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Learning in the Age of Networked Intelligence

In the next years we will live in a world where knowledge is readily available whenever and wherever we need it. Technology will allow us to store and carry huge amounts of information, and communications networks will provide us unprecedented possibilities for processing and applying knowledge.

To what extent the traditional aims of education will remain relevant in this changing world? Will the institutions of learning adapt, or will they be replaced with new forms of learning and knowledge management? How will learning and education look like in this new world of knowledge?

In this paper, I present ten "theses" on future education and learning, highlighting emerging trends that will shape future educational systems. The focus of this paper is on the impact of the innovation economy and knowledge society on learning.

To put the discussion in a context of social change, the paper starts with a brief review of Niklas Luhmann's analysis of the social function of education. The paper then zooms in to a more historical description of socio-economic transformations, with the aim at highlighting the distinguishing characteristics of the ongoing transformation towards the innovation economy and knowledge society. Specifically, the paper elaborates the changing dynamics of production models, arguing that in the last few years we have been in a globalization process that is qualitatively different from the earlier ones. This new model has consequences, for example, for skill demands and their regional distribution. A historical description of production models is useful, as educational institutions are optimized for the requirements of the past production models.

The emerging innovation economy is not only about the increased importance of new products, services and knowledge in making profit. It is also about new approaches in producing innovation and knowledge. Fundamentally, it is about new ways to link learning and social and economic change. To create these links, we need to revisit some traditional ideas about the nature of innovation. The paper therefore outlines a new theoretical view on innovation, which connects innovation with social change and learning. The new "downstream" innovation model highlights the active and creative role of user communities in making innovations real.

Historical description of the changing social and economic patterns is useful when we try to understand where we came from and where we are today. The paper, however, moves beyond the diagnosis of the historical trends, and proposes a set of possible futures. These are presented as ten "theses" about the future education and learning. The paper ends with a short concluding section.

Do We Need Education in the Future? A Sociological View

Human beings are born unique. They have a countless number of characteristics and experiences that make each individual different from the others. According to sociologist Niklas Luhmann, the existence of social order and meaningful communication requires that this potentially infinite complexity is reduced and simplified. To make society possible, human beings have to become "generalized" members of that society. According to Luhmann (2002), the Erziehungssystem of society –the functionally specialized system that upbrings and educates human beings– makes newborn human beings constituents of the society. In the context of social systems theory, the function of society's "Erziehungssystem" is to reduce social complexity.

"Upbringing" is needed to make children full members of the society. According to Luhmann, a specialized system of education emerges when society's functional differentiation increases. In the modern highly complex world, simple socialization and internalization of traditional roles and practices becomes insufficient, and the society starts to rely on a specialized functional system of education that "manufactures" a large variety of specialized persons that can occupy social roles. The primary social function of education is to produce "generalized persons," who can reproduce the society and keep it going.

According to Luhmann, the secondary function of the educational system is social selection. Human beings have different abilities and potential capabilities. The educational system therefore also functions as an evaluation and selection mechanism that puts human beings on alternative career paths.

Luhmann's description of socially specialized educational systems is based on his general theory of social systems (Luhmann, 1995; Qvortrup, 2006). Education emerges in this theoretical context as one of the many functionally diversified sub-systems of a modern society. Assuming Luhmann's description accurately characterizes the social function of education we can therefore ask whether future knowledge societies need educational systems. If Luhmann is right, educational systems are needed as long as new-born human beings have to be developed into socially differentiated "persons," and as long as the society benefits from the selection that occurs in the educational system.[1]

In the modern world, innovation rapidly reconfigures social categories. The post-industrial world is characterized by fluid social roles, unpredictable life paths, and increasing mismatches between traditional professional careers and labour market demands.

The processes of creative destruction operate now also inside educational systems. Luhmann, however, argued that educational systems have one stable core function that should remain even when everything else changes: to simplify complex societies and make them more predictable. Will there be other ways to achieve this in the future?

Somewhat paradoxically, the Information Society, itself, can be understood as a response to the increasing need for education. This is because one way to make societies more predictable is to make them more information intensive. Anthony Giddens (1985), for example, has argued that organized states are inherently information societies.[2] The generation of state power presumes reflexively gathering, storage, and control of information, applied to administrative ends. Urban planning, transportation systems, taxation, and central bank interest rate adjustments all require

[1] Luhmann's view is a highly abstract and "systemic" view on education. It may appear to contrast with humanistic views on education that emphasize individual development. Implicitly, a related view is adopted by educational planners, who try to match future job market requirements with educational curricula. The level of contrast also depends on how concepts such as individuality and development are understood. For example, the Confucian Daxue emphasized self-development that has its source in right knowledge, verified opinions, and the cultivation of persons. The ultimate goal of all education is illumination and shining virtue. According to Confucian thinkers, this, however, requires an orderly state. Harmony requires cultivated persons, who become cultivated when their minds are rectified by verified and researched opinions. Education, thus, leads to an orderly state, where fully cultivated people can take their proper positions in the society.

[2] For a discussion, see Webster (1995: Ch. 4).

huge data collection and information processing efforts. In other words, the society is managed and operated through an increasing number of statistical categories and related data that provides an accurate picture of the underlying social world.

One way of putting this is to say that an increasingly complex social world is simplified and made more predictable by representing it through information. Another way of putting the same thing is that the amount of information increases because the society becomes increasingly complex. This is one of the reasons why we describe the modern world as an information society.

In Luhmann's view, social categories are not only needed to manage societies and their complexity. A society could simply not exist without categorizations that simplify this complexity. Theoretically speaking, education and statistics are, therefore, complementary: education creates social categories that simplify social complexity, whereas statistics collects data that can be used to manage that complexity.

The paradoxical outcome is that when increased social predictability is gained through increase of information, the modern society reflexively uses all the available information to increase its complexity. The historically unparalleled pace of developments in information processing technologies has during the last five decades guaranteed that complexity can increase faster than predictability. In its traditional Luhmannian function, educational institutions, therefore, have been only partially successful.

The Information Society, however, also open new paths for development. From a social-systems point of view, information and communication technologies are technologies for managing social complexity. Information technology can therefore be used to tackle social complexity also directly. For example, the social importance of formal educational certificates is now declining, as the capabilities, interests, and reputations of people can be directly evaluated using information and communication technologies.[3]

We can now also use information technology to create social categories on demand.[4] The underlying social complexity can therefore remain high. In practice, people play multiple roles in the society, and they can switch among the different roles very rapidly using information and communication technologies. Persons can become more individual and unpredictable, as information processing capacity increases in the society. Statistically speaking, the increasing individualism does not matter, as socially relevant data can be collected and processed in real time.

Professional and vocational categories have been key social categories in shaping educational systems. The emerging knowledge society removes some traditional constraints for managing social complexity, creates new trade-offs, and shifts balances. This emerging new "world order" will, therefore, change the context of education in the future. The social system of meanings will increasingly be learned outside formal education. Formal education, in turn, will focus of the development of generic capabilities. Most importantly, the future educationalists and policy makers have to be able to answer the question why the society needs education.[5]

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[3] Instead of asking whether a job candidate has a formal educational status, a potential employer can now review the candidate's actual track record, blog postings, and possibly e-portfolios.

[4] A large variety of technologies are used today for dynamic analysis of information. These include software systems for data mining, online analytical processing, statistical clustering, rule-based decision support systems, and social network analysis, among others.

[5] This will lead to the classical question, whether it is possible to teach values (cf. Tuomi, 2005:50-5). In the global multicultural world, this question is both important and non-trivial.

The ongoing socio-economic re-organization of the society will also more directly influence vocational and professional categories. Vocational and professional categories emerge as complements for specific ways to organize labour. When systems of production change, vocational categories change. It is therefore important to understand how the emerging models of production differ from the earlier ones. The economy of the future is increasingly distributed geographically and innovation and novelty are the key sources of value. The traditional constraints of economic production and theory are radically changing as we move from the economy of scarcity towards the economy of value.

Do We Need Education in the Future? A Socio-Economic View

In industrialized countries, educational systems have developed during the years to address specific social and economic challenges that emerged in the 19th and 20th centuries. The legal, political and economic institutions that underlie vocational education and training, in particular, have evolved to answer the demands of industrialized mass-production. In many ways, the reality of educational systems reflects the need to optimize production in a historically unique setting, where boundary constraints were set by the limits of transportation capability, resource availability, access to knowledge, and coordination and information processing capacity. Information and communication technologies are now radically moving these boundaries both in industrialized and developing countries.

Technologies, vocations, skills, and the ways in which work is organized are closely related. Vocations, skills and organizations are different in agrarian, industrialized and knowledge societies. The currently emerging global knowledge society is unique in its capability to connect countries across geographical distances and economic levels of development. Development, in this context, does not necessarily mean, for example, that vocational and educational practices trickle down from the economically most advanced countries to the rest of the world. The best existing vocational education and training systems in the economically developed countries represent the best answers to yesterday's socio-economic challenges. In principle, there is no obvious reason why these systems would be beneficial in the emerging knowledge society. On the contrary, it is quite possible that educational systems that are optimized for the yesterday's world can be dysfunctional in today's and tomorrow's world.

To locate historically the formative factors that underlie modern educational systems, the ongoing socio-economic transformation can be characterized as the most recent link in a chain of production paradigms. Each of these paradigms has had its own "social logic" where specific ideas about "vocation," "education," and "training" make sense. When the paradigms have changed, these terms have become reinterpreted so that they have remained meaningful in the new context. Although the following description is a simplified outline of the historical development, it also highlights the economic importance of innovation and knowledge creation in the emerging knowledge society. Furthermore, this description allows us to distinguish two quite independent dimensions of development in the Information Society, both with substantial implications for education of the future.

According to Pérez (1985; 2002), the dominant "logics" of production have undergone five major changes since the first Industrial Revolution. Each production paradigm has been organized around a "standard way of doing business," in a way that effectively utilized a new generic key technology. Since the start of the first Industrial Revolution in England in the 1770s, there have been five such "industrial revolutions" and "techno-economic paradigms."

The first was based on mechanized work and new infrastructures such as canals and the wide availability of water power. The second paradigm, in turn, was based on steam and railways. It started in Britain and spread from there to the Continental Europe, the U.S., and eventually to the rest of the world. The second paradigm was also associated with the increased scale of production, which in turn was based on standardization of mechanical components, universal postal service and the emergence of telegraph networks. The third paradigm, according to Pérez, can be called the Age of Steel, Electricity and Heavy Engineering. Starting from 1875, it introduced cheap steel, which, among other applications, was used to build steam-engine based steel ships, worldwide railways, electrical networks for illumination and industrial use, as well as bridges and tunnels that complemented the new transport technologies.

The fourth paradigm, the Age of Oil, Automobile and Mass Production, was the leading organizing principle of most of the 20th century. It started in the North-America, and spread first to Europe and then to the rest of the world. This paradigm was associated with key new technologies such as the automobile, electricity, and the availability of cheap oil. The realization of the emerging economic potential required the development of infrastructures such as highway networks, airports, oil ducts, and worldwide telecommunications, and new production principles such as standardization of products, utilization of scale benefits, functionally diversified and hierarchical organizations, and the wide use of synthetic materials.

This fourth techno-economic paradigm is still of key importance when we describe the rational for many institutional structures of education. In particular, the implicit goals of technical and vocational education and training are frequently associated with the requirements of functionally diversified and hierarchical approach to organizing work. In this organizational setting, work tasks and related competences can be defined relatively easily. A functionally diversified and hierarchical organization fixes and stabilizes work tasks, in the extreme case making them routines. For such stable work tasks, relevant competences can be easily defined. Training and education for such work can, therefore, be specialized. The industrial structure, as it were, creates its “mirror image” as a professional and skill structure, and in the special case of the fourth mass-production paradigm, professional categories themselves become statistically dominant. In this historically unique situation, standardized vocational education can mass produce skills that are useful and in demand in the labour market.

Since the invention of semiconductors and general-purpose microprocessors, the economic system has increasingly been organized around efficient use of information and communication technologies. Pérez calls this fifth techno-economic paradigm the Age of Information and Telecommunciations. More frequently, it is called the Information Society.

The concept of Information Society hides two quite independent developments in systems of production. The first is the increased capability to coordinate labour across time and space. This aspect of the Information Society is often discussed in terms of globalization. The second can be found in the shifting sources of economic value. This, in turn, is often discussed in terms of innovation. Both have fundamental implications for educational systems. To understand these, we have to describe in some detail the currently emerging production model and its relation to the new models of globalization and innovation.

The Third Globalization as the Sixth Industrial Revolution

Streamlining history, we can distinguish three major stages of globalization. The first wave of globalization was based on physical transportation of goods and people. In its first stage, starting in the mid-19th century, raw materials and commodity products were transported by ships and railways, and production was coordinated by headquarters located in industrialized countries. In its latter phase, after 1940s, jet airplanes enabled managers to travel regularly to distant plants and develop integrated planning and decision systems. Due to limited communication capabilities, the first multinational firms, however, had a clear distinction between planning and production functions.[6]

In the mid-1960s, international telephony achieved a milestone when it became possible to make five hundred simultaneous telephone calls between Europe and North-America ([Hugill]). Multinational corporations, however, had considerable difficulties in effectively linking their regional operations before the continents were connected with fibre optic cables in 1992. In that year, only, 37,000 voice circuits were added between North-America and Europe. These technical developments were paralleled in other continents, as well.[7]

The second globalization occurred when the Information Society expanded beyond national boundaries. The limited communication capabilities of telex and international telephony expanded rapidly in the 1980s, and direct dialling of international calls, sending of faxes, and, towards the end of the decade, email messages became the backbone of multinational and transnational organizations.[8] The true impact of the new communication technologies was, however, felt only in the early 1990s, when corporations became able to exchange documents with rich content. This allowed large firms and their selected partners to coordinate and collaborate globally. As a result, multinational and transnational corporations are now properly called global corporations. The impact has been the geographic re-location of work and production during the last decade. The less visible impact has been the introduction of new work and management practices that rely heavily on information and communication technologies, as well as new knowledge and competence based views on organizations.[9]

The *third globalization* is the most recent phase in this re-organization of production.[10] It has a qualitatively new model, which relies extensively on broadband communication networks. In the previous phases, global division of labour has required separate stages of product planning, production, and delivery. The new internet-based business models make this redundant. The products and services that are purchased today are now increasingly configured and packaged in real time, joining product components and services using global information networks.[11] The model has emerged during the last couple of years, and it is spreading fast.

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[6] The implicit theory of organizing is reflected, for example, in the idea that corporations have "headquarters." The assumption of limited communication capabilities of firms also underlies the information processing view of multinational organizations (e.g., Egelhoff, 1988; Tushman & Nadler, 1978).
[7] Tuomi, 2002: Ch.4.
[8] The concept of transnational corporations was popularized by Bartlett and Ghoshal (1989), who argued that multinational corporations were characterized by centrally coordinated production for nationally specialized markets, whereas transnational corporations optimized their production for global markets.
[9] Since the mid-1990s, the knowledge-based view on firms has been an increasingly dominant view, leading to extensive research on organizational learning, knowledge management, and organizational sensemaking. For influential statements of these views, see, e.g., Brown & Duguid (1991), Hedlund (1994), Grant (1996), Nonaka (1994), Quinn (1992), and Weick (1995).
[10] This nomenclature, of course, is somewhat arbitrary. One could, for example, argue that the jet airplane created a qualitatively different second phase of globalization and the multinational organizational form. For the present purposes, I simply distinguish the "classical globalization," the "informational globalization," the third globalization, based on a "real-time virtual service configuration model."
[11] Zysman (2006) calls the underlying transformation in service production "the Algorithmic Revolution."

Examples of this production model include advanced travel reservation services. Whenever a customer clicks a button to reserve a flight ticket from an internet-based travel reservation system, the system dynamically generates a global network of services. One component service may be realized in the Bahamas, another in the customer's home country, one in India, one in Australia, for example. The underlying system of production is a transient global network of services that pops-up at the moment of production and synchronizes its operations in real time. This, obviously, requires a global broadband communication network, and standardization of service interfaces. Such real-time global connectivity would have not been possible in the 1990s. In the next decade, it will be the main-stream techno-economic paradigm.

In theory, comparative advantages would lead to global division of production and associated specialization of human skills and knowledge. Globalization, in the context of the Information Society, however, means that comparative cost advantages become absolute again.[12] Whereas the classical theory of international trade followed Ricardo and assumed that capital is sticky and does not move from one country to another, in the modern economy capital flows quite freely across country borders.[13]

The importance of absolute advantages is that employment follows capital. In economic terms, both the utility and individual demand for skills and knowledge change when opportunities for their use change. In those regions where absolute advantages lead to improved job opportunities, people flock to education that materializes the emerging economic opportunities. The key source of economic growth, then, becomes the amount of potential human capital that can be rapidly put into productive use. The shifts in capital are further accelerated because economically relevant knowledge and skills are often learned at work. Workers can rapidly lose their productivity if their skills are not used and updated regularly.

As a consequence, traditional professions and vocations have in recent years seen rapid shifts in regional demand. Forecasted needs for vocational skills have typically been based on historical trends. Trends, by definition, provide misleading estimates when structural change dominates. As a result of the very rapid globalization of production, educational planning has therefore become quite difficult.

The various techno-economic paradigms do not replace each other. Although steam engines are now economically a curiosity, canals, railways, steel, automobiles, petroleum products, and micro-electronics all have their role in the complex system of global economy. The various techno-economic revolutions have left their inedible marks as networks that connect cities, shipping terminals, airports, and communication centres.

The present socio-economic transformation is, however, unique in its capability to both create new domains of production and to reorganize the earlier ones. Knowledge society is not only the next

[12] The classical theory of international trade was based on David Ricardo's idea of comparative advantage, where each region can benefit by specializing in those types of production where it has relative advantages. According to Ricardo, although it is cheaper to produce both wine and cloth in Portugal than it is England, international free trade makes it still beneficial for Portugal to focus on producing wine and selling it to England to buy cloth manufactured in England. The relative advantage of producing wine in Portugal, compared with England, allows Portugal to use its resources to produce large enough amounts of wine so that it can buy more cloth from England than it would be able to make on its own. Both countries, therefore, end up better off by trading goods where they have relative advantages.

[13] The fact that both cloth and computers are today manufactured in China is an example of the rebirth of absolute cost advantages in international trade. Although the benefits of comparative advantage might make it useful for China to allocate its resources to textile manufacturing, in today's global world capital will easily flow in to set up a computer manufacturing plant, as well.

"modern" layer on top of the earlier ones; instead, it systematically "modernizes" traditional industries, agricultural production, as well as local markets and the production of crafts, arts, and values. Information and knowledge are "generic technologies" even more than steam, electricity, steel or petroleum, as basically all production and products can be enhanced by information and knowledge. Thus, in the current global socio-economic transformation, canals, railways, steel production, and cars all become integrated with information and communication technologies. The products of previous revolutions, as it were, become embedded into a complex global system of production, where real-time information, communication, and knowledge networks adapt the earlier technologies into radically new uses.

The ongoing transformation therefore also penetrates boundaries that emerged and were shaped through the forces of the previous techno-economic paradigm. Politically, one of the most important of these boundaries is the one that separated "industrialized" countries from "developing" countries. The global knowledge-based economy slices geographical regions in new ways, where national borders have decreasing relevance. Instead of geographical proximity or local availability of resources, the underlying organizing principle in the knowledge economy is based on global networks (Castells, 1996). The distinction between "developing countries" and "developed countries" is therefore becoming increasingly anachronistic. This change can now readily be seen, for example, in countries such as South Korea, India, and China, where regional hubs connect with global production networks. A similar reorganization can also be seen in the leading industrialized countries, where geographic specialization is now essentially based on diversification in the context of global systems of production.

This means that the challenges of vocational education will be surprisingly similar in countries that vary widely in their current economic level of development. This, indeed, is one of the key differences between the Industrial Age and the Knowledge Age. The Industrial Age in many ways produced the distinction between "developed" and "developing" countries. It also carried with it a specific global division of labour where vocational categories in both "developed" and "developing" countries made sense. The impact of the emerging global innovation economy is already clearly visible in developed countries. The impact, however, is not limited to developed countries. In the next few years, it will reach also the most remote villages, connecting them into the new global socio-economic system.

Education and the New Innovation Model

The other dimension that defines the Information Society is the importance of innovation for economic growth. Innovation has emerged on the top of agenda because the above discussed globalization process leads to increased cost competition, squeezing the profits in existing industries. Innovation counteracts this trend by creating new products and temporary monopolies that can lead to extraordinary profits. Financial capital accelerates the push towards innovation, as it concentrates on those areas where extraordinary profits are possible.

The way in which we conceptualize innovation has important consequences for educational systems of the future. The traditional model assumes that innovation consists of a process where an original insight is followed by product development, marketing and the diffusion of innovative products. This model emphasizes original "acts of creation" and the role of scientific and technical knowledge as the sources of innovation. When innovation is perceived to be a key to economic growth and industrial competitiveness, the need for innovation is then translated to a call for increasing levels of educational achievement and investments in higher education and research.

In practice, innovation rarely occurs according to this traditional model. Detailed studies on the evolution of socially and economically important innovations reveal that the key to innovation is the social adoption of new technological opportunities (Tuomi, 2002). “Original insights” are rarely original, and innovative ideas are often re-inventions. Furthermore, many important innovations are “system innovations” that add new innovative elements to existing systems or reconfigure existing systems in novel ways. Instead or the focus on the “heroic inventor” and his original acts of creation, recent research on innovation has therefore started to emphasize the processes that underlie the social adoption of innovative opportunities. In such studies, it has become clear that the term “adoption” is, in fact, quite misleading: the processes that determine the fate of innovative opportunities are better described as user-centric innovation, knowledge-creation, and learning.

Various authors have highlighted different aspects of this new innovation model, usually in the context of industrial research and development. Nonaka (1991) was among the early pioneers, arguing that industrial innovation should be viewed as an organizational knowledge creation process. Brown and Duguid (1991) linked organizational innovation directly with social learning that occurs in professional communities of practice. Kodama (1995) pointed out that product development occurs increasingly in multidisciplinary projects where complementary bodies of knowledge are brought together to create new products and product concepts. Kodama also highlighted the importance of “mutual learning” and “demand articulation” in product development. Von Hippel (1976; 1988), in turn, pointed out that users are often important sources of product development ideas, and that the traditional “downstream” phase of product diffusion is often linked to the “upstream” concept development. My own work (Tuomi, 2002) went further, essentially turning the traditional model upside down, arguing that the “creative act” that makes innovations real and defines them, occurs when user communities change their social practices. This, in turn, depends on dynamics of change and learning in an ecology of social communities.[14] To contrast this last model with the conventional “upstream” model, I will call it the “downstream model” below.

The downstream innovation model highlights the point that innovations are fundamentally social. In the traditional model, inventors were often described as extraordinary individuals who create new ideas, technologies and gadgets. Innovation, education, and technology policies that follow the traditional model tend to emphasize technical specialization and industrial application of knowledge. In the downstream model, the emphasis is on social learning and knowledge creation in communities of potential users.

The traditional innovation model that emphasized the “upstream insight” is inadequate in explaining the development of many socially important technologies and ideas. Insights and technologies become real when they are integrated in specific social practices. The interpretation of an idea or technology becomes fixed only when it starts to have practical implications for a specific community of users. A specific technical artefact can have multiple meanings if several communities use the same artefact in their practices. In this sense, a specific implementation of technological functionality is like a word that can look the same but mean different things in different languages. For example, telephone is used in many different ways in different cultures and social practices. The current dominant use, “social visiting,” is a relatively new way of using the phone. Historically, it was invented by mid-West American housewives, around 1920.[15]

[14] This view is different from, for example, Chesbrough’s model, which has a corporate-centric view on innovation and product development. Chesbrough (2003) popularized the term “open innovation” to argue that companies need to import and export knowledge through their organizational boundaries. As the empirical focus in my studies was on the historical evolution of Internet-related innovations, such as computer networks, the World Wide Web, and the Linux open source operating system, my theoretical models emphasized more social dynamics and sensemaking than corporate strategies.

The practical consequences of different innovation models are different. The traditional "heroic" model leads to calls for "creativity," understood in an individualistic sense. The user-centric "downstream" model, in turn, leads to a more social view, where innovation is perceived as a change and revolution in social practice. In the latter view, it becomes natural to ask, for example, why some possible revolutions fail and how some revolutions and revolutionaries survive. Furthermore, from a broader innovation policy perspective, one may ask what kinds of institutional arrangements make continuous revolution possible in some societies. In other words, one can ask how societies and economies can become innovative.

The demand for "innovativeness" has generated tensions in educational systems because it shifts the balance between two incompatible aims of education. First, education has a socially important function in civilizing people and socializing them in existing traditions and cultures. This is the function emphasized by Luhmann and Confucian educational systems, for example. This function is often realized by pedagogies that use rote learning and "transfer" of knowledge from a teacher to the students. Second, in particular in the industrialized countries, education also implements ideas about the development of individual human potential. The latter aim leads to pedagogies that emphasize individuality, creativity, and problem-solving capabilities. In its less individualistic versions it leads also to critical pedagogies that view education as a means for social progress.[16]

When innovation becomes increasingly important for the economy, the balance shifts from cultural transfer towards creativity. Whereas in the transfer mode existing stocks of knowledge and meaning provide the foundation for learning, in innovative learning the fundamental aim is to generate knowledge that is new to the society. In the latter case, students are expected to become able to produce knowledge and meaning that is new also to the teachers. Instead of transferring specific content to the minds of the students, innovative learning, therefore, focuses on producing capabilities for thinking, problem solving and knowledge creation.

How such innovative learning should be implemented depends on the underlying concept of innovation. If innovation is understood as problem solving in practical contexts, one might start from the individual experiential learning models (Dewey, 1991), or, for example, Nonaka's knowledge conversion model (Nonaka, 1994). If it is understood to emerge from the capability to use general scientific concepts in varying concrete situations, a natural approach could be, for example, the Davydovian method that emphasizes the formation of theoretical concepts by ascending from abstract to concrete (Davydov, 1982). If innovation, in turn, is understood as change in social practices, one might implement education using activity theory, where learning in educational institutions can be embedded in more extended social learning processes (Engeström, 1996).

The downstream innovation model, however, opens up also new possibilities. If a key bottleneck in innovation can be found in downstream social learning processes, the upstream innovation processes can also focus on facilitating downstream learning and knowledge creation. In other words, if the problem is not in generating "original insights" by a creator but in creative adoption and adaptation in the downstream user communities, "innovative products" can be designed so that potential users can easily innovate. When a new innovation is not determined by the original insight of the creator but emerges only when new technical possibilities change social practices, the

[15] The social use of telephony was frequently criticized by telephone companies and telephone salesmen, as "idle gossip" and "trivial communication." As Fischer (1992:84) notes: "Sociability, obviously an important use of the telephone today, was ignored or resisted by the industry for almost the first half of its history."

[16] These conflicting aims of education have been discussed in detail by Jarvis (1992). Well-known critical pedagogies include, for example, Freire (1972).

traditional subject-centric view becomes replaced by a more relational view, where subjects and objects interact.

For example, in the downstream model, innovative products can be introduced as generic "platforms" that enable users to figure out how they can be applied in the user community. The World Wide Web is perhaps the most prominent example of such an open platform for innovation (Tuomi, 2002). Such innovation platforms can also be designed so that they do not only allow user innovation but actually facilitate and promote it. For example, they may include functionality that is specifically intended to support user learning and "interpretative flexibility." In the future, an increasing number of products can be designed with pedagogic support built in. As a result, the capability to design for knowledge-creation, learning, and innovation will become economically important. This requires, for example, that technology designers become able to use advanced pedagogic models and concepts in their work practice.

Part II

The Future of Learning and Education: Ten Theses

In the previous sections, the educational system was described as a specialized sub-system of society, asking whether the Luhmannian function of education remains relevant in the knowledge society. We then discussed the socio-economic context where education and learning occurs, arguing that information and communication technologies are now fundamentally changing the dominant logic of production and value creation and that this will lead to a new conceptualization of innovation. In the innovation economy, also the social and individual objectives of education and learning need to be reconsidered. In this section, I will present ten theses on the future of education, as practical outcomes of the previous discussion.[17] Due to space limitations, the theses will be described only in a very condensed form. The discussion above painted a broad picture and provided the overall justification for the theses. Below the focus is on concrete claims. They can also be read as scientific predictions that follow from the theoretical considerations presented above. Although, strictly speaking, social developments can not be predicted as societies are reflexive, some developmental trajectories are, indeed, probable in many possible futures.

Thesis 1: Education becomes global

Both the demand and delivery of educational services is increasingly distributed across regions, and independent of location. Global competitiveness implies that also educational institutions will compete globally for brand recognition and students. Today, universities extend their geographic reach using electronic learning platforms and various forms of distance learning. As broadband networks become widely available across the globe, potential super brands emerge also in the educational sector. At the same time, the rapidly advancing open content and open educational resource movement will increasingly address the needs for mass education.[18] Open educational resources will also be widely available for informal learning and specialized education in local languages, as the OER model enables effective development and distribution of user-produced content.

[17] Earlier versions of these theses have been presented at the Joint DG JRC – DG EAC Workshop on "The Future of ICT and Learning in the Knowledge Society," 20-21 October 2005, and in "Innovations in Learning: The Present Future of Learning in the Knowledge Society," at the EU eLearning Conference, 4 July 2006.
[18] For a detailed study on open educational resources, see Tuomi, 2006.

Thesis 2: New disabilities become challenges for pedagogy

The Knowledge Society is a cognitively demanding society. Disabilities that were of minor importance in the earlier production paradigms, such as dyslexia, and attention-deficit hyperactivity disorder (ADHD), will have a profound impact on the life paths of people. Technologies and pedagogies will be adjusted to address these potential new sources of "digital divides" in a society where learning and cognitive capabilities are critically important. Similarly, as the life-long learning becomes extended to elderly demographic groups, technologies and pedagogies that compensate the effects of aging will be of high demand.

Thesis 3: Blogs become more important than formal certificates

Already today people compile extensive life histories using web logs and homepages. In some expertise areas, for example in computer programming, employment opportunities often depend on a track record that can be reconstructed by search engines and personal blogs. The digital identities of persons now consist of their own representations of achievements and experiences, as well as reputations that accumulate through the comments of others. The importance of blogs and homepages is now rapidly expanding beyond computer specialist communities, and user maintained ePortfolios are becoming common. Formal educational certificates may be components in such digital representations of capabilities, but their relative importance will diminish.

Individual capabilities also often have their source in the individual's capability to mobilize social resources. In the Knowledge Society it is often more important to know the right experts than to be an expert. Electronic track records provide a historical record on an individual's social networks and "social capital," which are important factors when people compete in the labour market. Traditionally, a high value has been put on "Ivy league" institutions, as educational certificates from them have implied good social connections. In the future, the existence of such connections can be directly observed through electronic track records. Formal certificates from respected educational institutions can be replaced by proof of actual merits and accumulated achievements in practical contexts. Personal "brand management" expands to cover digital identities over time and space.[19]

Thesis 4: Demographic change leads to slowdown in the growth of human capital in Europe

In particular in Europe, the increase in average educational attainment has resulted from the fact that the large post-war age groups received much more education than their parents. The movement of these large age groups through the educational system has generated fast growth in educational averages. Simultaneously, the increasing participation of women in higher education has amplified the effect. In the near future, these demographic flows slow down and become reversed in many European countries. On average, the indicators for educational attainment and the growth of human capital will show a declining trend. This will lead to rethinking of macroeconomic growth policies that emphasize the role of human capital. The attractiveness of Europe as a production location also declines, as product and labour market growth are important for production efficiency and innovation.

[19] Today, blogs are frequently used for such "brand management." They are also combined with social networking and profile management sites. At present, the most popular site is MySpace (www.myspace.com), which has over 150 million registered users. According to Alexa (www.alexa.com) traffic data, about five percent of internet users used MySpace daily in February 2007. This translated roughly to 50 million daily users.

Thesis 5: Home becomes the classroom

The availability of broadband networks will mean that classrooms become extended in time and space. One driver is the social and cultural diversity that globalization brings with it. Traditional societies are becoming increasingly diversified cultural mosaics, where parents want to provide their children with tailored education. For some parents, this means value- and culture-oriented education, whereas for others it may mean education that aims at social mobility and competitiveness in the labour market. The cost of producing customized and mass-customized education is radically declining, as it can be produced for a global market, including niche and micro markets that could not support such services locally.

Customized education, of course, easily works against the civilizing and standardizing function of education, emphasized by Luhmann. It is therefore also possible that policymakers will perceive standardized education as an objective in itself. Many parents will also find themselves unable to define what exactly they want their children to learn. Commercial educational service producers, national policymakers, and, for example, religious leaders will therefore offer competing educational “service packages.” Parents will often subscribe their children to educational services by following the choices of their chosen peer groups. The selection depends to a great extent on how the parents understand the role of education for individual development and the society.

Another driver is the transformation of work that results from the emerging knowledge-intensive production model. As parents have increasingly fuzzy boundaries between work and private life, it is increasingly difficult to organize education so that it matches the time and space requirements of families. Today, the time-space organization of schools fulfils two important social functions. One is to build cognitive and social competencies and transfer knowledge and values. The other is to put children in a safe environment so that their parents can participate in work life. In the future, these two social functions of schools will be increasingly separated. The efficiency of tailored and computer-supported education will increase, enabling effective learning outside classrooms. A broad network of social support can now be integrated with learning experiences, for example, by involving grandparents in educational processes.

The “day care” function of schools, on the other hand, will require increasingly flexible arrangements. Parents will pick educational curricula for their children from the global market for educational services, based on values and aims that parents prefer, and they will use the improved flexibility for reorganizing learning in time and space. As formal locally controlled educational certificates will decline in importance, parents will perceive a major increase in the richness of educational variety, with relatively little social or economic costs.

Thesis 6: Immersive social games replace the textbook

Play has a critical function in cognitive development. It creates an imaginary world, where new concepts and skills can emerge. For a young child, it provides a field of experimentation and experience where activity can become meaningful, and where a child can start to act in a cognitive way (Vygotsky, 1978:96).

Play is creative and therefore not always easy to control. Pedagogies that aim at transfer of knowledge have traditionally emphasized disciplined learning. Often discipline itself has been understood as an important outcome of education. Play, on contrary, has been viewed as something that children have a natural tendency for, and which should mainly be allowed during the breaks.

This strict separation of "work" and "play" results partly from the idea that learning occurs by knowledge transfer. Partly it follows from the concrete constraints in educational settings. An important constraint in traditional school learning has been the requirement that the same content has to be delivered to many students at the same time. This pedagogic constraint requires that the learning experience has to be controlled by a teacher who delivers the content, and who keeps the learning of a group of students synchronized. Such a teacher-centric model of learning has problems in using creative play in learning. Although children achieve the highest levels of self-control in play, traditional pedagogies organize learning with a centralized source of external control.

Vygotsky argued that the expansion of cognitive capabilities occurs in play.[20] To the extent that this is true, school learning has in practice relied on cognitive development that has occurred outside the educational system. In a way, schools have been able to free-ride play that occurs during intermissions and outside school hours. In the future, institutionalized development of cognitive capabilities will become more important than institutionalized transfer of existing knowledge, and the dynamics of play will therefore be directly integrated in educational practices.

Computer software will have an important role in this, as software is essentially a medium for creating rule-based realities. The declining costs of computing means that highly sophisticated and "realistic" simulators can now be implemented using cheap personal computers. In the future, games, however, will not only be useful in simulating the real world and providing platforms for skill and knowledge creation. They will also provide social microworlds that become platforms for creative and immersive experimentation.

Information and communication technologies can be used to make "real the unrealizable," to use Vygotsky's expression, and to provide expanded zones of development where new knowledge and advanced thought processes can develop. Whereas the textbook was an important artefact that synchronized a group of learners in a mass-production learning environment, play and games will be the media for learning that develops cognitive capabilities. Social games will emphasize peer-to-peer learning, at the same time developing the basic skills that are required in real world tasks in the Knowledge Society, where the skill in mobilizing social resources and socially distributed knowledge is often more valuable than their possession and ownership.

Thesis 7: Audio makes education portable

For almost a decade, digital memory has been a cheaper form of storage than paper. As the cost of digital memories have roughly halved annually in the last years, digital storage is now about three orders of magnitude cheaper than paper.[21] It is now economically and physically possible to carry huge amounts of data in a pocket. For example, a 40-gram Apple iPod nano can store about 140 hours of high-quality audio, and the larger 80GB iPod about ten times more.

Technology-oriented visionaries have often concluded that the declining costs of storage and improved processing power will make portable video an important media for education in the future. For example, an iPod can now store up to 100 hours of video. From a technical point of

[20] Vygotsky, of course, emphasized the importance of play for children. In the Knowledge Society, learning, however, does not end in adolescence. In play, things and actions stand for things and actions that they are not, thus allowing one to "play with" potential realities and to detach oneself from the actual constraints or reality. It is in such "zones of proximal reality" where learning and innovation occurs.
[21] The estimate is based on Grochowski & Halem (2003).

view, it is natural to think that rich media, with images, animation, and video, will dominate in the future.

In many applications, audio, however, outperforms video. For example, it is difficult to walk and watch video at the same time. Video requires concentrated attention, whereas audio can accompany many everyday activities without interfering with them. Audio can also be uploaded fast in a compressed format. In the near future, it is possible to wirelessly load 24 hours of audio while taking a shower in the morning. This means that personalized audio can easily be carried everywhere. Educational programming will be one of the important applications of portable and personalized audio. One natural application will be language learning. The new economics of digital storage, however, makes also other applications possible in radically new scale. For example, it is now possible to have full textbook libraries in audio format in a space that is comparable to a traditional library card.

Thesis 8: Products become pedagogic

The innovation economy is based on rapid introduction and adoption of new products and services. For a consumer, this means continuous learning about the possibilities and functionality of new products. As the amount of novelty increases, the end users have to consume an increasing amount of time and effort to learn how the new products and services work. In the last two decades, this has led to repeated calls for “easy-to-use” products and “user-centric design.”

The idea that a functional product, such as a television remote controller, could be “easy-to-use,” implicitly assumes that the functionality and the “proper use” of the product can be determined. This assumption contradicts the basic insight of the new downstream innovation model, where innovative products succeed to the extent they have “interpretative flexibility.” When products are made “easy to use” for a specific type of use, they are typically made difficult to use for other uses. In the old mass-production economy, this did not matter much, as the dominant style of use could, indeed, be defined as a “standard” or “average” way of using the product. Mass-products were implicitly designed for an anonymous standard user with standard ways of using products.

The logic of mass production therefore started from the assumption that there are typical proper uses of standardized products. In the emerging innovation based economy, the evolutionary dynamics of product and service innovations are different from the mass-production model. It will be easy and cost-effective to build in flexibility into product designs, and this flexibility will enable new innovation paths that are sources for profitability and competitiveness. At the same time, flexibility has to be implemented in a way that makes easy adoption and user-centric innovation possible.

These developments will lead to product and service designs that incorporate support for user innovation and learning. In the future, product designers increasingly design functional and meaningful product-user combinations, where the design is successful when the combination “works.” The combination, in turn, works when the product’s potential technical capabilities are complemented with user competence. Effective design of technical functionality, therefore, requires parallel design of paths that make the user a competent user. One way to do this is to implement “pedagogic veils” that can be “thrown over” complex product designs, so that a novel product can increasingly carry information and knowledge that supports learning processes that create competent users (Tuomi, 2005).

The new innovation model will therefore also create demand for sophisticated pedagogic models that can be used in product design. Active software help-systems have been studied extensively during the last three decades, and commercial software is now typically packaged with electronic manuals, tutorials and documentation. In the future, products and services will be increasingly integrated and enhanced with software. Products will know how their users can become competent users. Instead of sending people to classes and training courses, product designers will embed pedagogic functionality in their products. This will often make separate product- and application-specific training redundant. The downstream innovation model also highlights the point that user competence is always related to the underlying social practice. Technology adoption requires social learning. Future products will therefore embed pedagogic models that guide the user through "zones of proximal development" that make the user a competent member of the user community. In addition, they act as platforms for social innovation and experimentation, making possible social change that is required to make innovations real.

Thesis 9: Informal social learning becomes the key to competence development

Lave and Wenger (1991) argued that professional skills are often learned in a social process, where people participate in a specific community of practice. Lave and Wenger proposed that learning starts when novices gain the right for "legitimate peripheral participation" in the community, which gradually allows them to become competent "old-timers" and leading "gurus." In their work, Lave and Wenger popularized the idea that learning is fundamentally a social process and that knowledge resides in "communities of practice."[22]

Research has shown that high-level competences can be gained surprisingly fast when people participate in internet developer communities (Tuomi, 2001; 2002). For example, open source software communities have allowed relatively inexperienced software programmers to rapidly become globally leading gurus in sophisticated software architectures. Learning in these communities has often been based on informal observation and interaction with peers. Moreover, learning and competence development in internet developer communities typically occurs across distance, without physical proximity.

Internet hobbyists and developers were the early entrants to this new mode of competence development. In recent years, the model has, however, spread widely. Communities that focus on specific interests and practices are today a major source of knowledge and learning in many different domains, ranging from medical sciences and astronomy to medieval music, home building, finance, law, and cooking.

Informal social learning has always been an important source of skills and knowledge. New information and communication technologies, however, make it much more effective and visible. Informal learning in communities of interest and practice is typically problem- and practice-oriented. It is driven by the learner's motives and effectively uses her contextual and situational knowledge. New knowledge, thus, becomes naturally linked to what already is known, resulting in

[22] Historically, the importance of social processes in learning has been one of the key starting points in cultural-historical and socio-cultural theories of learning (e.g., Vygotsky, 1986; Scribner, 1997; Rogoff, 1990). The first detailed study on the emergence of scientific communities and their knowledge is by Fleck (1979), who in the 1930s described the history of syphilis and the evolution of its treatments and diagnostic practices through the centuries. The importance of communities of practice has also been highlighted in technology studies (e.g., Constant, 1984), in cultural anthropology (e.g., Douglas, 1996), in linguistics (e.g., Bakhtin, 1987), and, more recently, in science studies (e.g., Knorr Cetina, 1999). For a review and discussion, see Tuomi (2002 Ch. 6).

rapid accumulation of knowledge and skills. As the internet often makes also the learning process visible, the benefits of social learning accumulate fast.

The "virtual" community also provides support in an extraordinarily effective way. As more experienced peers typically are people who have themselves been in the learner's position recently, they can easily adjust their support so that it matches the learner's requirements. In Vygotsky's terms, the peers are optimal guides through the zone of proximal development. Furthermore, as the peers typically best support those learners who show a genuine intent of learning, the learners have to put a substantial effort in the learning process if they want to advance in the community.

In such communities, active learners can flexibly mobilize substantial amounts of social capital to speed up their competence development. As the community recruits more novices and as they become old-timers and gurus, the total accumulated learning capacity of the community increases. Informal communities of learning can therefore produce a learning dynamic that in economic terms has positive returns. The community may become a "common pool" learning resource that, in contrast to traditional economic resources, increases its value the more it is used.[23]

Many economically important competences are relatively short-lived in the innovation-based economy. Effective learning, therefore, requires flexible competence development models. Self-organized informal learning can in this regard easily fulfil the demand. Formal education, in contrast, tends to have much slower response time.[24]

Thesis 10: Educational programmes become integrated with real social change

A constant challenge for educational theory has been the missing link between school learning and cognition outside the school. Lauren Resnick highlighted this point in her 1987 Presidential Address for the American Educational Research Association:

> There is growing evidence, then, that not only may schooling not contribute in a direct and obvious way to performance outside school, but also that knowledge acquired outside school is not always used to support in-school learning. Schooling is coming to look increasingly isolated from the rest of what we do. (Resnick, 1987 :15)

Engeström (1996) reviewed the subsequent debate and proposed a model where learning activity is integrated with transformation of social practices outside the school. He argued that eventually the school institution has to be turned into a collective instrument for teams of students, teachers, and people living in the community. The objective of learning is not to learn for the school but to learn for life, and learning in real life means change in the practices of the community.[25]

[23] I have previously called such resource pools "fountains of goods" (Tuomi, 2005:444). Such pools are difficult to describe in economic terms, as historically the fundamental economic assumption has been that resources are scarce and can be depleted through use. In conventional economics, common-pool resources lead to the famous "tragedy of commons," where shared resources become destroyed.

[24] It would have been quite impossible for educational planners to respond to skill demand for internet video production, for example, as this was an invisible niche application just two years ago. Today, there are roughly 60 million people producing and distributing internet video clips using YouTube (www.youtube.com). Video production and distribution technologies are mainly learned through peer-learning and practical experimentation.

[25] Strictly speaking, Engeström's theory of expansive learning refers to activity systems (cf. Engeström, 1987). The activity-theoretic concept of activity is related to social practices, but the concepts can also be interpreted in theoretically different ways.

Engeström's "expansive learning" model is a model of innovative learning, and it is compatible with the downstream innovation model. It does not stop at individual development or change. Instead, it expands beyond current social reality, potentially transforming it. This model, therefore, builds an interesting link between discussions on innovation economy, knowledge society and the processes of learning.

In the innovation economy, an important generic capability is the capability to change social and economic realities. In the future, people therefore need to learn how to change the world and how to mobilize social resources. In the innovation economy, the demand for capabilities to initiate and manage social change increases, and new information and communication technologies make new forms of social change possible. As people increasingly learn skills and knowledge outside formal education, it also becomes increasingly useful to integrate in learning knowledge that people have learned outside formal education. In the future, social, economic and technical change will thus create pressures that will reverse the trend highlighted by Resnick.

Conclusion

A challenge with Luhmann's theory is that it abstracts the educational system in a way that detaches it from its material and practical context. Its abstractions are so strong that they purify the theory from all material, historical, and practical impurities, at the same time making it difficult to apply the theory in real contexts. In principle, it can suggest an answer the question why educational system exist as differentiated systems in a modern society; it cannot, however, say much about what people do in these systems.

In a somewhat similar way, economic theories that highlight changes in production paradigms may point to innovation as the new source of economic value. They can also explain how the needs for vocational education change as a result of new global production logics. Yet, to fully understand the nature of this change and its implications, we need to understand the processes that underlie innovation and value creation in the future. Here the new innovation models that focus on social learning and knowledge creation provide useful new insights.

When emerging technical opportunities are taken into use, social practices and the society itself changes. Since Schumpeter (1975), historians of economy and technology have argued that economic and social development is not driven by new technologies as much as it is constrained by the capability of social institutions to change. In the new innovation model, the benefits of new technological opportunities become real only when the society adapts its practices so that the new technology can be used in a beneficial ways. This means that the wealth-creating potential of a new key technology is realized only when social institutions change. New production paradigms do not emerge simply because new technologies become available. Instead, the dynamics of development is strongly constrained by the speed in which social institutions change. In the global innovation economy, the speed of change can become an absolute competitive advantage, in itself.

Social institutions include things such as legal, political, economic, and educational systems, as well as practices for organizing work and production. The availability of steam engines, railways, electric power lines, or telephone networks does not, in itself, dictate a specific world order. Social practices and technical systems co-evolve so that new technical opportunities are gradually taken into use in the society.

The potential of new key technologies are widely perceived already when key technologies are new. Yet, although the technology and its potential is there in a latent form, the social and institutional conditions are not. The requirements of the earlier paradigm are deeply ingrained in social institutions, including laws that regulate work, managerial practices, and educational systems that produce and certify skilled workers.

This is the situation where many developed countries find themselves today. An indication of the emergence of the Knowledge Society and its associated new paradigms of production is the fact that statistically visible social categories of the Industrial Age now start to have little descriptive value. Competitive business organizations are now experimenting with radically new forms of organizing and managing production. They are also trying to find new sources of economic value. The innovation models that underlie the emerging innovation-based economy are themselves changing, and an increasing amount of innovative activity is now focused on configuring existing knowledge and technologies in new economically useful ways.

The evolution of educational systems and practices, of course, depends on many factors that have not been discussed above. Possible futures, however, are not random. The potential paths for development are constrained by social and economic demand and technical opportunities. We do not necessarily have to imagine a non-existent future to outline probable developments. Instead, we can simply take the current situation, and try to see how it unfolds when no unexpected or unpredictable events intervene.

In the above, I have focused on the impact of the socio-economic transformation that is usually called the Knowledge Society. By outlining the historical development as a sequence of production paradigms, the discussion highlighted some novel characteristics of the emerging world, where information and communication technologies are widely used. The resulting vision is not a technical utopia or a dream. We do not need any new technologies to make this transformation real. The technologies are already there. The change that waits is change in social institutions and practices. Educational institutions and practices are at the core of the knowledge society and thus their transformation will be a key to make the knowledge society real.

I have presented a quite demanding and challenging argument above. It derives educational trends by zooming from a generic social and functional description of education to alternative logics of production, and further to a more detailed analysis of emerging patterns of innovation. The argument obviously is only a first sketch on a more complete canvas, and it also skips over many historically important factors. Fundamentally, however, this approach aims at a dynamic, historical and contextual description. It tells a story that allows us to ask where the educational systems came from and where they are today. Therefore, it also allows us to point the directions of future developments.

To make the narrative more concrete, I proposed ten theses about the future of education and learning. A generic evolutionary story of education and the role of knowledge is incomplete without showing where it leads and what are its natural consequences. The presented theses aim at converting the developmental trajectories into practical statements about the future of education. Due to space limitations, the theses have been presented more as provocative claims than fully argued propositions. Given the background story, the reader should, however, be able to recover the underlying logic. Although the theses are stated as factual claims about the future of education, more appropriately they can be read as topics for further discussion. As was pointed out above, in the future, learning is increasingly social and about changing the world. If we learn that some of the discussed developments are not what we want, we can also change the future.

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