Learning with Machines

Divisions and Transformations in the Era of Datafication

Jeremy Knox

1 Introduction

Contemporary times are increasingly characterised by the processing of data, collected by a range of information technologies, social media, and platform software, and networked infrastructures designed to quantify a broad range of human activity. As Zuboff suggests, "just about everything we now do is mediated by computers that record and codify the details of our daily lives" (2019, p. 182). This processing of data often utilises computational techniques known as "machine learning" (cf. Alpaydin, 2016), through which software systems are programmed to analyse large volumes of data for the purposes of deriving patterns and training algorithms. The resulting systems, it is often claimed, are able to produce, not only more efficient processing of information, but even new insights that mere human data-workers would be unable to perceive, given the huge quantities of data at play. The recent prominence of this technology has generated much in the way of hyperbole (e.g. cf. Mayer- Schonberger & Cukier 2013; cf. Tank, 2017), as so-called "big data", "machine learning" or "artificial intelligence" are portrayed as ground-breaking technologies, claimed to be on the verge of not only disrupting a range of commercial activity (cf. Bhatia, 2017), but also able to ignite a "fourth industrial revolution" (cf. Schwab, 2016). This kind of promotional and celebratory

discourse around data-driven technology is not only widespread, but seductive. As Kitchin suggests:

> "The power of the discursive regimes being constructed is illustrated by considering the counter-arguments – it is difficult to contend that being less insightful and wise, productive, competitive, efficient, effective, sustainable, secure, safe, and so on, is a desirable situation. If big data provide all of these benefits, the regime contends that it makes little sense not to pursue the development of big data systems." (Kitchin, 2014, p. 126)

It seems unsurprising, therefore, that the promise of data-driven technology has been directed increasingly in recent years towards the education sector. However, such interventions should not be seen as necessarily or wholly novel, given a decades-old drive to automate and digitise

educational activity with the use of technology. Howard and Mozejko (2015), for example, outline three periods – the pre-digital, that of the personal computer, and that of the internet – as key eras in which different kinds of technologies were proposed (and often overestimated) as revolutionary and disruptive innovations for all manner of teaching, learning, and administrative tasks. Nevertheless, partly as a result of the prominence of machine learning techniques, the contemporary era is one in which digital technologies appear to have sunk down into the mundane, everyday practices of education, not only collecting and processing more data than ever before, but also using the resulting insights to automate decision-making in unprecedented ways. As Selwyn et al. claim:

> "we are now teaching, studying and working in highly-automated and digitally directed educational environments. Over the past 10 years or so, responsibility for all manner of everyday educational decisions and tasks has been passed over to automated software, systems and platforms" (Selwyn et al., 2021, p. 1–2)

One of the key terms to emerge in the field of research and development is "analytics", used to refer to a broad range of techniques

> involving the processing of educational data. So-called "learning analytics" has been hailed as an imminent disruptive solution for wide array of educational activities (cf. Clow, 2013; cf. Cooper, 2012), being established around the prominent professional organisation, the Society for Learning Analytics Research, or SoLAR[1]. Importantly, as the literature in this area makes clear, learning analytics derives its methods from the disciplines of statistics, computer science, and psychology (cf. Siemens, 2013), in order to develop techniques and applications aimed at, for example, analysing and predicting student behaviours (cf. Dawson et al., 2017), or automating teacher feedback (cf. Pardo et al., 2018).

However, while university research has played a substantial role in developing computational techniques for specific applications in the educational domain, commercial activity has also been increasingly on the rise, often utilising techniques associated with learning analytics to develop commercial educational products and services. As has been documented extensively elsewhere (e.g. Williamson, 2021), the recent COVID-19 pandemic has greatly accelerated the uptake of such products and services, as public education institutions struggled to provide online provision during global school and campus lockdowns:

> "The "pivot" to 'online learning' and "emergency remote teaching" has positioned educational technology (ed tech) as an integral component of education globally, bringing private sector and commercial organisations into the centre of essential educational services" (Williamson & Hogan, 2020, p. 1)

A crucially important agenda for research has therefore emerged around the notion of the platformisation of education (cf. Decuypere et al., 2021), exploring the extent to which private companies and data-driven infrastructures are beginning to govern and intervene in a broad range of educational activity. This paper is particularly concerned with what such configurations mean for learning; both how and where it is

1 See: https://solaresearch.org/

assumed to take place, as well as how it is conceptualised and understood. This exploration does not necessarily require, it is argued here, a normative dimension as to the definition of learning, but rather an explicit interest in how its understanding is being shaped and influenced by the use of technology. The key question underpinning this enquiry is therefore: how is learning changing, given the significant incursions of data-driven systems and platforms, both in terms of how it is being practiced, as well as how those practices are rationalised. Two themes will guide this exploration over the subsequent sections of this chapter: division, highlighting the relationships between learning and technology corporations; and transformation, focused on the ways data-driven systems shape and modify the practice and understanding of learning itself.

2 Learning Divided

Where platforms are "altering the meaning, possibilities and potential functions of education" (Decuypere et al., 2021, p. 2), it seems pertinent to examine what kinds of learning are being encouraged and developed through platforms, and how the assumptions underpinning these forms of learning are in turn shaping what we understanding education to be. Following Van Dijck and Poell's definition of the platform, that is, a "programmable digital architecture designed to organize interactions between users – not just end users but also corporate entities and public bodies" (2018, p. 4), different educational actors, and hence differing kinds of learning, might be identified where commercial platforms become utilised in formal educational activity. This section will outline some of the key actors that are formed from the use of platforms in education, as well as different kinds of learning assumed to be taking place, with the aim of examining distinctions between the private owners of educational platforms and the public educational institutions that make use of them.

Perhaps the most obvious, is the learning undertaken by students as users of educational platforms. If one takes the promotional dis-

course around educational platforms at their word, then this kind of learning can be understood to take place as students interact with the software, ostensibly on an individual basis, to encounter resources and assessments. Depending on the platform, there may also be elements of the platform which facilitate synchronous or asynchronous communication between the student and the teacher(s), as well as with other students. While there are very particular ideas about the form of this learning, and ideas that are structured into the functioning of data-driven platforms themselves (as will be discussed in detail below), the fact that students are positioned as "learners" in platforms is perhaps to be expected, given the application of this technology to educational concerns. Platforms are typically promoted on the basis that they provide enhanced opportunities for students to learn, usually through claims of flexible access to resources or the ability of the software to "personalise" content (processes generally involving some form of machine learning that tailors defined sets of educational materials according to an individual's previous behaviour within the platform combined with aggregated behavioural data from previous users). In these ways, the learning undertaken by students is assumed to be made more efficient through either self-directed or customised access to educational content, where the platform serves as a kind of intermediary, able to deliver educational materials in ways impossible for the teacher alone. The next section will interrogate some of the assumptions underpinning this view of 'enhanced' learning through platforms; however, for now, it remains important to highlight the other, perhaps less expected, forms of learning that are operationalised by platforms, and the other platform "audiences" who, alongside the students, also undertake learning.

As procurers of commercial education platforms, educational institutions become a key actor, user, and audience. Or rather, the involvement of educational institutions consists of multiple actors, users, and audiences, and it is vital to distinguish these roles in order to understand the purpose and functioning of the platform. While specific institutional contexts and configurations will likely vary, it may be useful to distinguish between, on the one hand, different kinds of "on the ground" classroom educators, such as teachers, teaching assistants, and learning sup-

port workers, while on the other, different kinds of administrative and managerial roles, such as department heads, course administrators, and senior leaders (these being rough indications of roles that will undoubtedly vary across institutional and national contexts). Any and all of such roles are likely to be classified, just like the student above, as merely another "user" of the platform. Yet, each user role is assigned a distinct set of abilities and permissions within the platform, meaning that, out of all the possible data flowing through it, only very specific renderings and representations are available to each role. For example, a teacher may be able to view the names and assessment scores for individual students in their own class, but not any student from another class. Further, a senior manager might be presented with accumulated assessment scores across an identified subject area, but not the profiles or specific assignment grades related to individual students. The point here is not to try to define any particular configuration in precise accuracy, but rather underscore that roles are configured, in some fashion, even where abilities and permissions can be changed. In this sense, the platform is a carefully crafted and controlled environment, that organises, often in a fine-grained way, the interactions between different users, and between users and particular forms of data. Furthermore, it is important here to see the platform, not as a unified entity, or a single plane of data, onto which different users are supplied a particular "window", but rather as a system which is continually rearticulating, representing, and translating data, in a continual state of (re)configuration across its internal modular form and between its users. This point will be developed further below.

In terms of learning, these articulations are largely (re)configured around a desire to learn about students, through collecting, for example background information about individuals, measures of attendance, progress, and assessment, as well as calculations of year-group or cohort outcomes. Again, rather than focusing on precisely the kinds of analyses undertaken by any specific platform, the point here is merely to highlight that platforms engender and facilitate what might be seen as an entirely different mode of learning to that discussed above; learning about student performance. While the desire to know and understand students has undoubtedly been an aspect of educational institutions

for much of their existence, platforms establish what is arguably an intensification of surveillance and measurement, as fine-grained data representing all kind of student activity is presented as a resource for the enhancement of the institution. There are at least two important aspects to this form of learning. Firstly, in the sense that students become subjects of increased scrutiny, and are defined and understood by institutions through processes of measurement and attainment. In this way, the processes of learning about students undertaken through platforms constructs students as very particular kinds of learning subjects, constituted through a "data gaze" (cf. Beer, 2019) that privileges highly technologised and statistical forms of knowing in education. As Beer argues, the data gaze is an attempt to understand "new types of knowledge that are emerging along with an understanding of how that knowledge achieves authority, credibility and legitimacy" (2019, p. 1), driven as it is by an emergent industry of intensive data processing. The platform is one of the key sites through which such an industrial data-informed knowledge-making is shaping educational activity, as well as practices and assumptions about learning. As Grimaldi and Ball suggest, through educational platforms, the learner "is made visible, knowable, malleable and, overall, governable" (2021, p. 117), attesting to the ways institutions are adopting the practices of the data gaze to operationalise new forms of knowledge about students. In this sense, the learning undertaken by institutions can be understood as a form of power, with the ability to penetrate learning behaviours with new kinds of precision, and ultimately render students as pliable subjects through subsequent data-informed intervention.

Secondly, it is not just students who are recast through the "data gaze" of the platform, but educational institutions themselves. Rather than being simply institutions that teach students, data-driven platforms rearticulate schools and universities as learning organisations that undertaken processes of self-improvement through analysing learner data and modifying their operations as a result. This is largely what is meant by Lane and Finsel's framing of the "smarter university", which draws on big data analytics to "improve the student learning experience, enhance the research enterprise, support effective commu-

nity outreach, and advance the campus's infrastructure" (Lane & Finsel, 2014, p. 4). Notably, the improvement of student learning appears to be only one dimension within this much broader call for organisational efficiency through data. Cheslock et al. (2014) further challenge what they see as a dominant interest in student learning, and suggest a greater focus on other kinds of data generated by educational institutions, for the purposes of gaining more precise understandings of internal operations and streamlining institutional functions. They further stress in their conclusion the economic rationale driving the need for such forms of organisational learning:

> "The financial challenges present in higher education cause institutional leaders to face numerous decisions that could be made easier if accurate and insightful information about the organization could be extracted from the large amounts of data being collected." (Cheslock et al., 2014, p. 233)

As such, through the logic of the data gaze and the functioning of education platforms, educational institutions appear to be rearticulated as learning organisations, centred on forms of self-improvement and economic efficiency that extend well beyond measures of student performance.

However, educational platforms involve another set of key actors that are often overlooked in the general promotion of such services in education settings: the private owners of the software. As suggested above, the recent pandemic triggered a surge in partnerships between public educational institutions and private "ed tech" companies, typically offering some kind of platform-based service for schools, colleges, and universities to maintain their education provision "online". However, it is important to acknowledge that such enterprises have been around for some time, and the public education system has long been perceived as ripe territory for commercialisation. Platform software in education has typically been referred to as a "Virtual Learning Environment" (VLE) or Learning Management System (LMS), with key examples

being US-based company Blackboard[2], founded in the late 1990s, and the opensource Moodle[3], developed in the early 2000s. While originally developed as web-based repositories for educational materials, often incorporating modes of communication such as asynchronous discussion fora, VLEs and LMSs have gradually shifted towards more data-driven approaches, featuring, for example, analytic dashboards (discussed further below). More intensive data processing has also emerged in platforms that are explicitly focused on so-called "adaptive" or "personalised" learning, involving the use of machine learning techniques to recommend particular resources or assessments based on analyses of individual and group behaviours within the software. Notable examples here include: the ALEKS[4] (Assessment and Learning in Knowledge Spaces) platform, originally developed at the University of California, Irvine, and subsequently acquired by educational publishing company McGraw Gill Education; Century[5], a UK-based company claiming to offer platform services incorporating artificial intelligence and informed by neuroscience research; and Squirrel AI[6], a company based in China offering a similar "adaptive learning engine", having established research and development partnerships with a range of educational institutions and investors in the US. Alongside companies specifically focused on education, other technology corporations are increasingly viewing education as productive avenue for business. The most notable example here is Google, which, through its eco-system of platform services and application programming interfaces (termed APIs), constitutes a novel kind of infrastructure for pedagogy (cf. Perrotta et al., 2021) that is increasingly utilising artificial intelligence techniques to adapt and personalise educational content (cf. Williamson, 2022).

While on the surface, these education platforms simply provide "services" for students, teachers, and educational institutions, it is

2 See: https://www.blackboard.com/en-uk/about-us
3 See: https://docs.moodle.org/400/en/About_Moodle
4 See: https://www.aleks.com/about_aleks
5 See: https://www.century.tech/about-us/
6 See: http://squirrelai.com/about

important to acknowledge and examine the role played by the companies themselves, not only as technical designers and managers of the software and therefore influential arbiters in the forms of learning described above, but also as organisations that learn. However, the order of learning undertaken by owners of platforms software might be seen as substantially different from the kinds of activities discussed previously in relation to students, teachers, and institutional management. While students, teachers, and administrators, for example, are merely "users" of platform software, and therefore subjects of finitely controlled spaces ascribed to their respective roles and responsibilities, platform owners are able to access all flows of data. Importantly, this does not simply mean that platform owners are able to adopt any and all other "user perspectives" at their discretion (although presumably such functions are available), but rather that the platform is articulated in an entirely different way for its owners.

Zuboff's concept of the "division of learning" is useful here to emphasise this distinction; a term suggested to signal "ascendant principle of social ordering in our time" (Zuboff, 2019, p. 181). Although Zuboff (2019) does not examine formal education specifically, this division is located precisely between the owners of more general data-driven systems and their "end users" – Google is singled out as a key example of such arrangements. The critical orientation of Zuboff's (2019) argument is that such platform owners are able to undertake hugely advantageous forms of learning by analysing the data traces left behind by mere "users" (of, for example, social media services), thus entrenching significant inequality between those able to understand and practice data-driven processing techniques, and those limited to simply supplying data through their everyday interactions with information technologies. In this way Zuboff claims that learning is "captured by a narrow priesthood of privately employed computational specialists, their privately owned machines, and the economic interests for whose sake they learn" (p. 189), while the vast majority of the population are excluded from, not only the technical skills required for such learning, but the supposed financial benefits that result from it.

While Zuboff's stark rendition of the "unauthorized privatisation of the division of learning in society" (Zuboff, 2019, p. 191) might be interpreted as simply advocating more democratic training in data science (rather than questioning the assumptions underpinning such forms of learning – see Knox 2021), it nevertheless provides a useful acknowledgement of the power of the private sector which appears increasingly relevant for public education. As Zuboff underscores, platforms are constituted by two kinds of texts: firstly, the public interface that "users" encounter and contribute to; and secondly, a "shadow text" only available to platform owners and comprised of valuable data traces from which profit can be derived (2019, p. 185). Further, these texts are linked in the sense that the "shadow text" is produced from the surplus extracted from the public interface; a "raw material to be accumulated and analysed as means to others" market ends' (Zuboff, 2019, p. 185). Platform owners thus have control over both texts, so that the public interface can be controlled and shaped in ways that best serve the "shadow text" underneath. This presents a wholly different articulation of power than that typically described in the promotion of data-driven education, where students, teachers, and client-institutions are cast as the key agents of "smart" learning, technology enhanced pedagogy, or data-informed organisational efficiency. The profound insight emphasised through Zuboff's division of learning is that, at least from the software owners' perspective, all of the educational actors are mere "users" of the education platform software, limited to tightly controlled interfaces that are, in some form or another, designed in ways that enhance the underlying "shadow text" of private data beneath. Given that this "shadow text" is the primary source of value for business involved in the data economy, companies developing such systems have a vested interest in designing education platforms, not exclusively for a benevolent desire to improve education (although this is often what is emphasised in promotional media), but rather for the enhancement of their own databases and analytic abilities. As such, private education companies might be seen, not simply as suppliers of learning materials, or indeed intermediaries in new forms of online provision, but rather as organisations engaged in their own learning agenda. In this way, the entire gamut of educational

activity, however one decides to characterise it in terms of teaching, learning, and institutional management, becomes the raw material for a form of corporate learning focused on understanding (and intervening in) human behaviour. As Williamson suggests:

> "The analytics, data, and AI systems developed by global technology companies and edtech businesses have become experimental engines of algorithmic education—and school systems have become their laboratories" (Williamson 2021, p. 20)

3 Learning Transformed

As the previous section has emphasised, data-driven platform software is not a passive backcloth to educational activity, but rather an increasingly powerful authority, which functions not only to reconfigure and control the relationships between educational actors, but also to differentiate multiple practices of learning. This section continues this agentive framing of the platform by focusing on the ways such data-driven systems transform learning itself, rather than simply identifying, measuring, or enhancing it. One of the most persistent fallacies in discussions of education technology in particular has been the assumption of instrumentalism (cf. Hamilton & Friesen, 2013), where technologies are understood as neutral "tools", "employed for ends determined independently by their users" (Hamilton & Friesen, 2013, p. 3). Educational platforms appear to be marketed on precisely such assumptions, where teachers, students, and managers are presumed to be able to not only detect learning as it happens, but also exact control over it, all without the technology itself having any influence over how it is perceived, other than to simply "enhance" or "diminish" it (cf. Hamilton & Friesen, 2013). This section will suggest that such data-driven systems, rather than simply offering a transparent "window" on a core, underlying, and essential form of learning, function in ways that persistently transform learning in different ways.

One central and underlying dimension here is the extent to which data-driven platforms entrench very particular ideas of what "learning" is, by structuring-in specific concepts of learning as part of their design and functioning. Specifically, such data-driven educational platforms are largely underpinned by radical behaviourist concepts of learning, through which, as Friesen suggests, the work of psychologist B.F Skinner "has been making a comeback" (2018, p. 3). This is an acknowledgement that, at least in the field of education research and practice, Skinner's form of radical behaviourism has been out of favour for some decades, due to its somewhat stark view of the human subject as a passive tabula rasa, and the framing of education as a means of strict control over the environment in order to produce desired behaviours in students. As Skinner makes clear, in human beings' "struggle for freedom", within with education has a foundational role, the goal is "not to free men from control but to analyse and change the kinds of control to which they are exposed" (Skinner, 1972, p. 98). It is precisely such a vision of external control, accompanied by an apparent lack of interest in the inner workings of the mind, that has long been passé in educational theory, and particular in the development of associated technology, which, as Cooper (1993) notes, was responding to the subsequent "paradigm shifts" of cognitivism and constructivism in the early 1990s. Indeed, it does not seem particularly contentious to suggest that most contemporary educators assume learning to be some kind of continuously emerging social and relational process, where the work of Illeris (e.g. 2009) and Lave and Wenger (e.g. 1991) provide a broadly accepted conceptual basis. However, as Watters (2017) also suggests, "behaviour design" appears to be back in fashion, this time in the form of data-driven educational technologies that seek to adapt and "personalise" digital environments for the purposes of "nudging" and directing students towards predefined learning goals or measures of performance. This is precisely the orientation towards learning that appears to be foregrounded in the so-called "adaptive" and "personalising" platforms offered by companies such as ALEKS, Century, and Squirrel AI (as introduced previously). These systems are unambiguously designed to analyse student behaviours in fine-grained ways, for the purpose of exacting precise control over

learning activities and pathways, in ways strikingly similar to Skinner's vision for radical behaviourism. This is demonstrated clearly in the ways these platforms are structured around the notion of a "knowledge domain" or "knowledge space", which establishes a mathematical representation of all knowledge within a defined topic area, and therefore an ability to position and direct students within it. Siemens explains how the "knowledge domain" underpins the ability to track and control learners within data-driven platforms thusly:

> "Once knowledge domains have been articulated or mapped, learner data, profile information, and curricular data can be brought together and analyzed to determine learner knowledge in relation to the knowledge structure of a discipline. Data trails and profiles, in relation to curriculum in a course, can be analyzed and used as a basis for prediction, intervention, personalization, and adaptation" (Siemens, 2013, p. 1389)

In other words, once a specific knowledge domain, for example the topic "Algebra" (this is the example used in the promotional material for the ALEKS platform, see footnote 4) has been established as a map, individual students can be assessed for their existing knowledge, and not only placed somewhere within the domain, but also nudged and directed along particular pathways so that all areas of the topic are eventually covered. The pathways are formed by first dividing the knowledge domain into small fragments for which specific learning activities can be devised, and then deriving appropriate connections and sequences between these elements – Century, for example, terms the individual fragments "nuggets" (see footnote 5). This process of modularisation assumes that knowledge can be divided into sub-components, and re-assembled in multiple configurations according to individual needs. Such systems therefore seek not only to pre-define and delimit all possible knowledge within a particular topic of study, but also to render it as an environment of precise surveillance and control. This appears to leave no room for contestation or debate about what might constitute authentic knowledge within a particular subject area, and is therefore

clearly oriented more towards technical domains, such as mathematics. However, the sense of fine-grained control is important to emphasise here, described in the following way by the promotional material related to the ALEKS platform:

> "ALEKS intelligence uses machine learning based on Knowledge Space Theory to efficiently develop and maintain a detailed map of each student's knowledge. ALEKS knows, at each moment, with respect to each individual topic in the course, whether the individual student has mastered that topic and if they are ready to learn it now." (ALEKS, 2022)

Crucially, the assessment of mastery and "readiness to learn a new topic" in this explanation is undertaken algorithmically, subjecting students to a system of automated decision-making about their progress. Indeed, all of the data-driven platforms promising such "adaptive" learning foreground algorithmic decision-making, largely conforming to three discrete stages. Firstly, such systems automatically diagnose students through an initial assessment that supposedly determines their current understanding of a given topic. Secondly, this measure of already existing knowledge is then used to situate students within the "knowledge domain", but also to (re)orient the "knowledge domain" itself, according to the particular elements the student is assumed to be in need of addressing. Thirdly, students are then directed towards specific pathways through the "knowledge domain", by assessing their progress and comparing it to data from previous cohorts. This form of environmental management establishes an overtly radical behaviourist configuration of learning, in which students are analysed and controlled in fine-grained and intensive ways, throughout their entire interactions with the platform software.

The key question to be asked in this example is: to what extent can the data-driven platform be said to be "neutral" here; in other words, as a technology which simply identifies, measures, and enhances learning? Given the multiple forms of transformation arguably taking place – from an often-diverse body of topic knowledge into a definitive and bounded

"knowledge domain", from understanding into a diagnosed knowledge state, and from behavioural interactions with the software into "mastery" and "readiness" – such systems would seem to be substantially involved in producing or enacting particular forms of learning, rather than passively enhancing them. As such, one might perceive the manner of learning as being transformed, across both the functioning of the platform (which maps the "knowledge space", tracks students within it, and determines customised pathways) and the conduct of the learner (who responds to the defined learning tasks, progresses according to algorithmically-derived sets of activities, and ultimately achieves the state of "mastery" by exhibiting the correct sequence of behaviours). In this way, the technology can be understood, not simply as a neutral instrument for the analysis or enhancement of learning, but rather as agentive force that moulds and shapes learning in powerful ways, and works to transform learning into a distinctly behaviourist endeavour. More broadly, Knox et al. describe the increasing amalgamations of radical behaviourist theory and data-driven technology as the emergence of a "machine behaviourism" in education, deriving from:

> "the increasing entanglement of sophisticated arrangements of software, infrastructure, and code with theories of learning, in ways that powerfully shape both the governance and day-to-day activities of teaching and learning in institutions" (Knox et al., 2020, p. 31)

Another key dimension of the performative functions of the education platform can be examined in the ways that learning is (re)presented by the software itself. As Decuypere et al. suggest, the digital architecture of platforms can be understood through two different forms of interface: the Graphical User Interfaces (GUIs) and Application Programme Interfaces (APIs). The purpose of the former is to "present the back-end of the platform to the user in a pleasant combination of text and visuals", while the latter allows "platforms and software modules to communicate with one another" (Decuypere et al., 2021, p. 4). In this sense, the graphical rendering of data might be seen as a core modus operandi of the platform, representing, combining, and depicting various kinds of

data into pleasant visual surfaces. However, it is the specific "data visualisation" or "analytics interface" that is perhaps the most explicit depiction of learning within such systems. Indeed, such data visualisations are designed to provide straightforward graphical depictions of student progress and performance that ostensibly aid rapid interpretation, facilitate data-driven decision-making and therefore constitute "actionable intelligence". Such "analytics" provide data visualisations of various activities, such as student performance in assessments, or cohort retention measures, presented to different platform users according to predefined requirements. A teacher, for example, might be presented with data visualisations of individual student or class performance, while administrators or managers might be served with comparisons across classes or cohorts. Rather than simply (re)presenting learning, or indeed objectively depicting some kind of "raw" data beneath the platform, such data visualisations might be seen as actively constructing very particular notions of learning, and contributing to the wider behaviourist orientations of the software. As Williamson suggests, data visualisations amplify the:

> "rhetorical or persuasive function of data, allowing it to be employed to create arguments and generate explanations about the world and to produce conviction in others that such representations, explanations and arguments depict the world as it really appears" (Williamson, 2013, p. 131)

In other words, the data visualisations with educational platforms might be understood, not simply as straightforward, objective, and impartial "insights" about student learning, but as graphical depictions intended to reinforce a very specific vision of educational as measurable, quantifiable, and predictable. Typically, such visualisations offer various types of graphs and charts to depict assessment progress within individual tasks or overall courses, time spent active on the platform or interacting with specific resources, or indication of strengths and weaknesses within particular topic areas. Such (re)presentations might therefore be seen as carefully constructed in order to convey an idea of learning as

highly performative and individually measurable, overlooking other socially-oriented perspectives. Jarke and Macgilchrist, for example, contend that data dashboards "cannot represent the social complexities in which teachers and students live, work and learn", by rendering "structural inequalities invisible and students individually responsible" (2021, p. 12).

Across the radical behaviourist functioning of "adaptive" educational platforms and their persistent visualisations of performance and progress, therefore, is a rendering of learning as an intensely individualised undertaking. This individualising process is established at the very first encounter with the software, as students are diagnosed through an initial assessment, and intensified as they are situated and directed through the highly-controlled "knowledge space". Furthermore, analytic data visualisations encountered throughout the graphical interfaces of the platform, reinforce the sense of individualised experience, as students are presented with personalised depictions of performance. As discussed in the previous section, platform software functions by dividing and partitioning user interfaces, so students are necessarily channelled down highly individualised pathways with no technical means of viewing or experiencing the adaptive or personalised pathway of a peer. This, of course, does not mean that students, or indeed teachers, are necessarily or totally isolated as a result of the deployment of such "adaptive" or personalising platforms in education. However, it is important to emphasise here that such platforms appear to be designed in ways that leave no room for an understanding of the social institution of education, and seem to construct and accentuate a form of learning that is intensely individualised, not only in the sense of performance and attainment, but also with respect to inferences of responsibility. As Jarke and Macgilchrist (2021) highlight, the visual rendering of behaviour as individualised learning performance bolsters a view that students are themselves responsible for achieving better scores or improving predicted targets, aligning with a particularly neoliberal framing of education. As such, it is crucial to see such processes of individualisation as radically distinct from notions of self-direction or "student-centredness" in education. The individualisation (and "per-

sonalisation") produced through data-driven platforms functions to control student choice and agency in the learning process, with little room for any sense of agency in the definition of learning pathways or outcomes.

4 Conclusions

This paper has argued for an agentive understanding of the data-driven platform in education, where such technology does not simply serve as a passive backcloth, or indeed a straightforward "enhancement" to "human" pedagogical relationships, but rather functions in ways that significantly influence resulting educational activity. Decuypere et al. attest to the multidimensional ways platforms now "act" in education:

> "digital education platforms do not only generally guide users' decision-making processes and cognition; they equally contribute to structure particular forms of education and make specific forms of education visible, knowable, thinkable, and, ultimately, actionable, in ways that reformat, redo, restructure, and reconceive what education is or could be about." (cf. Decuypere et al., 2021, p. 7)

The particular focus of this chapter has been on the ways assumptions, understandings, and practices of learning are being shaped through the use of platforms. Two themes – division and transformation – suggested some of the functions through which data-driven platforms not only apportion and restrict flows of educational data across a range of actors, but also rearticulate educational conduct in terms of radical behaviourist perspectives, and introduce acutely performative and individualising routines through the focus on data visualisation. Across these dividing and transforming practices, student data are routinely aggregated, disaggregated, modelled, and compared; multiple processes that further transform learning practices into objective and measurable insights for the increasing surveillance and control of educational activity.

However, it is worth emphasising here that a fuller sense of the extent to which data-driven platforms impact education, and indeed "learning" as it is experienced by students, would require a much broader research agenda, with a specific focus on empirical analyses of such technologies in deployment in educational settings. Indeed, this is an important area for future research in this area, which has largely been focused on conceptual engagement with data, algorithms, and machine learning-type processing. A key aspect of generating broader understanding in this area is to examine what actually happens in classrooms or other educational environments where data-driven systems are being used – presumably, for example, in such scenarios individual students may have opportunities to interact with peers and teachers at the same time as engaging with platform software. Further, the behaviouristic and individual interactions with the software might be interspersed with group teaching, or some other socially-active pedagogical arrangement. In short, it seems likely that the use of data-driven platforms would only constitute one part of a broader set of "real world" and "messier" educational activities. Nevertheless, the data-driven functions examined in this chapter demonstrate some of the powerful imaginaries (cf. Beckert & Bronk, 2021) of educational futures being promoted, designed, and constructed by private companies increasingly involved in state education. These future visions are clearly of a learning that is divided between public educational actors and commercial entities, with the latter orchestrating new kinds of value and authority in the process. Further, such visions are being operationalised to transform learning into a form of data-driven radical behaviourism that privileges intensive performance measurement, and individualises student experience.

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