of the original smelter in 1902, complaints about cattle deaths started. Animal autopsies quickly revealed that the cause of death in the majority of the cases was arsenic poisoning. Evidence accumulated over several years that emissions were also damaging trees in a nearby national forest.

The Anaconda Company then found the chemist Frederick Cottrell, who, while a professor at the University of California, Berkeley, had developed a device that could potentially remove much of the arsenic from the emissions of the smelter. Called an electrostatic precipitator, he claimed it could solve the pollution problem at the Washoe site. Eventually the Anaconda Company did employ the device (in 1923), which reduced arsenic emissions to about one-third of their previous level. The Anaconda Company then sold the precipitated arsenic to manufacturers making insecticides in the American South. Unfortunately, that still left considerable amounts of arsenic being dispersed into the air (by some estimates, about 25 tons of arsenic per day) (LeCain, 2004), unsold arsenic that had to be disposed of at the site, and the complications of arsenic being used on agricultural fields elsewhere. Some of the on-site (unsold) arsenic was used as a wood preservative for local construction projects. When the plant finally shut down in 1981, there were over 250,000 cubic yards of concentrated arsenic dust on the property needing to be treated or otherwise disposed of. The arsenic pollution was neither entirely relocated nor rendered harmless. In 1987 the U.S. Environmental Protection Agency relocated all of the citizens of nearby Mill Creek when it was discovered that arsenic had been spreading into the surrounding areas.

The Anaconda Company is considered a textbook case of a technology fix. The core problem was the pollution and its impacts on people and the biosphere, but the solution did not actually address those impacts. Instead, the alleged solution of the electrostatic precipitator shifted the problem (to a less visible form) without actually solving it. Consequently, there is some reason to think that the impacts of the pollution got worse as a result of the fix, harming more people and a larger portion of the environment of the United States than it might otherwise have done.

Consider another example: methadone. (For a fuller treatment, see [Etzioni and Remp, 1973]). A long-acting narcotic that lacks the euphorigenic properties of heroin, methadone has been proposed as a potential fix for heroin addiction. The idea is to provide methadone to heroin addicts and return them to normal lives. The effects of methadone are longer lasting than those of heroin and once at a maintenance dose, users do not need increasing doses. The 'high' of methadone is more consistent and prevents the withdrawal symptoms associated with other opiates. The side effects are few and often non-existent. A heroin addict can switch to methadone and live a normal life without having to find more heroin every four to six hours to maintain the high and avoid withdrawal. The effect of methadone can last more than a day, allowing addicts to become more functional.

The treatment is controversial. Some allege that substituting methadone for heroin does not actually address the underlying problem, namely the addiction itself. Methadone users remain addicted to a potent narcotic, and failure to remain on methadone produces withdrawal symptoms. As a result, methadone has been called a technological fix – an alleged solution that ignores the underlying problems and substitutes a proverbial band aid for genuine treatment.

Lastly, let us consider one specific case of agricultural genetic engineering. The underlying problem is human well-being in the face of hunger. The alleged technological fix is genetically engineering agricultural crops to increase food yields. One of the more famous of these projects is "Golden Rice," a genetically engineered form of rice designed not only to be widely accessible, but also to be rich in nutrients (particularly vitamin A) to help combat certain maladies that disproportionately impact the poor. Such genetic engineering is widely considered to be a technological fix. As Miguel Altieri puts it, "By challenging the myths of biotechnology, we expose genetic engineering for what it really is: another technological fix or 'magic bullet' aimed at circumventing the environmental problems of agriculture (which are the outcome of an earlier round of technological fixes) without questioning the flawed assumptions that gave rise to the problems in the first place" (Altieri, 2001). Note the emotional and morally loaded language that is associated with alleged technological fixes.

Complaints about Golden Rice are often strident. Some allege that genetic engineering is simply a profit-driven enterprise that trades on allegedly alleviating a social problem through technology while actually ignoring it. Genetically engineered crops can be expensive and often carry hidden costs (such as requirements to use the company's brand of other inputs and imposing penalties for non-compliance) (Altieri, 2001). Others complain that crops like Golden Rice, even if distributed freely, shift attention away from the actual problems, which are poverty, political instability, and other decidedly human concerns. That is, the claim admits that the problem *appears* to be a lack of food, when in fact the core problem concerns human institutions. The promotion of technological fixes allegedly ignores impediments that undermine the solution. For instance, white rice has social and religious significance in many cultures, which makes it unlikely that Golden Rice would easily replace it on a large scale. Perhaps most significantly, many argue that genetic engineering tends to ignore the unintended consequences that come with monoculture. Such crops are allegedly more susceptible to disease, are more likely to suffer catastrophic failures when certain pesticide-resistant pests adapt to the crop, and suffer increased problems with the depletion of nutrients in the soil.

These three examples (arsenic scrubbers in copper smelting, methadone treatment for heroin addicts, and genetically engineered crops to address hunger) all share the same basic feature: they are all instances where a technological innovation has been proposed to address what is, at bottom, a social harm. The technological innovation, however, does not actually address the underlying *social* problems rooted in human behaviour, and thus allegedly fails to be an effective remedy. Yet despite the apparent clarity of this point (and indeed, it is difficult to imagine humans being interested in solving problems that are not, at bottom, *social* harms in any event), we find that this fundamental feature of technology fixes is not always well understood. The scientific and technological solutions proposed were not themselves the problem – each was a tool that was fundamentally poorly used because they did not reflectively take into account the fundamentally social nature of the concerns they were intended to address.

3. EXPANDING THE CONCEPT OF A TECHNOLOGICAL FIX

We argue that the phenomenon here is actually broader than one might at first believe. What is occurring with an instance of a technological fix is essentially the same phenomenon that happens when a patient prefers a pill to a lifestyle change to address a medical problem. That is, the 'problem' with technological fixes is essentially about behaviour and not technology. There is nothing wrong with applying a technological innovation to solve a technological problem. Developing new crops to increase crop yields is, *ceteris paribus*, a wonderful advancement. The issue is, in part, what people *expect* from the technological fix in terms of addressing underlying social concerns. People expect a technological innovation to solve social problems, and then blame the resultant failure on the technology. Let us consider three additional examples of technological fixes to clarify our understanding of the concept: eyeglasses, seizure disorders (especially childhood epilepsy), and social media.

It is not certain when eyeglasses were invented. The Romans discovered the ability to use glass to enhance their ability to see small things, but the earliest recorded instance of (more or less) wearable eyeglasses dates back to the thirteenth century in Italy. Primitive glass-blown lenses were set into frames of wood, horn, or leather and held before the face. Temples (the 'arms') on glasses for hands-free use were added in the seventeenth century. Whenever they were invented, eyeglasses constitute a rather potent technological solution to the relatively common problems of viewing small items and instances of defective vision. The point is to note that technology fixes are surprisingly prevalent when one stops to think about the concept, and often they are innocuous as well.

Consider another, more complicated example. Epilepsy is a disabling neurological disease that causes seizures. It occurs in both adults and children. Many cases of epilepsy can be controlled with one of a number of antiepileptic drugs, but approximately 30–35% of patients have 'refractory' epilepsy, which is defined as epilepsy where at least two trials of appropriately chosen antiepileptic drugs have failed to relieve seizures (D'Andrea Meira et al., 2019). It should be noted that a successful application of a drug does not necessarily eliminate seizures; success is measured by reducing the frequency of seizures in patients. Despite nearly a century of pharmaceutical work and many new anti-epileptic drugs, about 35% of patients remain refractory.

Interestingly, dietary approaches to treating seizure disorders have been studied since at least the 1920s, with results that are arguably better than any of the primary anti-epileptic drugs currently being used. The problem, of course, is that treatment options that significantly alter the diet of patients are psychologically hard to maintain, especially if the prescribed diet involves avoiding addictive substances such as sugar. Such is precisely the case with ketogenic diets that have been studied as treatment options for children with refractory epilepsy. Ketogenic diets greatly restrict sugar and carbohydrate intake, emphasizing high fat and moderate protein meals instead. Consider one telling discussion:

> *In general, 10–15% of children who initiated the diet were seizure free 1 year later, 30% had a >90% reduction in seizures, and 40% to 50% found that the diet was either too difficult to continue or insufficiently effective and therefore discontinued it during the first 6 months* (Freeman et al., 2007).

Ketogenic diets have been shown (with reasonable consistency) for 100 years to be an effective treatment for childhood seizure disorders (at least as effective as pharmaceutical options), but most parents reject the option. Those who consent to start the diet for their children frequently do not finish the course of treatment, even when the results are positive. Unsurprisingly, there is a correlation between the perceived effectiveness of the treatment and its perceived restrictiveness (Freeman et al., 1998). Parents complain that it is unfair to seriously reduce the sugar and carbohydrate intake of children, or complain that diets without them are too difficult to maintain. Parents who report early successes on the diet, however, report no problems with the diet and do not claim it to be too restrictive.

We maintain that this case study is an example of a technological fix. It might look superficially different, but the underlying structure of the case is exactly the same as the previous examples. A technological innovation (new drugs) is proposed to solve a 'human' problem. The problem we are trying to solve is the presence of debilitating seizures in children with refractory epilepsy. There is a solution that scientific study suggests might be generally effective. That solution, however, requires a *social* (behavioural) change: parents must modify the behaviour of their children, specifically in terms of what they eat day in and day out. But there is a fix: additional pharmaceuticals. Thus, the question arises as to whether 'successful' drugs actually treat the underlying problem – namely, what is causing the seizures – or whether they simply treat the symptoms while enabling patients to continue behaving in ways that might undermine their own health goals. If the underlying problem is fundamentally related to diet, then no additional pharmaceutical fixes are likely to produce a definitive solution. To be fair, the same question can and should be asked of proposed dietary approaches as well. But here we are focusing on what we take to be the critical distinction. Dietary solutions involve changes in social behaviours whereas taking drugs shifts much of the burden to a technical issue (the efficacy of the drug with respect to alleviating symptoms), leaving the underlying medical issues potentially untouched. If one administers pharmaceuticals to children, expecting that a drug alone will solve the underlying health problems that are likely importantly tied to diet, then it is the case of a technological fix in its worst form. Note, however, that the pejorative sense of a "tech fix" is tied to the expectations people have about the ability of technology to solve problems that also involve human behaviour.

Consider a yet less obvious example. Facebook addresses certain social needs (or at least wants and desires) of persons. In our populous and complicated modern society, interpersonal interaction can be daunting and people often find it difficult to establish meaningful connections with others. Facebook is a kind of tech fix for people (even introverts) that provides an allegedly safe environment to interact with people all over the planet. But Facebook by itself is not a root cause solution. It does not directly address the underlying problem: the difficulty developing interpersonal connections when there is physical separation (and it does not physically bring people together). There is a sense, as a result, in which it is inappropriate to *expect* Facebook to 'solve' the problem of social distancing in society. As Facebook grew into an increasingly centralized, monopolistic, and in some respects unchecked presence, so too ensued a host of unintended consequences: loss of privacy, commercialization that allows for exploitation, and various kinds of social manipulation that extend to influencing elections and altering public opinion (Adams, 2018; Davis, 2018; Dutt et al., 2018; Riedel and Knoop, 2018). Real-life bullying and stalking now have cyber versions enabled, and perhaps exacerbated, by social media platforms. As people tend to post only positive things about themselves, these platforms also create false exemplars for people, generating unrealistic expectations about what constitutes well-being. Such distortions have been associated with increased suicide rates, depression, and more (Yoon et al., 2019). All of the familiar problems with social interaction accompanied the innovation of Facebook.

Even if Facebook was not explicitly created or intended as a technology fix for interpersonal communication, it can clearly be viewed as a tech fix. According to a popular story, it was created simply out of a 'can-do' attitude by Mark Zuckerberg (Carlson, 2010). Consider the history of Zuckerberg's creation. He gathered a little social network experience with his "Facemash" site, allowing students to rate the hottest person out of two pictures of students presented. It gained popularity quickly, but also generated complaints from professors because of alleged offensive content. Zuckerberg was nearly expelled due to violating university privacy concerns and he encountered intellectual property problems with his simultaneous launch of HarvardConnection alongside the actual foundations of the Facebook Website.

Zuckerberg moved on from these beginnings, creating "TheFacebook," claiming to be better able to execute such a project than the school administration. Zuckerberg later stated that it was his intention to create a universal website connecting people around the university (Cassidy, 2006). "By luck or design, Zuckerberg had tapped into a powerful yearning: the desire of hundreds of ambitious and impressionable young people to establish themselves and make friends in an unfamiliar environment" (Cassidy, 2006). Facebook is easy to use, especially given other technological developments such as cell phones and the prevalence of complementary software programs that automate or perform a variety of additional functions. People used to regularly call one another, now they "keep up with one another" on Facebook. This "keeping up," however, is a profoundly solitary set of actions. It is more convenient and can be done whenever (and increasingly wherever) one wishes. It is arguably easier to post comments and pictures on one's own schedule without having to worry about the concerns or schedules of others. Facebook is a technological fix for the problem of social isolation that does not necessarily engage the underlying issue of how human behaviour generates that very isolation. Whether Zuckerberg intended that solution is not relevant; people have *made* Facebook into such a fix independently of his original design.

Thus, it can be seen that the concept of a technological fix encompasses a broader set of examples than one might initially recognize. An obvious additional example, especially given the COVID-19 pandemic, is the nature of vaccines. Although we are not going to argue it here due to limited space, we believe that our analysis applies well to vaccines. Here the social nature of technological fixes is yet more apparent, given the concerns about anti-vaccination sentiments and (often mistaken) beliefs about how vaccines work (for example, the belief of some with COVID-19 that once vaccinated, masking is not required and viruses can no longer spread). Equipped with this sharper conception of technology fixes, we now briefly discuss the centrality of behaviour before testing our expanded conception by applying it to contemporary discussions in software engineering.

4. THE BEHAVIOURAL COMPONENT AND A NEW MODEL

Simply noting that the root causes of the issues that tend to produce technological fixes are social is not particularly insightful. What is required is some sort of guide or model that allows one to more reliably and effectively evaluate proposed technological solutions. We suggest that the application of insights from behavioural psychology and behavioural economics provides an opportunity to develop a superior model, or more accurately, to develop a heuristic that guides what models and fixes we use in varying contexts. In short, technological proposals need to include analyses of their impacts in light of the increasingly sophisticated understanding of human behaviour. These analyses must include not only the social upshots of any program, but also the nature of those tasked with implementing the fix as well.

What one might call a 'behavioural revolution' has occurred in the social sciences: the recognition that oddities or superficially suboptimal behaviours display predictable regularities. Instead of carefully engaging the world through reason, human beings more often use heuristics that are mental 'short-cuts' that enable them to cope with decision-making in a complex environment. Often these 'shortcuts' owe to evolutionary features, but regardless of their origin, understanding that humans are *predictably* influenced by biases and other kinds of factors that shape decision-making is critical to evaluating solutions that involve humans, even if those solutions are 'technological.' Kahnemann (in collaboration with Amos Tversky) laid the groundwork in his now famous book *Thinking Fast and Slow* (Kahneman, 2011), but similar insights are now regularly applied in many fields. Thaler and Sunstein argue in their work *Nudge: Improving Decisions About Health, Wealth, and Happiness* that public policy should be shaped by manipulating these regularities. Their proposals include altering the 'decision-architecture' of choices like whether (and how much) one should contribute to retirement savings programs and even how food is presented in public schools to encourage the selection of certain of (allegedly healthier) food (Thaler and Sunstein, 2009). Some of the upshots are impressive. Noting that people are strongly susceptible to inertia and a status quo bias, some researchers experimented with altering how organ donation programs work. In Europe, countries that allow drivers to opt into a program of organ donation by taking an additional step (signing a release) have participation rates that are relatively low, whereas nations who have similar programs but allow drivers to opt *out* of the program (i.e. the default selection is to participate) have extremely high rates of participation. Altering the default option significantly impacts the behaviour of people (Childress and Liverman, 2006; Thaler and Sunstein, 2009). One has now a reasonably good understanding that people are subject to predictable biases for the status quo.

This article is not the place to review the considerable and growing literature in a variety of fields concerning behavioural psychology. Critiques of the field are numerous. For a start, see (Ariely, 2009), (Hummel and Maedche, 2019), and (Puaschunder, 2018). Furthermore, there is controversy when it comes to how to *apply* these insights in policy contexts, with some arguing that it amounts to manipulation and threatens increased governmental coercion. For our purposes, we remain neutral with respect to that issue. Our point is that, however implemented, policies that employ technological fixes need to take account of these advances in the understanding of human behaviour. Doing so will clarify the concept of a technological fix and how they might be better evaluated to avoid unpleasant or ineffectual outcomes.

Thus, what does the addition of behavioural insights imply for conceptualizing technological fixes? In short, it requires that policy makers and other proponents of technological fixes (a) add a reflective component to the process that explicitly considers the behaviour of agents (applied to *both* those who are developing/implementing solutions while they do so *and* the individuals impacted by these policies) as they interface with the new technology, and (b) articulate explicit ends and values for the policy/proposal that focus on what we have characterized as 'root cause' issues. Lowering the amount of CO_2 in the atmosphere might be a nice thing to do, but the *underlying* issue is not greenhouse gases but how humans behave given their incentives and the current state of the world.

Consider, just as a quick start, the problem of refractory epileptic seizures in children. Pursuing a new pill that might provide some relief for some patients but leaves the underlying dietary behaviours unchanged is arguably a less effective policy than a proposal that *also* engages the human decision-making that is integral to the health of the afflicted persons. This might involve, for instance, developing drugs that come with behavioural prescriptions.

5. APPLICATION TO SOFTWARE ENGINEERING

We now turn to apply our analysis to software engineering. We contend that so-called 'failures' in information and software systems, even when clear examples of problems associated with employing technological fixes, may be better understood and then corrected by recognizing that even in highly technical fields the core issues tend to be *social* and not strictly technical. The technical solutions, even when they fail, are themselves value neutral. The real issue lies in *connecting* the technical aspects of software engineering with the underlying social constraints that impact both development and use.

At the outset, understanding the impact of our conceptual analysis on software engineering requires recognizing what is happening in software development projects. Before software is implemented, there is usually a phase in its development called 'requirements engineering.' Even in modern agile software development processes this phase exists and attempts to accurately characterize the problem to be solved and define at least a first prototypical milestone to be achieved. What follows is an admittedly simplified representation of modern software development. Orthogonal developments to agile development processes include user centered design (UCD) (Rubin and Chisnell, 2008) and design thinking (Wölbling et al., 2012). These share many of the properties with agile software development. Both approaches behave similarly as each stresses the importance of feedback cycles with actual users. However, in this paper we prefer the closer comparison to agile as its feedback mechanism and flexibility in allowing the actual problem to change over time is closer to a normative solution that we intend to elaborate on in future work.

Consider the example where one is tasked to build an alternative social network site to give some options to Facebook. One would probably first sit down and discuss the set of features intended for this site to offer, such as an attractive login screen, a list of posts, possibilities to define friends, access content about people, and so forth.

These features and artifacts are called requirements and the process of finding and defining them is called requirements engineering or requirements analysis. The requirements engineering phase can be much larger in terms of time and scope than the actual development and implementation phase. Traditionally, one would think a long time about all the features that could potentially make a new social network site attractive, and would do so in advance of actually developing the software. Research would be done to determine which users could (or should) be attracted, what type of things could be shared, how issues surrounding permissions and privacy would be handled, and one might even try to forecast potential legal issues and strategize about how to handle them. However, more recent approaches visit the requirements phase more often, "spreading out" such brainstorming over the entire development process. As we learned from Facebook's case, problems regarding privacy, the creation of echo chambers, and copyright related issues can arise much later *after* implementing the initial prototype. Having an opportunity to go back and re-evaluate the initial requirements before final implementation is a great potential boon. Perhaps one might build in opportunities for change after the new program is deployed on a test group, talking with the people who participated in the trial about *social* concerns, as well as the technological features of the program. Modern software development processes typically leave some space for such re-evaluations with respect to 'technological' issues (ease of use, compatibility issues, and so forth), but often do not include more social requirements that are easy to overlook in the process. This type of requirements analysis is generally considered an important phase in a software development process. Looking at the requirements (and eventually re-assessing them) is important for building software that solves existing problems. Yet it turns out that often the actual user is overlooked in software development projects, leading to an acceptance problem where the users reject the product. Sometimes this rejection is attributable to the simple fact that they were not part of its creation. Also, there are often no ways for developers to report back the problems discovered while *implementing* the software once past certain stages of the development process.

Consider a classic example of failure with respect to the software development process that is suggestive of the dangers of a technological fix: the London Ambulance Service Aided Despatch System (LASDAC) (Beynon-Davies, 1995). The software designers for the ambulance service essentially ignored the feedback of the users as well as developer warnings during the process. In this multi-million-pound project, new software for the London Ambulance Service was developed to dispatch ambulances all over London with the aim of reducing response times for emergency calls. It was supposed to replace the existing manual dispatch system but produced a catastrophic failure upon its deployment and was potentially complicit in multiple deaths that were otherwise likely avoidable. At least 20 people might have lost their lives as a result of the failure (Page et al., 1993; Beynon-Davies, 1999).

The program was designed to route incoming emergency calls to a central location where the calls would be logged and caller information would be processed (nature of the emergency, location, etc.). The relevant information would then be transmitted to an 'allocator' who, having pinpointed the patient's location, would dispatch an ambulance along with pertinent information about the emergency. The alerted ambulance crew would confirm receipt of the dispatch call and the ambulance location would be monitored to ensure efficient arrival at the scene. The program used Microsoft Windows and other specialized software, running on a series of personal computers and file servers. The system was deployed on 26 October 1992 and problems started immediately. The system soon received a spike of '999' calls (for Americans: similar to '911' calls in the United States), causing an increase in incorrect information being reported and flooding the screens of the operators with calls and warnings. Some operators claimed that some of the calls then scrolled off their screens, causing confusion and triggering alarms that led to further chaos. Inefficient ambulance allocations were made as a result and dispatch times reached as high as three hours. Added complications emerged when callers had trouble relating accurate information quickly, as is not unexpected in cases where people are panicked or under severe stress. As the subsequent IT services director of the London Ambulance Service Ian Tighe noted, 'Members of the public who call us are often distraught – they need to rattle out a problem. We can't say to them, "Will you hold on while I bring up this computer screen?" In that situation, staff are going to go back to using paper and pencil' (Masters, 1997). The technological fix of an advanced software system designed to improve emergency service response time was a clear failure.

After the failure of the initial program, however, a successor project met with greater success (Fitzgerald and Russo, 2005). Today such computerized dispatch systems are common and function well. Clearly, we argue, the problem was not that a new technology was deployed. The questions are now: what went wrong and what changed in the second project that enabled greater success? We suggest that the initial experience of the developers was essentially a poorly understood technology fix: they failed to employ a process that was sufficiently sensitive to the social and behavioural aspects of their project. And when a more reflective and attentive process was put into place, greater success was had.

We thus start by concurring with the public inquiry, which concluded: "On 26th and 27th October the computer system did not fail in a technical sense. Response times did on occasions become unacceptable, but overall the system did what it had been designed to do. However, much of the design had fatal flaws that would, and did, cumulatively lead to all of the symptoms of systems failure" (Page et al., 1993). The system *did* have a technical failure later in November as a result of a programming error, but this was arguably the least of the problems of the program. For a variety of reasons, the system had not been properly tested, the dispatch and the ambulance crews were not adequately trained, and there was a serious lack of communication between the management, staff, and developers. As a result, despite warnings that the development timetable was overly ambitious, a poorly managed program was mistrusted by all who used it and proved unable to handle even the routine work it was designed to make more efficient. As the subsequent public report noted, the problem was not simply one of software failure; the problem was that what the software *needed* to do and how it *needed* to function were largely ignored. For instance, the system essentially assumed that the data input by the crews in the field and the dispatch operators would be largely perfect the first time, despite the high stress nature of the work being done. To make matters worse, as errors grew, alarms in the program were triggered, increasing the stress level and confusing the screens of the dispatch operators. The users of the system were not involved in its creation and thus expected the system to fail, probably compounding whatever problems otherwise arose. These are decidedly *human* factors.

In a later statement about the successor project published in Personal Computer World, Avril Hardy, the development manager for Central Ambulance Control at LAS at that time, reports several positive changes regarding stakeholder inclusion being responsible for the success under its new service's IT director Ian Tighe. Hardy contrasts the collaborative approach of Tighe's team with the first attempt in 1992. 'The first time, users didn't have any input in the early stages of the project, but once the system was there, they probably had too much input. The suppliers were too willing to make changes the minute someone said "wouldn't it be nice if ...?"' (Masters, 1997). Hardy points out that the first project did not allow any input of the "users" into the requirements analysis ("in the early stages"), and after allowing them to use the "final" system they got too much input and were indiscriminate about how the feedback should be processed. In the new attempt under Tighe, the users were involved in the creation of the new system, their "needs" were taken into account. Not surprisingly that led to more acceptance and a cultural shift in valuing the created product and, therefore, standing behind this fix. Instead of going over the heads of users like in the initial LASDAC development, they were involved from the start. "This time, the IT director and his staff started by talking to us about what we might need" (Masters, 1997). Tighe also implemented an incremental approach involving several steps and intermediate prototypes, allowing for adjustments and feedback from the actual users multiple times during development. It also resulted in the actual stakeholders rating the outcome positively. Hardy remarks that winning the "confidence" of the users (both dispatchers and ambulance crews, for examples) was a key part of providing a solution that was accepted by its users. This involvement and communication showed the users that the provided fix was really adding value to their process and solving a problem for them through technology (software and the computers on which it ran).

The second attempt at a computer-aided dispatch system shows how important the amount of prototyping is to allow the stakeholders to give feedback and increase buy-in. Seeing some quick but not final and maybe even error-filled results led to a better end result as it helped make every involved stakeholder aware of the challenges and made them complicit in developing effective solutions. All of this shows – even if not named as such – how a more reflective and behavioural-centered approach successfully integrated stakeholders, reacted to changes, mitigated risks, achieved acceptance, and ultimately succeeded. And thus one reaches the critical point: the changes that were implemented to make the system successful were not generally technological changes at all. The problems with the implementation of the system were fundamentally *social*. The dispatchers and crews needed to understand and accept the system, needed to have proverbial 'buy-in' and feel a part of the process. We thus conclude that the London Ambulance Service case demonstrates that technological fixes are themselves value neutral – there was no wrong per se with the software or the attempt to implement a computer-aided dispatch system – but any such technological project must be understood as having a critical social component. In order to meet with success when implementing technological innovations, careful attention must be paid *primarily* to the social features of any such changes.

6. CONCLUSION

In some respects our conclusions are not new. Others before us have noted that problems with projects are more often behavioural in nature rather than strictly technical. As T. J. Pinch's study of the space shuttle Challenger disaster reveals, even *diagnosing* a purely technical problem is complicated by human factors dependent on understanding how persons tend to behave (Pinch, 1989). Thus, we argue that *solving* problems with sophisticated technical elements must also pay careful attention to human behaviour at every point in the process.

Recognizing the ineliminable element of humanity in the occurrence of technological fixes allows one to note that the "fixes" themselves are not necessarily the problem. A fix is value neutral. Whether it is an appropriate solution depends on the ends and means being employed. Developing a process to smelt copper that reduces arsenic emissions is a great technological achievement, just as is crafting pharmaceuticals to treat symptoms of epileptic diseases. But some technological fixes get a bad reputation because they are not 'fixing' the actual problem that people (often unconsciously) wish to address. Sometimes the fixes defer or shift the problem, but sometimes they actually work. It depends on how well one accounts for human behaviour. We think people might be hard pressed to deny the success of optical lenses in solving problems associated with poor eyesight or with the need to view small objects. Tech fixes are not automatically good or bad – they are descriptively what they are. The issue then becomes *when* the normative element *can* reasonably enter the decision-making and developmental process that leads to a policy.

Often it is not known what the cause of an identified problem is, so one might not understand the root cause until later. Let us look, for example, at the Facebook case: they wanted a dating application (and later a student's profile application) but discovered that there was a larger need for a social communication platform. They built something that helped their dating needs, but it became a tech fix for broader social issues, which in turn generated unintended consequences that are now pressing and difficult to handle.

At some point when one believes that a policy or tech fix is failing, we suggest that one *first* needs to look to human behaviour: build in reflective and recursive elements that apply explicitly social concerns, which occur in almost all processes earlier than many people believe. When Facebook started to become immensely popular, that was the time to reflect on consequences and behavioural issues instead of just enjoying profit. Reflection happens naturally and comes from different avenues, but it needs to be institutionally encouraged and made widespread. For example, in the agile software manifesto, one marks in the code (as a comment) concerns about possible consequences. Thus, even if one cannot predict the implications, developers are encouraged to make a note of it anyway and revisit it consistently.

The lesson is simple: we should not fear technological fixes. Nor should we seek to constrain them in some misguided attempt to set technology against human needs and interests. Instead, we should fear bad processes – technological and otherwise – that ignore social concerns and the basics of how human persons behave. Technological processes and innovations are fundamentally *human* endeavours.

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REFERENCES

Adams, T. 2018. Facebook's week of shame: the Cambridge Analytica fallout. The Guardian. https://www.theguardian.com/technology/2018/mar/24/facebook-week-of-shame-data-breach-observer-revelations-zuckerberg-silence

Altieri, M. A. 2001. *Genetic Engineering in Agriculture: the Myths, Environmental Risks, and Alternatives*. Food First/Institute for Food and Development Policy, Oakland, CA.

Ariely, D. 2009. *Predictably Irrational, Revised and Expanded Edition: The Hidden Forces that Shape Our Decisions.* Harper Collins, New York, NY.

Bajak, A. 2018. The dangerous belief that extreme technology will fix climate change. The Huffington Post. https://www.huffpost.com/entry/geoengineering-climate-change_n_5ae07919e4b061c0bfa3e794

Beynon-Davies, P. 1995. Information systems 'failure': the case of the London Ambulance Service's Computer Aided Despatch project. *Eur. J. Inf. Syst.*, **4**, 171–184.

Beynon-Davies, P. 1999. Human error and information systems failure: the case of the London ambulance service computer-aided despatch system project. *Interact. Comput.*, **11**(6), 699–720.

Carlson, N. 2010. At last – the full story of how Facebook was founded. https://www.businessinsider.com/how-facebook-was-founded-2010-3

Cassidy, J. 2006. Mark Zuckerberg and the making of Facebook. https://www.newyorker.com/magazine/2006/05/15/me-media (accessed 2020-08-19).

Childress, J. F. and Liverman, C. T. (eds). 2006. *Organ Donation: Opportunities for Action.* National Academies Press, Washington, D.C.

D'Andrea Meira, I., Romão, T. T., Pires do Prado, H. J., Krüger, L. T., Pires, M. E. P. and da Conceição, P. O. 2019. Ketogenic diet and epilepsy: what we know so far. *Front. Neurosci*., **13**, 5.

Davis, S. 2018. Russian Meddling in Elections and Referenda in the Alliance. Report. NATO Parliamentary Assembly, Science and Technology Committee. https://natolibguides.info/nato-russia/reports

Dutt, R., Deb, A. and Ferrara, E. 2018. "Senator, we sell ads": analysis of the 2016 Russian Facebook ads campaign. In *International Conference on Intelligent Information Technologies*, pp. 151–168, Springer, Berlin.

Etzioni, A. and Remp, R. 1973. *Technological Shortcuts to Social Change*. Russell Sage Foundation, New York, NY.

Fitzgerald, G. and Russo, N. L. 2005. The turnaround of the London ambulance service computer-aided despatch system (LASCAD). *Eur. J. Inf. Syst*., **14**(3), 244–257.

Freeman, J. M., Vining, E. P., Pillas, D. J., Pyzik, P. L., Casey, J. C. and Kelly, L. M. 1998. The efficacy of the ketogenic diet–1998: a prospective evaluation of intervention in 150 children. *Pediatrics*, **102**(6), 1358–1363.

Freeman, J. M., Kossoff, E. H. and Hartman, A. L. 2007. The ketogenic diet: one decade later. *Pediatrics*, **119**(3), 535–543.

Hummel, D. and Maedche, A. 2019. How effective is nudging? A quantitative review on the effect sizes and limits of empirical nudging studies. *J. Behav. Exp. Econ.*, **80**, 47–58.

Kahneman, D. 2011. *Thinking, Fast and Slow*. Farrar, Straus and Giroux, New York, NY.

LeCain, T. J. 2004. When everybody wins does the environment lose? The environmental techno-fix in twentieth-century American mining. In *The Technological Fix: How People Use Technology to Create and Solve Problems* (Rosner, L., ed.), pp. 137–153, Routledge, New York, NY.

Masters, S. 1997. Emergency room: London's Ambulances won't crash again, says new IT expert. Personal Computer World. https://web.archive.org/web/20070927184407/http://www.pcw.co.uk/computing/analysis/2073427/emergency-room-london-ambulances-won-crash-again-expert (accessed 2020-07-28).

McKibben, B. 2004. *Enough: Staying Human in an Engineered Age*. Griffin, New York, NY.

McKibben, B. 2019. *Falter: Has the Human Game Begun to Play Itself Out?* Wildfire, London.

Page, D., Williams, P. and Boyd, D. 1993. Report of the Inquiry into the London Ambulance Service, February 1993. South West Thames Regional Health Authority, London.

Pinch, T. J. 1989. How do we treat uncertainty in systems failure: the case of the space shuttle Challenger. In *Social Responses to Large Technical Systems: Control or Anticipation* (La Porte, T. T., ed.), pp. 143–158, Kluwer Academic Publishers, Berlin.

Puaschunder, J. M. 2018. Nudgital: critique of behavioral political economy. In *Proceedings of the 9th International RAIS Conference on Social Sciences and Humanities, Princeton, NJ, USA, April 4–5, 2018*. Scientia Moralitas Research Institute, pp. 87–117.

Riedel, G. A. and Knoop, C.-I. 2018. Facebook–Can Ethics Scale in the Digital Age? Harvard Business School. https://hbsp.harvard.edu/product/319030-PDF-ENG

Rosner, L. 2004. *The Technological Fix: How People Use Technology to Create and Solve Problems*. Routledge, New York, NY.

Rubin, J. and Chisnell, D. 2008. *Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests*. John Wiley & Sons, Hoboken, NJ.

Thaler, R. and Sunstein, C. R. 2009. *Nudge: Improving Decisions About Health, Wealth, and Happiness*. Penguin Books.

Weinberg, A. M. 1966. Can technology replace social engineering? *The University of Chicago Magazine*, **59**(1), 6–10.

Weinberg, A. M. 1967. *Reflections on Big Science*. MIT Press, Cambridge, MA.
Weinberg, A. M. 1994. *The First Nuclear Era: The Life and Times of a Technological Fixer*. AIP Press, New York, NY.
Wölbling, A., Krämer, K., Buss, C. N., Dribbisch, K., LoBue, P. and Taherivand, A. 2012. Design thinking: an innovative concept for developing user-centered software. In *Software for People: Fundamentals, Trends and Best Practices. Management for Professionals* (Maedche, A., Botzenhardt, A. and Neer, L., eds), pp. 121–136, Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-31371-4_7
Yoon, S., Kleinman, M., Mertz, J. and Brannick, M. 2019. Is social network site usage related to depression? A meta-analysis of Facebook–depression relations. *J. Affect. Disord.*, **248**, 65–72.

Tehnoloogiliste uuenduste sotsiaalne olemus

Marc Hight ja Ulrich Norbisrath

Artiklis on väidetud, et mõistet “tehnoloogiline lahendus” (*technological fix*) mõistetakse tihti valesti, sest pannakse liigset rõhku sõnadele “tehniline/tehnoloogiline”. Antud termin kätkeb endas rohkem väärtusneutraalsust ja sotsiaalset küsimust kui tehnilist. Pärast tehnoloogiliste lahenduste arusaama analüüsimist ja laiendamist on leitud järeldusi rakendatud mitmele juhule, sealhulgas näiteks tarkvaratehnikale. On jõutud järeldusele, et innovatsiooni ja tehnoloogiliste lahenduste otsustusprotsess on seda tulemusrikkam, mida enam võtta arvesse inimkäitumise põhialuseid.