THE EDUCATIONAL INTELLIGENT ECONOMY

INTERNATIONAL PERSPECTIVES ON EDUCATION AND SOCIETY

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INTERNATIONAL PERSPECTIVES ON
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THE EDUCATIONAL INTELLIGENT ECONOMY: BIG DATA, ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND THE INTERNET OF THINGS IN EDUCATION

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INVESTOR IN PEOPLE

An extremely important addition to the Comparative and International Education literature that stands out for its comprehensiveness and erudition. The topics covered here are not only thematically diverse, but extend the boundaries of scholarly inquiry by raising fundamental questions with which all members of the Comparative and International Education scholarly community must seriously engage. *Irving Epstein, Ben and Susan Rhodes Endowed Professor in Peace and Justice, Chair of Educational Studies, Director of the Center for Human Rights, Illinois Wesleyan University*

This book sparkles with insights about the emerging Educational Intelligent Economy and the challenges that new, fast-paced, commodified and borderless technologies are posing to policymaking and governance. This is the new "go-to" reference for my own explorations of big data, machine learning, AI and predictive intelligence that I have been waiting for! *Radhika Gorur, Associate Professor, Deakin University. Australia*

The book offers readers "concerned descriptions" of the current developments and provides valuable and timely contributions for exploring dilemmas, risks and potentialities of the dynamics of the Educational Intelligent Economy. A very insightful knowledge repertoire is finally furnished to interfering with and possibly challenging the existing power asymmetries in education research agendas and global policy. *Paolo Landri, Deputy Director and Senior Researcher, Institute of Research on Population and Social Policies, National Research Council in Italy*

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FOREWORD

Gita Steiner-Khamsi

This book breaks new grounds on several fronts.

Semantically, the authors of this book flesh out a vocabulary that, until recently, was only mastered by a small group of technology experts. The Fourth Industrial Revolution, Intelligent Economy, Big Data, Information Technology (IT), Operational Technology (OT), and the Internet of Things (IoT) connecting IT and OT, are but a few of the terms associated with data mining, machine learning, and artificial intelligence. A clear indication of the professionalization of this new area of research is the boundary work that the experts currently undertake vis-á-vis non-experts as well as within themselves. As a result of the expertization process, new journals have been launched, associations established, and books produced. Unsurprisingly, the terms associated with this rapidly expanding field of research are currently undergoing a remarkable semantic differentiation process. The term "data" has become ubiquitous to the extent that experts have started to break it down into 13 forms or more: big data, machine data, dark data, real-time data, etc. (Jules, Chapter 1 in this volume).

Analytically, the authors have followed Gillespie's (2014) advice: "sociological analysis must not conceive of algorithms as abstract, technical achievements, but unpack the warm human and institutional choices that lie behind these cold mechanisms" (as cited in Williamson, 2016, p. 8). Hyped as innovations and prerequisites for the "intelligent economy," humans and institutions in the education sector increasingly use these technologies in governance, teaching and learning, and testing. Drawing on the rhetoric of knowledge-based economies, governments have partnered with businesses to take the digital revolution to scale, or as Jules (2019) has astutely phrased it:

> The transition from governments to markets and the evolution of market-based economies to knowledge-based economies imply that the new sources of wealth are intelligence in the form of information housed in clouds, harnessed through data procedures, broken down into uniquely tailored bites, and off to the highest bidder. (Chapter 1 in this volume)

Clearly, the fast advance of digitalization and datafication in education has generated new transnational alliances to "tame" the digital transformation process (Salajan, Chapter 11) or to actually propel it at global scale (UN Secretary General, 2019), respectively.

Finally, several authors of the book reflect on the, mostly negative, transformative power of digitalization and datafication on learning, governance, as well as

educational policy and planning. From a sociological systems-theory perspective, any fundamental change constitutes an irritation which requires systems to learn, adjust or, to use a term that resonates with this community of experts, to recalibrate. Without any doubt, the digital revolution qualifies as a fundamental change. Therefore, the questions that arise are: What has the digitization revolution done to education? Who has benefited, who has lost as a result of system learning, adjustment, or recalibration?

Two fundamental principles of financial transaction are important to bear in mind. First, if the consumers do not need to pay for a product, they themselves become the product. The "prosumer" phenomenon in data mining (Ritzer & Jurgenson, 2010), that is, the blurred line between consumer and producer, has been scrutinized in several chapters of the book. Second, there is a particular logic of the economic system that is reflected, and exacerbated, in the digital revolution that deserves to be unpacked. Even though digitalization and datafication in education may have salutatory effects in some areas of education, it is the underlying for-profit habitus that has detrimental effects and is in need of theorizing.

In many countries, it is the businesses and international organizations that are the main actors steering the digital revolution in the education sector. A closer examination of their collaboration reveals the trend toward standardization, testing, and internationalization (Steiner-Khamsi, 2016; Steiner-Khamsi & Draxler, 2018). A few comments on these trends may be in order here.

Essentially, businesses rely on an economy of scale to sell their products and services. Standardizing learning outcomes in the form of OECD PISA's twenty-first century skills, testing them at the end of lower secondary and eventually at the end of primary school, and administering the test to as many countries or educational systems as possible, is good business. Big Data – defined by its volume, velocity, and variety – helps to continually test and refine the product in order to sell tailor-made variations or adaptations thereof to a large number of customers.

Furthermore, directing attention to the intersection of public/national and private/global is likely to yield new insights and open up new avenues of research: by default, public means local or national, and private may operate at all levels, including at the international level. A project of the modern nation-state, compulsory education is national in terms of accreditation, teaching content, and language of instruction. In contrast, private providers are able to orient themselves and operate both at a local, national and an international scale. For example, the ubiquitous talk of global markets and the attractiveness of international student mobility has helped boost the attractiveness of international private schools and transnational accreditation in education. If the trend continues, "international" is likely to become increasingly positively associated with cosmopolitanism and 'national' with backwardness and parochialism. In an era of globalization, the national orientation has become in and of itself a burden to governments. In other words, public (national) education is not doing well. The digitalization of education is deepening the crisis of public education, because national governments need to rely on the expertise, products, services

of the private sector to implement the digital revolution. They hire companies that, in the name of innovation, constantly generate new datafication and digitalization needs, reach out to new clienteles, and create an ever-expanding market. By default, the private sector thinks global, because thinking big enables them to transfer, and sell, one and the same product across the globe.

Arguably, it would be too narrow to think of the private sector merely as a provider of products and services. The private sector has become a major policy actor and is influential in setting reform agendas and formulating policies. As Lubienski (2019) points out, we are dealing nowadays with a "market place of ideas" and an "overproduction of evidence" (Lubienski, 2019, p. 70). He succinctly states:

> Into the chasm between research production and policymaking, we are seeing the entrance of new actors – networks of intermediaries – that seek to collect, interpret, package, and promote evidence for policymakers to use in forming their decisions. (Lubienski, 2019, p. 70)

The private sector has not only made itself indispensable for amassing data across national boundaries but also for interpreting it. It does so for its greater project of an "intelligent education," that is, an education that is informed by what works and what does not work. Needless to state, from the perspective of policy borrowing research, it is cause for alarm that innovations are uncritically transferred from one context to another thereby disempowering local actors and local solutions.

In other words, datafication and digitalization per se are not the problem. On the contrary, there are many positive uses that come to mind. For example, one may use data for advocacy purposes (registering the number of internally displaced out-of-school children and youth) or for digitalizing knowledge products and making them openly available for free. The issue is that the Fourth Industrial Revolution is at the mercy of for-profit companies who control the knowledge, means, and global networks to scale up digitalization and datafication to keep themselves in business.

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INTRODUCTION: THE EDUCATIONAL INTELLIGENT ECONOMY, EDUCATIONAL INTELLIGENCE, AND BIG DATA

Florin D. Salajan and Tavis D. Jules

The central tenet of this volume is that the world is witnessing the steady and gradual transition from a knowledge economy or society to an *educational intelligent economy* premised on the exponential production of digital data to measure, analyze and predict educational performance in comparative perspective. Furthermore, the digitization and datafication of educational output in the "data-driven, algorithm-mediated economy of the twenty-first century" (Economist, 2019, p. 1) have intensified the processing and analysis of data leading to the emergence of a form of digital education governance through massive flows of "Big Data" (Williamson, 2017). The shift in the massification of data storage and flows and the algorithms generating foresight capabilities unimagined barely a decade ago is of such magnitude that some have argued it represents a quantum leap in offering solutions for social and economic problems (Mayer-Schönberger & Cukier, 2013). In describing the core features of Big Data as residing primarily in its volume, velocity, and veracity but also in its exhaustiveness, flexibility, and scalability, Kitchin (2014) considers Big Data a disruptive innovation powerful enough that "a data revolution is underway that has far-reaching consequences to how knowledge is produced, business conducted, and governance enacted" (p. 2). Given its perceived value and its potential to engender both progress and pose unforeseen challenges, this type of data may be construed as *educational intelligence* to be exchanged, exploited, and leveraged for a multitude of purposes in the global educational markets and worlds of policymaking. We posit that at the heart of the intelligent economy is educational intelligence, which encompasses both individual and system-level processes. This has the real potential of

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unleashing the creative capacity of educational systems to find innovative solutions in harnessing the learning required to manage and steer data integration at the intersection of Big Data, cloud computing, social media, mobile and automation technologies, and scientific discoveries that continuously reshape the way we live, work and learn.

The term educational intelligence appears to have a long history and may be traced to the rise of data in education (Lawn, 2013). It has been used under varying semantic connotations and with diverging meanings over time. Thus, during the mid- to late-nineteenth century, the *Journal of Education for Upper Canada* (Department of Public Instruction for Upper Canada, 1848–1866) construed educational intelligence as information collected from the academic world as updates and news about individual scholarship and institutional developments. Though no explicit definition was provided, a section of the journal titled "Educational Intelligence" was devoted to recording and disseminating such information, suggesting an understanding of the term as a process of information gathering with the purpose of building a shareable list of updates for public consumption, not connoting an intent to gain advantage in an adversarial, conflictual or competitive context.

More significantly for the field of comparative and international education, Sir Michael Sadler's take on educational intelligence at the beginning of the twentieth century is illuminating for its foresight and significance in steering educational research and reporting on comparative analyses of educational systems. Having served for eight years and accumulating a wealth of experience as Director of the UK Office of Special Inquiries and Reports, Sadler suggested that a change in the Department's title was more fitting its then current scope and purpose. Thus, in recounting his reflection on this matter, Sadler opined:

> The present title is too obscure, while that suggested in lieu of it would more clearly denote the work of the branch, as the Intelligence Department of the Board of Education. It would also more closely conform to the nomenclature adopted for the Intelligence Divisions of the Admiralty, War Office and the Board of Trade. (as cited in Sislian, 2004, p. 8)

Sadler's predilection for including educational intelligence in the renaming of his former office and elevating its importance to that of the domains of defense or commerce is telling in his intent to equate educational intelligence with military or economic intelligence. It implies that he regarded educational intelligence as vital data assets with strategic value to be safeguarded and leveraged in extracting benefits for the investigation and steering of educational systems. It is hardly coincidental that Sadler would advocate for an acknowledgment of educational data as a form of intelligence in the sense of sensitive information to be gathered and employed in comparative studies of educational systems. During the nineteenth, century comparison became increasingly more reliant on statistical data, and world expositions acted as competitions of sorts for educational systems (Lawn, 2013). According to Crossley (2014), at that time, and still today, "the primary motivator for such comparisons came from the economic competition between nation-states" (p. 16). Sadler was likely keenly aware that such educational intelligence was an essential tool not only in developing a thorough understanding of one's national education system but also in measuring its performance in

contradistinction with those of other countries. In this sense, it may be presumed that apart from the rather benign aims to drive the governance, improvements, and reforms in the UK's educational system, Sadler treated educational intelligence as an avenue to propel national education into an influential political and economic position internationally.

To a certain degree, Sadler's implicit analogy of educational intelligence to information gathering for defense or economic aims is a precursor to Revel's (2010) use of economic intelligence as meeting three distinct needs of actors in a globalized world: the mastery of strategic information, economic security, and influence. All three features can be transposed to the structures and institutions of national educational systems, as they seek to compete in an increasingly competitive educational market characterized by the rapid production, flows, and consumption of ever larger quantities of data. In Revel's (2010) conception, "economic intelligence," combines several concepts and practices including "competitive intelligence, economic security, risk management, lobbying, public diplomacy, soft power (governments), business diplomacy (companies)" (n.d) to regulate the flow of information among public and private actors. In essence, economic intelligence is a governance mechanism that is "recognized as a professional tool for strategy and management for states and companies in the globalized world" (p. 2). Others have extended the discussion on economic intelligence to account for the "identification of relevant sources of information, the analysis of the collected information and its manipulation to provide what the user needs for decision making" (European Commission, 2002, p. 9).

Discourses on economic imperatives emanating from the competition in the global markets have long penetrated educational policy parlance, as national governments in knowledge-driven economies have placed an ever-larger emphasis on the role of education in the production of knowledge in the era of seemingly limitless global flows of information. In Steiner-Khamsi's (2004) words, "there is no doubt that there are economic gains associated with educational trade. The education export business is a lucrative one" (p. 205). Thus, large-scale international comparative studies, such as the OECD's Programme for International Student Assessment (PISA) and the Programme for the International Assessment of Adult Competencies (PIAAC) or the IEA's Trends in International Mathematics and Science Study (TIMSS) have become a treasure trove of critical data in the governance of education for a whole host of institutional and individual actors intersecting the worlds of academia, policymaking, business, industry, and civil society (Williamson, 2017). Along with vying for recognition in academic league tables, these various entities have vested interests in demanding increasingly more rigorous standards of quality and accountability from educational systems to extract socio-economic benefits. As such, the "comparative advantage" or "comparative disadvantage" of each system can be determined and politically and economically utilized (Steiner-Khamsi, 2004, p. 207).

Hence, on the one hand, the educational intelligent economy amounts to a space where data is instrumental in assessing and protecting the outputs of educational systems. On the other hand, in this space, data is traded as a commodity among public and private actors seeking to influence educational policy.

Not incidentally, third parties involved in the measurement of educational Big Data derive financial benefits from providing statistical and predictive analytics services (Crossley, 2014), in this sense underscoring the lucrative character of educational data in the educational intelligent economy. Consequently, analogous to Revel's (2010) concept of economic intelligence, educational intelligence represents a prized asset in this econosphere, as national education systems and international organizations, such as the OECD or the EU seek to: (i) master the utilization of Big Data for forecasting and planning educational reforms; (ii) determine the financing of education based on performance, accountability and benchmarking; and (iii) influence educational policy to effect adjustments or improvements in educational systems.

Notwithstanding the predominant economic value of data in the educational intelligent economy, it is important to note that, even understood as educational intelligence, data has essential functions for instructional processes on which any institutional performance ultimately rests. In this context, educational intelligence takes on rather benign or technical connotations in contrast with its primarily strategic nature described above. For instance, Aziz et al., (2014) conceptualize educational intelligence as a process to "effectively manage data in an academic environment" using a model combining "technologies, tools, and technique, people (students, academia, and other stakeholders) to achieve constructive knowledge that helps improve the teaching and learning process" (p. 52). Immersing the concept into the ongoing discussion on Big Data analytics, Khan, Shakil, and Alam (2016) suggests that educational intelligence "can be used to describe the use of techniques, reporting applications and analysis tools to gain insights into critical operations in the wider education system" (p. 29). At this level, educational intelligence acquires purely techno-statistical importance, driven by analytical and algorithmic logics designed to generate objective representations of educational inputs and outputs.

Although tactical and technical value, along with impact, are uncontested features of educational intelligence, these only partly explain the shaping of an educational intelligent economy. Three additional descriptors need to be considered in outlining its emerging contours. First, *control and regulation* of Big Data flows and who exerts them are instrumental in understanding how public and private actors manage access to the value of data as a commodity to be exchanged on open markets. Operating in a fluid environment characterized by rapid influxes and accumulation of structured and unstructured data (Cantini, Chellini, & Sagri, 2016; Reimsbach-Kounatze, 2015; Struijs, Braaksma, & Daas, 2014), poses challenges that compel national governments and international organizations to attempt the formulation of fitting policy technologies and develop responsive digital platforms for managing Big Data in educational systems. This leads to the second descriptor of the educational intelligent economy, namely the *purpose of intentional deployment* of Big Data in education. As national systems devise avenues to increase their capacities for data organization and administration, the aims for data collection become central to the question of institutional and systemic data management in education: to what ends do national educational systems gather and parse educational intelligence? The responses are

unquestionably many and varied, but range from the evaluation of academic results to identify both strengths and weaknesses to be addressed or the monitoring of output for the enhancement of educational governance to converting academic innovation into viable solutions to advance socio-economic priorities. In this process, the *manifest lucrative value* of Big Data serves as the third descriptor of the educational intelligent economy. Even as the massification of data streams has a disruptive effect on the so-called education markets (Ball, 2003; Robertson & Komljenovic, 2016), a multitude of actors either compete against one another or form coalitions to reign in its seemingly amorphous expansion. At the same time, these actors converge to exploit the commodification of data exchanges in education to extract revenue and profitable endeavors for a coterie of contracting agencies engaged in large-scale data analysis, in an environment Santori, Ball, and Junemann (2016) denoted by the term "edu-business."

While it can be argued that these semiotic markers of the educational intelligent economy are not entirely new and could be detected in other technological manifestations in economies and societies over the past couple of decades, the novelty of this rising space rests in its scale, complexity and variability in the era of Big Data, artificial intelligence, machine learning, and predictive analytics. Evermore sophisticated computing logics and designs premised on capturing vast amounts of data originating from a multiplicity of smart technologies have led to forms of "algorithmic governance" in socio-technical systems (Pitt, Busquets, Bourazeri, & Petruzzi, 2014) that have spilled over into shaping educational bureaucracies through "governing software" promoted by non-governmental intermediaries (Williamson, 2015). Unprecedented computing power currently outstrips bureaucracies' capacity to formulate macro-policies in time to regulate the processing, storage, and ownership of data across national, let alone global educational networks. Where consensus on policy exists, this revolves around the protection of privacy and personal data use rights, as demonstrated by the General Data Protection Regulation enacted by the European Union. From initial formulation to actual implementation, it took eight years for this policy to come to fruition, a period in which the nature and scope of data have changed in radical ways. As salutary and necessary as this regulation is for safeguarding the personal data of billions of users worldwide, it is not designed (nor was it intended) to scrutinize the ownership and exploitation of other forms of data publicly or privately traded across global networks for commercial purposes. The continuous challenges in regulating data flows to discourage illegitimate or harmful uses through responsive policy mechanisms and instruments present a complex problem for educational researchers in the educational intelligent economy, as the sophisticated machinery of data production continues to accelerate its pace to advance public interests, but, more frequently, serve bankable intents.

Access to Big Data, the "new commodity" in the twenty-first century economies, and its uses and potential abuses, has both conceptual and methodological impacts for the field of Comparative and International Education (CIE). Innovations that have been restricted to the technology sector are gradually starting to move into education as companies seek to monetize social data, dark data,

and Big Data. As Gorur, Sellar, and Steiner-Khamsi (2019) put it, "twenty years after the market reforms in education, education systems are drowning in data and their administrators have become champions in international comparison" (p. 1). In this context, educational intelligence is all around us and, therefore, the focus over the past five years has been on how to better make sense of data (both historical and contemporary) by detecting patterns to amplify its value. Of particular importance in this discussion, is the ability of data to restructure national educational systems to make room for newer educational actors at the dawn of the so-called "Global Education Inc.," defined by policy actors and a neoliberal imaginary (Ball, 2012). Even more pertinent for CIE is the potential of these myriad types of digital data, whether promising or questionable, to revolutionize comparative methodologies of educational research (Gorur et al., 2019). Coming full circle then, Sadler's elevation of educational intelligence to the strategic status of military or economic intelligence was prescient for the current era of massive accumulation, transfer and parsing of data in a global economy in which educational institutions wrestle for competitive advantage, as partly demonstrated by the importance currently placed on academic league tables (Crossley, 2014). Indeed, this phenomenon is bound to exert a comprehensive and lasting impact on the comparative analysis of such data, the implications of which are difficult to fully comprehend at this point in time.

CHAPTER OVERVIEWS

Given our framing of data as a form of *educational intelligence* situated at the intersection of Big Data, AI, Machine Learning, and the Internet of Things in education and new economic imperatives driven by the advent of the Fourth Industrial Revolution, the chapters in this volume are clustered under four main thematic areas. The first theme attempts to reconceptualize the role of data in comparative and international education in anticipation of the marked transformations that Big Data are expected to usher in education more generally and CIE in particular. The chapters grouped under the second theme ponder the conceptual power and limitations of methodologies designed for the governance of education, as Big Data introduces novel or alters technologies of measurement and design of education. The third theme addresses the forces exerting balancing or imbalancing effects on education, workforce participation and industry in the era of Big Data. Under the final theme, several chapters offer unique case studies ranging from policy formulation to historical legacies (re)interpreted in the context of educational intelligence, each with a focus on a distinct region of the world. As this thematic compartmentalization suggests, the volume brings together a group of scholars from a rich set of multidisciplinary perspectives employing a variety of analytical approaches to the *sui generis* phenomenon embodied by Big Data in education and its central role in shaping the contours of the educational intelligent economy. The rest of this introduction provides concise descriptions of these timely contributions to this fascinating area of inquiry.

In Chapter 1, Tavis Jules chronicles the emergence of data as an instrument of educational governance and comparison, under the tutelage of increasingly more influential policy-informing entities, such as the IEA, OECD and other similar bodies. He contends that data in itself can be considered an assemblage exerting (re)territorializing effects on educational governance as it interfaces relationally with assemblages operating by virtue of their subsuming and, at the same time, subordinated relationship to data. Consequently, Jules argues that, at the dawn of the educational intelligent economy driven by the Big Data paradigm and associated technologies of predictive analytics, a new age of educational governance with a "big G" emerges, characterized by the co-evolution, coordination, and concurrence of steering mechanisms, in the interstices of which data sources form the algorithms of governance with a "small g." The implications for the educational intelligent economy rest in the manner in which these layers of governance will continue to seek an equilibrium or struggle to prevent disruption as educational intelligence becomes increasingly commodified, consumed, and codified in algorithmic technologies of educational managerialism.

In Chapter 2, Bjorn Nordtveit and Fadia Nordtveidt offer a critical narrative problematizing the indiscriminate use of Big Data to further reinforce colonial tools of dominance in research. They also point to the pressing need for CIE researchers to be aware of the perils and paths of Big Data utilization and pattern replication from the global north to the global south. The discussion is tied to the emergence of educational intelligence in the global economy and how this may either ameliorate or, on the contrary, exacerbate the imbalanced duality of research imperatives from the North to the South (and vice-versa).

Ryan Ziols provides an intriguing discussion in Chapter 3 by analyzing the discourses on assessment and categorizations of mind capacities via multiple socio-, bio-, psycho-, demographic factors. Tracing the history of cybernetics to elucidate large-scale assessment assemblages, Ziols applies a novel lens to examine the measurement of the socio-psychological at the interface of Big Data, learning analytics, and artificial intelligence, through the perceptron metaphor in a continually comparative-competitive educational environment.

Chapter 4 delivers Brent Edward's critique of mainstream evaluation methodologies employed by supranational organizations increasingly involved in and steering the global governance of education. He draws attention to the pitfalls of statistical and quasi-experimental approaches embedded in large-scale impact evaluations, such as PISA or TIMSS, and the ramifications such undertakings have for policymaking. Thus, Edwards cautions that in the absence of ensuring ideal conditions or contexts, something he argues is a virtual impossibility, policy decisions in the era of Big Data is fraught with the perils of replicating skewed assumptions about educational systems' performance in comparative perspective on a scale of magnification of unprecedented and unpredictable consequences.

In Chapter 5, Jason McGrath and John Fischetti engage in an imaginative examination of schooling based on innovative urbanism principles embodied in the design of cities in three different countries. Through anticipative thinking models drawing on urban planning techniques, they attempt to cast a vision of the school as a novel concept in the new millennium and problematize its place

at the intersection of three fundamental ideas, that is, the role of the teacher and learner, the design of a school, and the purpose of compulsory schooling. These ideas are explored through foresight analysis informed by three possible scenarios providing alternative proposals for their transformations given the pressing needs for sustainability, incorporation of new technologies and promotion of innovative pedagogical principles. Via a contrasting content analysis of school publications, the authors contend that, notwithstanding the possibilities inherent in novel conceptualizations of schools, the traditional thinking about school designs and schooling practice prevails in current educational policy.

Vasudha Chaudhari, Victoria Murphy, and Allison Littlejohn offer a relevant discussion in Chapter 6 on the role of lifelong learning for an emerging educational intelligent economy, given the digital transformations brought about by Big Data and AI. If offers a vision of how the complexities of incorporating Big Data into formal and informal systems of education may alter the way in which individuals learn and develop flexible competences enabling to navigate intelligent digital systems enmeshing the economy. The chapter further points to the need for regulatory frameworks to steer intelligent educational data gathering to safeguard individuals' privacy and right for data ownership.

In Chapter 7, Elizabeth Roumell and Kevin Roessger construct a coherent argument for the connection between adult education policy in comparative perspective, highlighting the use of PIAAC data, and its potential to interface with Big Data analytics to drive economic policies for a more intelligent allocation of workforce resources. They explore how these processes may feed the economic trends toward the use of "intelligence" to monitor and induce self-regulation in socio-economic and educational systems to inculcate intelligent choices for education throughout individuals' lifespans.

Chapter 8 contains Aleksei Malakhov's description of data mining, machine learning and predictive analytics and their role on both formal educative processes especially related to monitoring and tracking of student performance. He then extends that discussion with a consideration of the ramifications such uses of data may have on employability in the Canadian context, but also in comparison with other labor markets.

In Chapter 9, Petrina Davidson, Elizabeth Bruce, and Lisa Damaschke-Deitrick examine the role non-profit organizations promoting educational programing and performance play in the steering of educational governance in the transition from a knowledge economy to an educational intelligent economy. They posit that such organizations expand their reach in the educational market and the governance of educational use of data by sustaining and sponsoring data-driven measurement instruments that inform policy production for subsequent stages of educational output. They suggest that a whole network of similar organizations exert increasing influence in educational governance in an educational intelligent economy.

Chapter 10 offers Luis Alvarez León's examination of the arrival of AI in the automotive industry and the manner in which this will create tensions and cleavages in training levels between various categories of auto engineers and