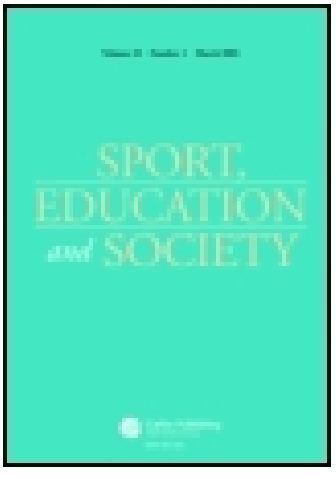

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Ben Williamson[a]
[a] School of Education, University of Stirling, Stirling, UK
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Algorithmic skin: health-tracking technologies, personal analytics and the biopedagogies of digitized health and physical education

Ben Williamson*
School of Education, University of Stirling, Stirling, UK

The emergence of digitized health and physical education, or 'eHPE', embeds software algorithms in the organization of health and physical education pedagogies. Particularly with the emergence of wearable and mobile activity trackers, biosensors and personal analytics apps, algorithmic processes have an increasingly powerful part to play in how people learn about their own bodies and health. This article specifically considers the ways in which algorithms are converging with eHPE through the emergence of new health-tracking and biophysical data technologies designed for use in educational settings. The first half of the article provides a conceptual account of how algorithms 'do things' in the social world, and considers how algorithms are interwoven with practices of health tracking. In the second half, three key issues are articulated for further exploration: (1) health tracking as a 'biopedagogy' of bodily optimization based on data-led and algorithmically mediated understandings of the body; (2) health tracking as a form of pleasurable self-surveillance utilizing data analytics technologies to predict future bodily probabilities and (3) the ways that health-tracking produces a body encased in an 'algorithmic skin', connected to a wider 'networked cognitive system'. These developments and issues suggest the need for greater attention to how algorithmic systems are embedded in emerging eHPE technologies and pedagogies.

Keywords: *Algorithms; Analytics; Biopedagogy; Data; Dataveillance; Health tracking; Self-quantification*

What does the study of computer algorithms have to offer to research in health and physical education? In a recent article in *Sport, Education and Society*, Evans and Davies (2014) argue for a research agenda exploring new forms of the governance of health and physical education curricula and pedagogy, while in his provocation for this new Research Forum section of *Sport, Education and Society*, Gard (2014) demands that researchers consider critically the 'digital future' of health and physical education. Responding to both, this article explores an important emerging dimension of governance in the digital future of health and physical education: the current growth of digital technologies designed to enable students to track, monitor and analyze their physical activity. Variously referred to as self-tracking, personal

*School of Education, University of Stirling, Pathfoot, Stirling, FK9 4LA, UK. Email: ben.williamson@stir.ac.uk

informatics, personal analytics or technologies of the 'quantified self', these digital technologies are part of a rapidly growing global market in wearable electronics and biosensor platforms designed to allow users to collect and analyze biophysical data on their own physical activities and health. Designed around algorithms and physiological models expressed in computer code, these devices are increasingly augmenting, mediating and governing the ways in which individuals and social groups engage with their own bodies and health, and transforming the ways that people undertake physical activity.

This article is based on an initial survey of health-tracking products designed for use by schoolchildren. Rather than viewing such products in isolation, I consider them in the context of emerging empirical and theoretical literature on self-tracking in order to raise some critical challenges for the future of physical education. I further situate these technologies as part of an emerging trend to configure schools as 'data platforms' within which a wide range of data tracking, sensing and analytics technologies are being mobilized to monitor and measure student activities, performances and outcomes (Mayer-Schönberger & Cukier, 2014). The emergence of what I term 'smart schools' in which networked database technologies have been thoroughly embedded (Williamson, 2014a), and that Lupton (2014) calls 'sentient schools', signifies how data-tracking technologies are now being positioned to provide a constant stream of knowledge, in real time, about the activity and performance of every aspect of the institution, from facilities and administration to classroom pedagogy and student progress. By focusing on health and activity tracking devices in terms of their underlying algorithmic systems and processes, I argue for greater attention in health and physical education research (as well as in educational research more generally) to how algorithms are interweaving with processes of educational governance and control in these emerging smart and sentient schools.

By governance I mean two things. First, as Evans and Davies (2014) and Gard (2014) have already argued, and reflecting wider shifts in educational governance (Ball & Junemann, 2012), health and physical education is increasingly being governed by a hybrid mix of commercial providers with business interests as well as government agencies acting on public health agendas. This mixing and networking of actors from the public and private sectors is all part of what Macdonald (2014) articulates as a characteristically neoliberal approach to the governance of physical education through diversifying resources, expertise and services locally and globally. Within this, physical education is now being shaped by discourses of markets, opportunity, choice and competition. But I also draw on conceptualizations of governance from research that has focused on the ways in which human beings and bodies have been understood, managed and treated—either for purposes of care and cure or for individual and social reform and improvement—through 'biopolitical' techniques associated with medical, psychological and neurological sciences (Lemke, 2011; Rose, 1999; Rose & Abi-Rached, 2013). According to this body of work, medical science, psychology and neuroscience have become central to how people are governed today, and increasingly in how they are encouraged to understand and

care for themselves. In the clinic, such processes of governing have always been at least partly technical, relying on various technologies such as diagnostic survey instruments, psychological tests and newer developments like brain imaging. My argument is that health tracking is an emerging technology of governance, enabling people individually and socially to understand and care for their bodies, and to identify problems requiring cure or improvement. The algorithms installed in health-tracking devices act to translate physiological signals recorded from the body into data, presented as numbers and visualizations, that enable this kind of bodily self-governing to take place.

As a market in such devices for young people and children grows, many targeted for use in health and physical education in schools, I argue, it is imperative to understand better the functioning of such devices, the ways they might interlace with school pedagogies and how they might influence how students learn about their own bodies and health. These 'self-mediation interfaces with health', as Rich and Miah (2014, p. 301) describe them, have become 'inextricable from the manner in which people learn about health'. This is not a case of technological determinism, but a complex interweaving of algorithmic processes with commercially produced tracking devices and contemporary public health agendas into physical education pedagogies that are intended to govern and shape the ways young people see and care for themselves. I argue that health and physical activity tracking technologies aimed at the schools market provide the hardware and software for an emerging form of digitally mediated biopedagogy, and speculate on how such a digital biopedagogy might be producing a body that is wrapped in a layer of 'algorithmic skin'—that is, an individual whose physical activities, movement and overall healthiness are at least partly animated by algorithmic processes.

To be clear, the article is intended as a response to Gard's (2014) provocation in this Research Forum section to consider how digital technologies might shape the future of digitized health and physical education—or 'eHPE' as he terms it. By engaging with recent critical literature on algorithms and exploring recent technical developments, it offers some critically informed speculations about the implications of self-tracking and the role of algorithms in shaping and governing the future of health and physical education.

Socio-algorithmic interaction

In his account of the agendas shaping physical education's future, Gard (2014) suggests that it is likely to become increasingly digitized, especially as new technologies of 'big data', surveillance, 'exergaming' and automation converge with current political, economic and public health imperatives. Some digital technologies are already well embedded in physical education curricula and pedagogies, such as fitness testing, movement analysis software, kinetic videogaming and digital pedometers. Mobile and wearable physical activity monitoring devices that collect biophysical data from users are now being developed and promoted for the physical education schools market. These emerging forms of eHPE depend on computer

technologies and software that, like all computational processes, are constituted by algorithmic procedures expressed in computer code. The algorithmic constitution of software is an emerging topic in social scientific research, but is virtually absent in educational research (Williamson, 2014a). It is worth considering for a moment why a deeper consideration of algorithms, and what has been termed 'algorithmic power' (Beer, 2009), is necessary for eHPE research. My approach is not to specify every technical detail of how an 'algorithmic system' works, but 'to be able to understand some of the logics or principles of their functioning in order to critically engage with the ways in which systems work on a theoretical level' (Bucher, 2012, p. 1177).

In his recent book *Nine Algorithms That Changed the Future*, MacCormick (2012, p. 3) defines an 'algorithm' simply as 'a precise recipe that specifies the exact sequence of steps required to solve a problem'. However, algorithms are more than simply computer science abstractions and routines for sorting and structuring data. As Bucher (2012, p. 1165) contends, 'algorithmic architectures dynamically constitute certain forms of social practice'. According to this view, much of contemporary everyday life in a heavily mediated world is governed by various sorting and filtering algorithms determining what users encounter online, perhaps most obviously in our encounters with major commercial organizations such as Google and Facebook (Bucher, 2012; Mager, 2012). Algorithms have also emerged as an important object of analysis in studies of science (Mackenzie, 2006), cultural politics (Lash, 2007), identity formation (Cheney-Lippold, 2011), surveillance (Amoore, 2009), popular culture (Beer, 2013) and digital governance (Williamson, 2014b). Such studies go beyond computer science conceptions of algorithms to account for their contemporary social power. As Beer (2013, p. 81) argues, 'algorithms are an integrated and irretractable part of everyday social processes' that can 'reinforce, maintain or even reshape visions of the social world, knowledge and encounters with information'. Algorithms are not only *products* of social, political, economic and cultural processes, but also *productive* of further social, political, economic and cultural effects (Kitchin & Dodge, 2011). Given such accounts of the complex relational interweaving and interaction between algorithms and social worlds, it is perhaps more accurate to write of 'socio-algorithmic' processes and practices, and to acknowledge that algorithms are both socially produced and socially productive, than to imply that they act deterministically as mechanical or objective technologies.

Perhaps most significantly, however, algorithms privilege automaticity, quantification, proceduralization and automation in human endeavours, and reflect an historical tension between notions of autonomous human sociality and the imposition of systemized procedures (Gillespie, 2014b). A concern with the 'politics of algorithms' reflects these longer concerns over the insertion of computational procedures into human practice or, as Neyland (2014, p. 5) argues, over the modelling of 'human action through mathematical logics of order'. In order for an algorithmic system to function, he claims, the world outside of the system has to be mathematically modelled in such a way that it can become part of 'the social world of the algorithmic system' (Neyland, 2014, pp. 10–11). Moreover, Gillespie (2014a) argues, as

algorithms are increasingly being designed to anticipate users and make predictions about their future behaviours, users are now reshaping their practices to suit the algorithms they depend on. This constructs 'calculated publics', the 'calculated approximation of a public' through its traceable activities and the subsequent presentation of a public back to itself that shapes its very sense of itself, thus helping to constitute 'publics that would not otherwise exist except that the algorithm called them into existence' (Gillespie, 2014a, p. 189).

The notion of a calculated public, both measured and presented back to itself, is important in considering the role of self-tracking technologies and algorithms interacting with students in eHPE. Ultimately, we need to consider how certain forms of health data are chosen for collection by these devices; inquire into the evaluative criteria, promises of objectivity and models of health and the body built into their algorithmic systems; consider how these algorithms are constructed to anticipate users' behaviour and predict their likely futures; and examine how these calculative activities conjure new publics and new subject positions into being.

The 'quantified self' as a 'calculated public'

It is worth briefly restating at this stage that the use of health tracking in eHPE is an emerging issue, with little evidence to date that there has been any sustained take-up of such devices in schools. The point I want to make is that a market for health tracking in physical education is emerging that is linked to a much wider global trend often captured in the term 'quantified self', and that by taking seriously this movement, its associated technologies and the basic algorithmic functioning of its models, we may be able to apprehend some of the issues facing educators in the digital future of physical education. Focused on the ideal of a 'data-driven life' and 'self-knowledge through numbers', self-quantifiers use statistical data collected from self-tracking mobile devices, electronic biosensors and data analytics apps to understand their personal health and, on that basis, to modify and optimize their health behaviours (Wolf, 2010). The term 'quantified self' has since been applied to the use of health-tracking devices for various practices of 'lifelogging', 'lifestreaming', 'self-science' and 'personal informatics'.

To give a general technical sense of this area, digital health-tracking devices include a variety of smartwatches, wearable biosensors, accelerometers, pedometers, biometrics, GPS devices and Wi-fi or Bluetooth-enabled clothing and wearable body metric textiles, plus assorted smartphone applications and peripherals. Swan (2012) describes an emerging 'sensor mania', where personal health-tracking technologies are part of a vast interconnected 'Internet of Things'. Twinned with these devices, a huge range of apps to support user-led health data collection are available to track and analyze physical movement, food and drink intake, energy expended, sleep levels, blood glucose levels, cholesterol levels, calories burned, mood and emotion, inactivity and more. These apps allow users to interpret and visualize the health data collected through tracking devices, and to use these insights from the data to inform their health behaviour choices. Some health-tracking apps also feature built-in

'personal analytics' capacities that permit users to synchronize and connect different datasets in order to generate more fine-grained data about their own health, dietary and physical activities.

Major computing and mobile technology companies have entered the field, including Apple and Google, and a lively entrepreneurial 'start-up' scene has emerged (Boessel, 2013). Strong interest in self-quantification has also been expressed by medical professionals and by governments, and health tracking is an emerging topic in government health strategies. The UK organization Nesta (2014) has documented the emergence of a number of trends related to personal health data for medical, governmental and commercial purposes alike, and speculated on the further emergence of devices and practices such as wearable sensing technologies, biometric cards, health-based 'data currencies', body 'hacking' and data-driven citizen 'care circles'. In addition, a distinctive cultural discourse has emerged around these health-tracking devices and apps. The emphasis is placed on personal goals and challenges, 'life projects', personal discovery, motivational prompts and nudges, being rewarded for meeting or beating goals and using insights gained from data to make healthy lifestyle choices. The language of social science is also invoked through commitments to 'self-ethnography' and 'self-science'. The quantified self is an emerging hybrid assembled from social science methods, public health agendas, digital tracking, social networking and the 'start-up' discourse associated with Silicon Valley entrepreneurship.

There is now evidence of self-tracking and quantification technologies being designed for use by younger people, including very young children. Within the quantified self community itself, there are some emerging indications of 'quantified child' activities mobilizing health-tracking technologies and techniques. A number of commercial child-tracking devices and applications have been launched to allow parents to generate knowledge about their child's health. These include sensor-enabled 'smart diapers' to enable urine analysis and identify health patterns, and 'smart baby clothing' activated with 'sleep algorithms' and temperature and respiratory sensors to continually monitor infant health (E. Williamson, 2014).

The physical education schools market is an obvious target for health-tracking products. A key emerging area is health-tracking devices and apps for students that are designed to encourage healthy lifestyles, aid dietary planning and encourage physical activity. Popular features of health-related apps for children include the concept of caring for virtual creatures by fulfilling their dietary and fitness needs, often combined with various gaming and competition elements and online social media environments (Hswen et al., 2013). For example, Zamzee consists of a wearable physical activity meter twinned with a social media experience and personalizable avatar, as well as online leaderboards and facilities for accessing individual activity graphs, sending status updates and earning virtual currencies. Another hybrid health gaming/social media platform for children is Sqord, which consists of a wearable data logger, an online social media environment and a personalizable on-screen avatar called a PowerMe. Sqord is marketed as 'one part social media, one

part game platform, and one part fitness tracker'. Extensively piloted and tested in schools in the USA, Sqord is targeted firmly at the physical education market:

> Sqord gives you an administrative reporting tool with quantifiable metrics on the physical activity, levels, and participation of each of your players. No more guesswork or gray areas in measuring physical activity. Sqord puts the numbers in plain view, and allows your teachers and coaches to see exactly what's what in real-time. (Sqord, 2014)

Sqord users can compete with one another on an online leaderboard through everyday physical challenges, as measured by their activity trackers, and are able to win medals and 'sqoins' as rewards for completion of goals, which can be used to purchase upgrades and personalized features. The Sqord social media environment promotes peer competition as a motivational technique. Sqord also provides an administrative reporting tool for educators to access metrics on the physical activity levels and participation of each child player. Likewise, Polar Active is a wristwatch device that twins with the online polargofit.com online environment to allow teachers to view, analyze and evaluate their students' physical activity. This product, along with others, forms part of an emerging market in wearable physical activity monitors now being promoted to schools that combine tracking and sensing capacities with built-in algorithms for estimating health (Schaefer, Van Loan, & German, 2014).

Sqord, Polar Active, Zamzee and others act as a bridge between the quantified self trend and physical education pedagogy, and represent a convergence of devices, software, apps, techniques and discourses of self-quantification with pedagogic practices, commercial imperatives and governmental health agendas. As Rich and Miah (2014, p. 305) have argued, 'increasingly, younger people engage with these technologies as pedagogical devices through which they learn to recognize themselves and/or others as good, healthy, active and/or having desirable bodies in the pursuit of healthiness'. This hybrid mix of pedagogic technologies and modes of self-management is ordered and organized (at least partly) by underlying algorithms and their inbuilt models of the body in order to make the health of the child amenable to measurement and management. Self-quantification is, then, more than a participatory online movement: it invites powerful commercial, governmental and medical research involvement. These are not neutral and value-free activities, but politically and economically charged industries for which individual health data can act variously as sources for governmental policymaking, academic knowledge production and revenue creation. As such, self-quantification produces a 'calculable public', a public that is presented back to itself through the data organized and coordinated by algorithmic approximations of its traceable health activities. Such a public is made amenable to being calculated upon by a spectrum of government and medical agencies, third-party analysts and commercial data industries. In turn, it is incited to identify itself and act upon itself in terms of those numbers and their modes of visualization. Having identified some of the key technologies and techniques of self-quantification, including those designed for use by children in educational settings, the rest of the article provides an initial conceptualization of the operational

principles of these algorithmic systems—that is, it does not provide a specification of the technical functioning of the algorithms at work, but an account of the proceduralization of human actions that they model.

Biopedagogies of body optimization

Self-quantification represents a new algorithmically mediated pedagogic technique for governing and ordering the body. Rich and Miah (2014) have recently called for more attention to the 'public pedagogies' of health technologies—the pedagogical processes operating in the kind of digital devices and environments described above that bear on what and how people learn about their bodies and health. Elsewhere in the physical education literature, 'biopedagogy' is an accurate term for these new digitally mediated techniques of bodily monitoring and enhancement. If 'pedagogy' refers to forms of conduct, knowledge and practice acquired from someone or something considered an appropriate provider, as Bernstein (2000) conceptualized it, 'biopedagogy' refers to pedagogies in which the actual physical body, bodily practices and healthy conduct of the learner are made into the object of intervention. Such 'body pedagogies' generate and convey knowledge, competencies, skills and moral codes, which define what the body is and ought to be, whose and what bodies have status and value, and what 'body work' needs to be done to make one's body 'fit' (Evans & Rich, 2011).

These pedagogies, and the digital companies that provide the devices, apps and resources to mediate them, have a crucial role to play in the governing of children's health. Governing through physical education pedagogies here refers, as Vander Schee (2009, p. 558) phrases it after Foucault, to the deployment of 'particular knowledges and truths about the ways in which individuals should conduct their lives for the betterment of self and society'. Indeed, from this perspective, pedagogy is itself a governing practice (Pykett, 2012). Thus, in previous studies of physical education, technologies such as fitness testing and performance data collection have been conceptualized as pedagogic technologies of governing aimed at optimizing the well-being of both the individual and the social order as a whole.

The emerging technologies of the quantified self, including those designed for children and with pedagogical intentions in physical education, have become central to how physical activity is now being classified, categorized and represented, and thus governed and made amenable to management and improvement. Algorithms have been positioned as powerful classificatory mechanisms for moulding and making health and physical activity data intelligible, in ways that govern and order the body of the child and influence how children learn about their bodies and health. Just as 'the decision to classify students by their standardized achievement and aptitude tests valorizes some kinds of knowledge skills and renders other kinds invisible' (Bowker & Star, 1999, p. 6), the health-tracking technologies being promoted in physical education can be understood as sorting systems for classifying and categorizing physical activity, thus valorizing certain kinds of activities and rendering others as undesirable. Such forms of classification are not mere bureaucratic formalities but

hold serious material force as threads that are tied to the ways that schoolchildren are likely to learn to conduct their own lives and bodies.

Although the health-tracking technologies emerging in physical education vary slightly from product to product, based on proprietary algorithms that calculate and present data differently, they are all based on standard algorithmic classification systems that make individuals' health data combinable, comparable and amenable to data visualization and representation. In order for these technologies to function, certain expert understandings and classifications of the body and of healthiness, derived from various sciences, have to be accommodated through being mathematically encoded in physiological models and algorithmic systems. In devices targeted at schools, such as Sqord, a particular socially produced understanding of the malleable and improvable child's body has been folded into the classification systems and algorithms through which it functions. As Neyland (2014, p. 11) puts it, the task of an algorithm designer is to 'build a world out there into a world in here, in the algorithmic machine'. In the case of self-tracking, monitoring and personal analytics devices in eHPE, this can be rearticulated as a concern with transforming the child's body into a calculable model in the algorithmic machine. The algorithmic models that are built into pedagogical self-tracking technologies combine various bioscientific understandings, physiological models and forms of medical and psychological expertise. Devices such as Polar Active, Zamzee and Sqord classify the child's body and health in ways that are intelligible to children, and that touch them in very real corporeal ways by enforcing particular norms and attaching statistical measurements, as encoded in their algorithms, of bodily health and physical activity. This algorithmic and classificatory system enforces a particular understanding of what 'health' is, as defined through the classificatory scheme written into their algorithms, which can thread back into the ways that schoolchildren will come to see, identify and conduct themselves.

Such socio-algorithmic processes are not neutral, objective sources of knowledge. Instead, as Lupton (2013, pp. 14–15) argues, 'the data themselves and the algorithms that interpret them and make predictions based on them are social actants' with a 'profound impact on how individuals view themselves and the world'. Self-quantification encourages children to understand their bodies as 'personal laboratories', and in terms of 'objective' data and metrics rather than subjective, haptic and sensory-embodied knowledge. It makes the body of the individual visible in terms of data, calculable as numbers, and on that basis amenable to enhancement, though as Nafus and Sherman (2014, p. 1793) caution, self-trackers

> interact with algorithms not as blind, mindless dupes, but as active participants in a dialogue that moves between data as an externalization of self and internal, subjective, qualitative understandings of what the data means.

While there is certainly interpretive flexibility in how users engage with technologies, self-quantification algorithms also do structure and shape possibilities for action. The ways in which health-tracking technologies may be enforced through their use in school pedagogies and curricula may also work to reproduce and solidify social

norms and expectations around child health, not least as they interact with existing public health agendas around, for example, obesity.

As a result of these emerging biopedagogies of self-quantification in eHPE, children are increasingly, it seems likely, going to be incited to view their own bodies as malleable, correctable and improvable, and to experiment upon themselves to make themselves better than they are. Sqord, for example, encourages child self-trackers to customize their 'PowerMe' avatars and to display them to one another via a social media environment. As the website explains,

> Everything in Sqord centers around you and your fully customizable PowerMe. Make yours look like you, or make it how you want to look that day. Your friends will see you your way, and you'll see them how they want to be seen. (http://www.sqord.com/)

Consequently, the body of the learner has been made into a seemingly legitimate pedagogic site for presentational enhancement. The point being made by Sqord and similar products is that the body can be taught, improved and optimized, and through 'the process of collecting, visualising, sharing and monitoring such data on one's body in a public space, users learn about the body in terms of appropriate forms of maintenance, development and repair' (Rich & Miah, 2014, pp. 305–306). Self-quantification is part of a technologically solutionist obsession with 'tuning' and 'perfecting' the body with the right algorithms. The child's body is made amenable to being recoded and reprogrammed, manipulated, enhanced and optimized according to new socially desirable norms as modelled, organized and ordered in algorithmic system of self-quantification.

Pleasurable predictive dataveillance

A central issue for researchers of self-quantification with children and in physical education is that of surveillance. In particular, self-tracking devices, when twinned with powerful data analytics software, can transform simple 'monitoring' into the 'prediction' of children's future behaviours and bodily health. In contrast to typical images of digital surveillance being undertaken covertly by government agencies and commercial companies, self-tracking appears to be a more benevolent form of surveillance. Indeed, as with many other forms of digital 'dataveillance', individuals increasingly submit to being monitored and tracked by voluntarily surrendering their personal data (Raley, 2013).

Part of the seduction of voluntary surveillance through health tracking, particularly as it is now being marketed to children and schools, is the tactic of designing the technologies along the lines of videogames or competitions. Creature-based apps such as Sqord, Fitter Critters and Zamzee represent the 'gamification' of digital health among children. Many mainstream self-tracking devices and apps feature gaming elements, such as competing with others on specific physical activity challenges or racing to complete goals. Programmes and devices that promote healthy eating habits using points and fitness and weight loss coaches for game

consoles are obvious examples of gamification. These techniques promise to make everyday tasks more rewarding, fulfilling and fun, using incentivization and rewards to shape desirable behaviours such as physical exercise or healthy eating habits. Whitson (2013) refers to gamification strategies in self-tracking as 'pleasurable surveillance'—a kind of self-monitoring and self-policing done voluntarily and for fun. However, the algorithms that enable children's physical activity and health data to be translated into games and competitions are not politically innocent. Many of the algorithms enabling these devices and apps are proprietary to the commercial companies producing them, are variable in what and how they measure and calculate the data and are rife with embedded value judgments that reward some activities and not others.

Applying a concern with data-based surveillance to health tracking, Ruckenstein (2014, p. 69) argues these devices make formerly 'unknown' aspects of bodies and lives more 'detectable', 'transparent' and 'visible'. Through such personal analytics being promoted in physical education in products like Sqord, the individual child is to be 'sliced' up or deconstructed into data flows; the body and mind abstracted into data visualizations, composites of information and representations. For example, Sqord enables students to generate data visualizations that chart 'activity points' won for activities they have performed at an hourly, daily or weekly scale, as well as to use these activity points as a form of virtual 'currency' to purchase customizations for their graphical on-screen avatar. These informational and decorporealized data-based versions of the self, or 'data doubles', enable children to see, know and understand the problems of their corporeal selves through seemingly objective, scientific and reliable representations of the data. The algorithms at work in such devices and apps enable biophysical data to be captured as an input, and then translated in real time into a digital output as numbers and data visualizations that have the power to persuade students of their bodies' problems and then nudge and coerce them to reform themselves. Personal analytics do not just render the body as abstract graphs, tables and figures in real time, but make it actionable.

It is clear that the emergence of health-tracking technologies in schools enable a pleasurable and voluntary form of dataveillance to become one of physical education's future pedagogies. It should also be noted of course that there are continuities here with how fitness testing, pedometers and movement analysis software have already been accepted as surveillant technologies in physical education. Indeed, the widespread acceptance of fitness and activity assessment tools like Fitnessgram in the USA suggests that newer digital forms of personal analytics will be easily accommodated into physical education provision in schools in ways that will exacerbate existing uses of student data for surveillant and performative purposes. As Gard (2014, p. 833) notes in relation to Fitnessgram:

> there is evidence that schools … are structuring their physical education programmes—and therefore the information they use to instruct children and explain their programmes to the broader public—in ways that prioritise student performance in these data collection exercises. … Fitnessgram is one example—doubtless others will follow—of how HPE might be digitally shoehorned into

> conformity with the worldwide trend towards measurability, accountability, performativity and standardisation in other areas of the curriculum.

The latest upgrades to Fitnessgram itself also feature data-mining functionality, web-based data collection, mobile apps, and reader-friendly graphical visualizations that demonstrate how new technical developments in mobile activity monitoring and data analytics are feeding back into existing surveillance products. These are making the collection, accumulation and dissemination of large datasets about children's physical health and fitness more easy and efficient to administer to accomplish. Lupton (2014, p. 9) suggests that the use of digital self-tracking devices and apps in school-based health and physical education is a form of 'imposed self-tracking' and argues that 'some physical education teachers are beginning to require their students to wear such devices as heart-rate monitors to determine whether they are fully participating in set exercise activities and to compare their exertions with other students'. We can see from such examples how the data are becoming not just a tool for measurement, but are actually influencing pedagogic practice, curriculum design and disciplinary techniques. This is leading, as Selwyn (2014, p. 9) notes in relation to digital data use in education more generally, 'to a recursive state where data analysis begins to produce educational settings, as much as educational settings producing data'.

Moreover, the personal analytics embedded in health-tracking and activity-monitoring technologies are part of a much wider socio-technical trend in the development of predictive 'machine learning' techniques. 'Machine learning' is the term to describe 'intelligent' software systems that utilize adaptive algorithms and statistical models to analyze users' data in order to anticipate or even predict their future actions. Utilizing 'taught algorithms', Mackenzie (2013, p. 399) argues, 'programmers construct models that predict what people will do' through 'transforming data on events, actions, behaviours, beliefs and desires' into probabilistic predictions of the future that then can be used to decide on the action to be taken in the present. The statistical models and algorithms of predictive machine learning techniques are enmeshed in powerful social currents of thought. Machine learning is part of a world in which 'probabilistic outcomes' and predictions about the future increasingly influence people's 'everyday actions, habits and practices' (Mackenzie 2013, p. 396). Driven by the machine learning techniques and the adaptive algorithms of personal analytics, health tracking may then be understood not just as a real-time data practice but as an anticipatory or 'future-tense' practice, premised on the use of devices programmed with the power to predict probable personal actions based on the analysis of data traces of past actions.

Through self-tracking technologies of anticipation in physical education, the student is to be solicited as a little expert of the future, enabled to anticipate, calculate, predict and project a spectrum of bodily probabilities and possibilities. The student's data double is the source for algorithmically mediated modes of self-anticipation and projections of possible futures. As such, self-quantification techniques in physical education might be approached analytically as an emerging form of both pleasurable

and predictive biopedagogy—a pedagogy of bodily inspection, monitoring and improvement based on the anticipatory technologies and algorithmic systems of predictive analytics and enacted through techniques of gamification and dataveillance. All of these raise an important issue for the digital future of health and physical education. The predictive capacity of personal analytics makes it possible to apply algorithmic processes to predict students' likely futures and, on that basis, to pre-empt their actions and activities. Yet little is known about the selection, values and assumptions of the 'training data' that machine learning algorithms act upon. Such data may be incomplete, partial, or even incompatible with the data that the algorithm will operate on 'in the wild' (Gillespie, 2014b). Decisions about how to train a machine learning algorithm will always be made by algorithm designers and computer programmers. Given that such data can only ever remain partial and approximate, and how they reflect the value judgments and assumptions built into the data's models, there is a real possibility here that students' healthiness may be increasingly determined by automated procedures, and their future lives shaped by algorithmic systems embedded in the value systems and decisions of computer coders rather than physical educators. This certainly adds an extra and largely hidden layer of complexity to the trend in outsourcing of health, sport and physical education (Williams, Hay, & Macdonald, 2011), further complicating existing concerns about the suppliers authorized to select physical education resources or to define the quality of physical education materials (Evans & Davies, 2014).

Corporealgorithmic connections

So far we have considered how educational health-tracking devices constitute a new form of biopedagogy, and identified the surveillant and predictive capacities of such technologies for the data-based shaping of students' future lives. But what happens to the body of the student in practices of health and activity tracking in eHPE? In line with post-humanist literature which has sought to erase the boundaries between humans and non-humans and to reveal the technological metaphors that we use to understand ourselves(e.g. Hayles, 1999), many of the metaphors used to describe the technologies and techniques of the quantified self routinely juxtapose the body with machinery. This includes metaphors of measurable 'input/output' ratios from cybernetics, vehicular imagery of 'a dashboard for your body', computer imagery of 'body hacking' and the 'body as the ultimate computer' and data-related references to the body as a 'data factory emitting digital exhaust' (Lupton, 2013, pp. 26–27). Using such technological metaphors of intense human–computer interaction, people are represented merely as 'nodes' in the 'Internet of Things', exchanging data with other people as well as with other objects and devices through networked communication and informational infrastructures:

> The body in this discourse becomes positioned as a 'smart machine' linked with other 'smart machines'. Bodily sensations become phenomena that are mediated and augmented through machines, transformed into data and then communicated back to the user. This vision of the body as augmented via self-tracking devices

> present a digital cyborg, in which such devices not only become prosthetics of the body but extend the body into a network with other bodies and with objects. (Lupton 2013, p. 27)

Through health-tracking data, the body appears increasingly as part of an extended and distributed digital information system. Similarly, in their article on the pedagogies of self-tracking, Rich and Miah (2014, p. 308) describe a condition of 'posthuman technological mediation and prostheticisation', in which 'new sensorial experiences, such as the wearing of fitbit health bands, which vibrate when you achieve your activity goals, combine different pedagogical forces to produce embodied ways of knowing'. Self-tracking technologies targeted for use in physical education likewise link children into distributed networks of hybrid sensorial experiences that are produced through an amalgam of wearable devices, physical gaming activities and algorithmic modes of data analysis and visualization.

Certainly devices like Sqord connect students prosthetically to various wearable devices. But the connection of the body to the machine in health tracking is subtler than this. Rather than the cyborg image of the artificially prosthetized body, self-tracking connects bodies into a web of data, analytics and algorithmic forms of power—a 'corporealgorithmic' coupling of bodies and flows of data. From such a perspective, the body can be perceived as part of a distributed system of information, interfaces, data and devices that coordinate, pattern and connect it up to wider networks. The body in such imagery is conceived as a biological core, a skeletal, muscular and nervous system, which is increasingly surrounded and augmented by technical and information infrastructures, a range of 'artificial skins' and a 'networked cognitive system' (Beer, 2013, p. 131). These artificial skins, however, are leaky and porous with the wider informational environment so that the 'mobility of data meets the mobility of bodies' (Beer, 2013, p. 162). Digital technologies, from this perspective, open up the body to data flows and the dynamic experience of interfacing with information. Such interfacing is itself now constitutive of much human experience, as bodies have become increasingly overlaid with data and information:

> Gradually we are adding a new skin of data to the world, a skin which can also have its own life…. What we are seeing is data gradually becoming a part of how we see the world as it becomes embedded in all of the surfaces we come across, and the moving actors that span them, whether birds and trees or cars or us. (Thrift, 2014, p. 1264)

Intricately webbed into data flows through mobile devices and wearable sensors, the body moves in 'coded spaces' where the flow of data through the environment can shape physical movement and activity (Kitchin & Dodge, 2011). It is clear that metaphorical accounts of personal data as bodily surfaces and 'artificial skins' linked to wider networked systems resonates with images of the quantified self as node in a mosaic of connections, mathematical models and proceduralized actions. In this

sense, health-tracking data act as a kind of active and algorithmic layer of skin that does not only sheathe but animates and orders the body.

For eHPE, such developments raise the possibility that devices such as Polar Active, Sqord, Zamzee and the rest will increasingly interlace children with algorithmic models that have the power to shape the ways in which they think about and activate their own physical capacities. In post-humanist media theory, it has been recognized that the nature of consciousness and subjectivity changes over time as media technologies change—that subjects conceive of themselves and act in relation to the technical environment (Hall, 2013). In the contemporary social media environment, within which emerging health-tracking technologies for physical education must be situated, subjects are increasingly being coordinated by pre-programmed patterns of information that are based on the algorithmic tracking and analysis of their personal data. There is symmetry here with recent theoretical and empirical work in biopolitics, which has shown how the body in recent discourses has been reconceived as a kind of programmable software that can be controlled through sequencing the right kind of codes—whether genetic or computational (Lemke, 2011). The body and even the brain are increasingly viewed as malleable, plastic and improvable (Rose & Abi-Rached, 2013). As data captured from the body are processed by health-tracking algorithms, specific health problems can be identified and new personalized goals set. This process repositions the student's growing body and subjectivity as the co-constructed product of biology and algorithms—a biological body that is increasingly augmented and expanded through its interconnection with vast coded and networked systems of sensing, monitoring, tracking and control, and with their underlying algorithmic systems of analysis, anticipation and prediction. The pedagogies of health-tracking produce a student growing up in a body with algorithmic skin.

Conclusion

This article has aimed to contribute to the discussion in this new Research Forum on the likely 'digital future' of health and physical education. To that end it has explored the idea that health-tracking and personal analytics technologies designed and promoted for use in eHPE are an emerging form of biopedagogy concerned with the algorithmic governance of the body. These biopedagogies are part of the culture of self-optimization and self-knowledge through numbers—a solutionist obsession with 'tuning' and 'perfecting' the body with the right algorithms—that pervades the calculated public of the self-quantification movement. Undergirding self-quantification is a particular set of socially produced classification of healthiness that are now encoded and modelled in the algorithmic systems that track, measure and metricize physical exertion and other bodily and psychological activities. These models are part of a broader issue of how the 'world out there' can be translated 'into a world in here, in the algorithmic machine' (Neyland, 2014, p. 11), a process that involves translating the body of the student into quantifiable data and fitting them to pre-existing classifications. Students are to be governed through particular classifications

and models of the body that can be captured and tracked as calculable data by socio-algorithmic procedures.

The logic of such self-quantification technologies in eHPE is that if the student's body can be counted and calculated, it can also then become amenable to being governed and controlled. The child's body in this discourse has been redefined as a kind of software that has been made amenable to being acted upon, enhanced and optimized, as instructed by codes and algorithms. This is a process not only of real-time data collection and analysis, but also of future-tense prediction. These activities are part of an increasing concern with imagining the future in contemporary biopolitics, a concern at least partly interwoven with the technical capacity of computational statistics, machine learning algorithms and predictive analytics to construct probabilistic predictions of individuals' future actions and behaviours. Such technologies of anticipation have the potential to exert material and corporeal effects on the health of children. Metaphorically speaking, the biological and corporeal figure of the quantified child is wrapped in algorithmic skin, an artificial informational membrane that continually interacts with, and is activated by, a densely coded informational environment. Self-quantification practices are connected to a vast networked cognitive system that increasingly has an active power to shape the body that moves through it. This raises serious concerns about the extent to which students' physical development may be hybridized with flows of media and data, and the role of data gadgets in formatting individual and social health. Built into the algorithmic models of self-tracking eHPE hardware and software is a particular classification and ordering of the socially desirable child that conforms to a messy mix of commercial, governmental and medical aspirations regarding the moral ordering of society as a whole.

These developments make it important for researchers to interrogate the role of the algorithms that are increasingly interwoven with the classification, control and governance of health and physical education. The algorithms that enable health and physical activity tracking devices and apps to function privilege automaticity, quantification, proceduralization and automation in human health. These algorithms enact a range of assumptions and models of healthiness and social norms of how students should conduct their lives and improve their bodies. Such technologies can be seen as extensions of the complex of medical, psychological and neurological technologies through which governments and businesses seek to understand populations in order to better manage them, or market to them. As such, algorithmic health-tracking processes are also interlaced with public health agendas and governmental and medical strategies which put the emphasis both on digitized forms of health data collection and on individuals using such data to take care of their own health—'people-powered health' mediated by emerging technologies as Nesta (2014) imagines it. As more and more health-tracking devices and apps designed for use in educational institutions become available, the governance of physical education pedagogies is likely to become more and more subject to commercially produced health-tracking systems and their built-in algorithmic models and assumptions about children's health and physical activity.

Moreover, the digitized future of health and physical education is likely to mirror the wider development of data-driven schools in which data tracking, sensing and analysis, facilitated by software and data analytics algorithms, will increasingly influence and shape administration, curriculum, pedagogy and assessment. Such 'smart schools' will mobilize the constant collection and connection of data as a form of artificial sentience, making every aspect of school performance into a real-time process of data collection, analysis and feedback. Such technologies will ramify and solidify existing regimes of performance management, whilst also serving to accelerate the use of data for predictive purposes. As data analytics technologies such as educational data mining and learning analytics become increasingly powerful through the use of machine learning algorithms that can be used to build predictive models, these sentient and smart schools will become able not only to provide real-time data on student progress, but also to make 'future-tense' predictions of their likely outcomes and to prescribe automated interventions that might pre-empt them. As machine learning algorithms and predictive analytics from the wider data-tracking ecosystem leak into schools, it is likely that the future pedagogies of eHPE will be based on new forms of anticipatory knowledge and predictive forecasts of students' future healthiness that will make it possible and perhaps pedagogically desirable to intervene to pre-empt their future lives.

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