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Nordic long-term planning and educational policies in the fourth industrial revolution

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In the last two centuries, the world has experienced rapid technological development, often described as a series of industrial revolutions. These revolutions have not only increased productivity but also disrupted older industries and caused unemployment among their former employees. One of the main strategies for avoiding polarization between workers displaced from older industries and the beneficiaries of change has been education: primarily trying to adapt the skill levels of workers to the new demands of the economy. For a long time, these attempts seemed successful. In the early 1970s, on the cusp of the third industrial revolution, advanced economies still enjoyed full employment, despite centuries of labor-saving technological progress. However, the third industrial revolution, characterized by the creation of an information society, has deviated from the former in respect that unemployment and employment in low-salary jobs have remained high, despite decades of attempts to alleviate the situation through educational and other means.

In the 2010s, many observers believe that the information society has evolved to such an extent that we are at a qualitative tipping point; it is time to talk about a fourth industrial revolution. Although the exact nature and even existence of the fourth industrial revolution are subjects of discussions, it is generally characterized by increased automation through robotics and artificial intelligence (AI). This would further reduce the demand for human labor in manual jobs and in white-collar jobs previously untouched by automation. In addition, the rapidly decreasing costs of renewable energy production are believed to have a disruptive influence on the fossil fuel industry. Concerns are raised that this might lead to mass unemployment on a scale not experienced before and cause polarization between a few highly skilled individuals, who are essential to the new economy and who cannot be replaced by robots, and everyone else.

The phrase ‘industrial revolution’ was coined in 1799 in France as an attempt to describe the country’s efforts to catch up with England’s industrialization.¹ Thus, the concept did not originate among economic historians describing technological and economic changes that had already taken place but was invented by actors intent on bringing about change. Also, in the case of the fourth industrial revolution, reform-oriented actors are the pioneers in the use of the concept. In a revolution, old truths are invalidated and the path towards

the future can be remapped. The idea of an impending, inevitable revolution is therefore useful for reformers seeking to legitimize their descriptions of current problems and proposals for future solutions.

According to a study conducted by the OECD in 2013, Sweden and Finland were the two countries in the world where employees have experienced the greatest technological and organizational changes in the workplace, while Norway was number six.² In addition, a traditional part of the Nordic model has been to use education to reduce inequality. Thus, it is particularly fruitful to study strategies for combating the polarizing effects of technological changes in these three countries: the technological pressure for change is imminent and the motivation to find a solution can be expected to be comparatively high. Adding to the general challenge that technological development provides to the Nordic model, Norway, Sweden, and Finland all face particular threats, which are paradoxically imbedded in the specific nature of each nation's success. Swedes fear that their long period of strong economic development is threatened by the poor basic skills of school leavers. Finland has struggled economically for a decade, and claims are made that its position as an educational model country makes necessary school reforms difficult. Meanwhile, in Norway, it is feared that wealth from the petroleum industry has hampered innovation and education.

The aim of this chapter is to analyze how government planning in Sweden, Finland, and Norway perceives the challenges caused by rapid technological and societal change, and its recommendations for how the educational system should adapt to these challenges. Long-term forecasts and plans for economic and social development will be investigated to determine whether they predict a future in which technological advancement will continue at the current pace, or whether they foresee an imminent dramatic increase in the pace of innovation and technological advancement. The role long-term plans prescribe for education in meeting these scenarios will also be explored. In addition, it is investigated how the conclusions from the long-term forecasts affect plans for the education system and curricula directly regulating the present school system.

Optimists and pessimists

The hopes connected to technological development, as well as the fears that it will cause mass unemployment, are based on the belief that productivity will rise as a consequence of labor-saving innovations. However, Erik Brynjolfsson, Daniel Rock, and Chad Syverson have pointed out a paradox in this regard. While technology optimists, such as technologists and venture capitalists, foresee imminent productivity gains from AI, robotics, and other emerging technologies, pessimists – economists, sociologists, statisticians, and government officials – notice that measured productivity growth is actually declining. Brynjolfsson, Rock, and Syverson claim that both optimists and pessimists may be right: for example, while AI is a general-purpose technology (GPT) that has

great potential to raise productivity, it takes time and additional investments to reach that point. Since the increased amount of time and resources spent on AI innovation has not yet resulted in any significant output, productivity seems to be falling. A similar decline in productivity has been observed during periods of investment in earlier GPTs, such as portable power (electricity and the combustion engine) in the 1910s and information and communication technology (ICT) in the early 1990s, after which productivity accelerated from 1915 to 1924 and from 1995 to 2004.³

The discussion regarding skill-biased technological change is rooted firmly within the pessimist paradigm: it is an academic discussion among economists based on forward projections of historical data. On the other hand, the discourse on the fourth industrial revolution is rooted in an optimist paradigm, propagated by technologists who predict an imminent technological and social transformation. In effect, proponents of the fourth industrial revolution are also using a historical argument to support their view. However, rather than extrapolating from the recent trajectory of the development curve, they look at historical inflection points in the curve – the first three industrial revolutions – and predict that we are now approaching yet another such event, which might be more rapid and disruptive than the previous ones.

Wolfgang Streeck bases his prediction that the current interregnum will continue indefinitely on the absence of a practically possible vision of a progressive future.⁴ Among technology optimists, progressive visions do undoubtedly exist. However, their practicality remains to be proven.

Skill-biased technological change and education

A common explanation for the rise of income inequalities since the 1970s is skill-biased technological change. According to this theory, some technologies are so demanding of skill that only the most skilled individuals benefit from them, thereby elevating their incomes and leaving the rest of the workforce behind. However, the topic is hotly contested. Among the controversial issues are the questions of why earlier technological changes have not caused the same effect, how the phenomenon is related to globalization, and whether it can be observed outside the United States, which has been the object of most research. Another central question is whether there is a deterministic relationship between current technological change and inequality, or if the outcomes can be affected by, for example, educational policies.

In recent decades, the number of workers employed in high- and low-wage jobs has increased, while it has decreased in middling jobs. David Autor, Laura Katz, and Melissa Kearney claim that computerization has replaced middling routine tasks but has raised the productivity of low-wage manual work as well as of high-wage abstract work. As a result, wages for abstract work are elevated, while wages for manual work either rise through increased productivity or sink due to increased competition from displaced routine workers relocating to manual tasks.⁵

According to Daron Acemoglu, the last 200 years of US and European history suggest that unemployment and low wages caused by technological change are temporary. However, he stresses that this time around it might be different. If earlier technological changes increased the demand for labor and increased wages, and the present combination of technology and abundant labor supply does not, we may today face technology-driven unemployment despite the historical record.⁶

Claudia Goldin and Lawrence Katz claim that skill-biased technological change cannot explain the growing polarization of the last decades, since skill-biased technological change has occurred at a fairly continuous rate since the late 19th century, a rate that was only slightly elevated during the years 1979–1999. Instead, they argue that the widening gaps are attributable to a reverse in the trend of increased education that took place in the 1970s. Their interpretation is that although skill-biased technological change increased the demand for skilled workers from the late 19th century until the 1970s, the supply of educated workers increased even faster, reducing the wage premium for education and thereby curbing income inequality. Since 1980, the demand for skilled workers has increased faster than the supply, which has been hampered by, for example, rising costs of college education in the United States. As a result, wages for skilled workers have gone up and income inequality increased.⁷

According to Goldin and Katz, widespread secondary education contributed to enhanced economic growth and income equality in the United States from the late 19th century. They even suggest that ‘it was mass secondary school education that checked the more extreme forms of socialism later embraced by Europe’.⁸ Thus, the United States experienced less polarization than Europe in the early 20th century because of its uniquely advanced and egalitarian educational policies, while in the 21st century it has lagged behind countries such as Sweden, Finland, and Norway in educational and thereby also economic and social equality.

However, job polarization is present also in the Nordic countries. From 1993 to 2006, Norway and Sweden experienced classical polarization with an increase in high- and low-wage jobs and a decrease in middling jobs, while Finland experienced a downgrade with an increase in low-wage jobs and a decrease in both middling and high-wage jobs.⁹

The fourth industrial revolution and education

One of the earliest iterations of the fourth industrial revolution was the German Industrie 4.0, launched in 2011 by the federal government. It was hoped that technologies such as the Internet and improvements in robotics would allow for production that is tailor-made to the customers’ individual preferences.¹⁰ In contrast to earlier factories that have produced large quantities of identical products, Industrie 4.0 tracks each individual product at every step, implementing adaptations according to the specifications of the consumer.

The most visible advocate of the idea that we are approaching a fourth industrial revolution is Klaus Schwab, executive chairman of the World Economic Forum (WEF). According to the WEF, the fourth industrial revolution ‘is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres’.¹¹ The WEF made the fourth industrial revolution widely known through its 2016 world forum and has proposed strategies for closing the inequality gap in the fourth industrial revolution, acknowledging the importance of education.¹²

Michael Peters argues that in order to adapt to the fourth industrial revolution, education must become an open ecosystem by utilizing new technology. For example, massive open online courses (MOOCs) could mitigate the adverse effects of rising college fees, which hinder people from acquiring skills needed in the transformed, knowledge-intensive labor market.¹³ Similarly, Carl Benedikt Frey and Michael Osborne claim that MOOCs can mitigate constraints set up by economy, geography, or lack of time. According to them, traditional education with rigid programs spanning a specific period of time represents an outdated factory-based education that emerged during the 19th-century industrial revolution.¹⁴

Also Erik Brynjolfsson and Andrew McAfee see improved education, such as MOOCs, as a way of combating the ‘spread’ of incomes that technological change can produce, but they do not believe that technology will solve the problem by itself. On the contrary, since some highly motivated self-starters take part in university courses through MOOCs at the ages of 12–14, originally small knowledge gaps are enlarged. They claim that digitization of education will only reduce the spread if serious efforts are made in that direction.¹⁵

Forecasting the future

In Finland, Sweden, and Norway, long-term governmental forecasting generally recognizes that technological change will transform society and that the schools need to adapt. However, in these three countries there are also important differences in the descriptions of how, and to what extent, these changes will affect society and its educational system.

Norwegian planners foresee that the country’s wealth based on hydrocarbon fuels will decrease. They also fear that the oil incomes have caused imbalances in several important sectors of Norwegian society. *Produktivitetskommissjonen* notes in its final report of 2016 that productivity growth had dropped alarmingly since 2005. Petroleum revenues had fed the growth of the service sector, where productivity remained low. The commission blames the resource-based economy for the low efficiency and completion rates in the Norwegian education system, and the low innovation level in the business sector. It concludes that the general level of education is the most important factor for productivity and predicts that future industries will increasingly be knowledge-based. Therefore, it is problematic that the number of masters and doctoral students in Norway are low, especially in the sciences. According to

the commission, there is not a single world-class university in Norway, while its research system is 'subject to extensive political skewing towards broad social objectives'.¹⁶

The technologies associated with the fourth industrial revolution are seen as a solution to these problems. However, compared to Sweden and, particularly, Finland, Norwegian planners put relatively little emphasis on the need for becoming a technological leader and exporter of high-tech industrial products. Instead, they consider it of great importance that Norway is able to benefit from innovations originating elsewhere in order to raise productivity in its large service sector.¹⁷ Focusing on use rather than invention of technology has, according to technology historian David Edgerton, made sense historically, since countries that have mainly copied innovations made elsewhere, such as Italy, have managed to achieve similar growth figures as centers of innovation, such as Britain.¹⁸

Although Swedish *Långtidsutredningen* discusses the future impact of nano-, bio-, and information technology, fields into which Sweden has invested heavily, the report envisions a relatively undramatic development. It foresees that the industrial restructuring that has been going on for decades will continue at the current pace. In addition, the report considers Sweden well adapted for the challenges to come because of its high-functioning systems of higher and adult education. However, the comprehensive schools' ability to provide coming generations with basic skills is a concern.¹⁹ The report also notices a significant difference in labor participation between native and foreign-born residents. Since the report concludes that the gap can be explained entirely by differences in education and skills, it recommends raising the educational level of immigrants.²⁰

Referring to economic research on skill-biased technological change, *Långtidsutredningen* believes that with education the Swedish labor market can upgrade instead of polarize. This is already happening among women, and in order for men to follow, they might need to be educated in occupations traditionally filled by women.²¹ *Digitaliseringskommissionen* predicted more disruption, quoting estimates that 35–53 percent of jobs will be lost to digitalization within two decades. Since digitalization is skill-biased, it benefits those with high education over those with low. Routine work would be replaced, causing a middle job squeeze, which will increase competition among manual workers. This can cause a rift between people with different educational levels, a development that society counteracts by, for example, life-long learning and a competence insurance that enables individuals to reeducate in the middle of their careers.²²

Digitaliseringskommissionen's report also contains a radical vision of Sweden in 2030, written by the consultancy firm Exponential Holding AB. There, teachers are transformed into tutors, as students learn to search for relevant information online and collaborate digitally with peers across national borders. Teaching has become optimized as schools have improved their ability to collect and interpret data. By emphasizing interdisciplinary thinking and

entrepreneurial skills in schools, humans are prepared for niches where they can still compete with computers in the labor market.²³

Technology's role for raising productivity in the public sector receives little attention in Sweden. *Långtidsutredningen* discusses the public sector at length, but its suggestions for handling increasing stress on public welfare services are limited to redistribution of existing productive capacity through raised retirement age, raised taxes, or changed priorities between public commitments.²⁴

It is in Finland that we find the most dramatic visions about technology-driven transformation of society and the most revolutionary ideas about education. The 2015 report *Finland – The Silicon Valley of Industrial Internet* claimed that Finland could follow one of three development paths. As 'the Silicon Valley of industrial internet', Finland would gain 48,000 jobs by 2023. However, this was only possible if the executive management and boards of companies as well as the public sector commit to this goal. This development path was described as the best possible future, where the industrial internet is the 'New Nokia'. If Finland did not achieve this but still managed to become an 'agile applier' of the industrial internet, 16,000 new jobs would be created by 2019. However, if Finland instead became a 'sluggish follower', 16,000 jobs would be lost by 2019.²⁵

The report suggested 15 measures that would help Finland become the 'Silicon Valley of industrial internet'. They included improved adult education at different organizational levels, reformed university programs emphasizing phenomenon-based education and software skills, utilizing digital learning materials and online courses, learning from best practices between companies, and tax breaks for individuals seeking to educate themselves at their own initiative. In addition, it suggested that 5 percent of public procurements should be earmarked for innovative solutions. This would improve productivity in the public sector and support tech companies.²⁶ The report *Suomi osaamisen kasvumalle* claimed that since the labor force in Finland is not growing, it is vital to utilize digitalization and technology in the service sector in order to maintain social and health-care services.²⁷

The emphasis on Finnish companies learning from each other, rather than competing against each other as in a liberal market model, is not surprising considering that Finland displays the highest degree of corporatist enterprise cooperation among the Nordic countries.²⁸

In 2013/2014, the report *100 Opportunities for Finland and the World* launched a devastating attack on the present Finnish educational system. Among its drawbacks were inefficient centralization to physical school buildings, half a billion yearly trips to school, and internalization of the 'out-dated teaching content' of teachers. This led to an increasing deficit of know-how despite educational investments, which was mirrored throughout the economy. However, the report contained a vision of how technology could help alleviate these problems:

The lectures of the best experts are attended independently online, the exercises are performed on the computer or with the help of remote

controllable robots and simulators, and the instructor supervises the performance and directs it, if required. Gaming is applied to teaching. Discussions and peer learning take place in shared projects online or by meeting in person. Virtual glasses and remote controlled robots are used in on-the-job learning. The robots give examples of the work to be performed, and with their help the instructor can supervise and guide the learner without being physically present. Know-how is proven and evaluated independently from the teaching, and in rapidly changing areas the proof of know-how is temporary.²⁹

Unfortunately, '[p]olitical decision-making, interests of trade unions, and habitual values and reverences' slowed down necessary change.³⁰

A follow-up report in 2018 reiterated that one of the greatest threats against a future-oriented learning process was the teaching profession's aversion to change and lack of knowledge. The great power of the teachers and university professors and their organizations was slowing down change.³¹

The ferocity of the report reflects that it is taking on a formidable adversary, the strong Finnish teaching profession. Other reports support an alternative vision of the future of Finnish education, which values the competence of the nation's teachers and portrays it as an asset that Finland can market and sell internationally. So far, Finnish educational exports have focused on traditional teacher competencies rather than technology. However, also reports that show strong support for Finnish teachers stress the need for technological innovation. There, Finnish teachers are not described as reactionary but as 'generators of change'.³²

Signs of problem have been visible in Finnish higher education for a while but have only recently been taken seriously in government reports. In 2015, a report from the Ministry of Education and culture mentioned that entry rates for tertiary education had declined from 77 percent to 63 percent from 2005 to 2012, making Finland drop from sixth to tenth place among OECD countries. This development was apparently not considered to be of pressing concern, since it was not addressed in the final recommendations of the report.³³

In the Ministry of Education's Visio2030 report of 2017, the fact that the share of 25- to 34-year-olds with higher education (41 percent) had shrunk beyond the OECD average was indeed considered problematic, although the problem was attributed to slow throughput rather than low entry rates. Since Finland's public spending as a share of GDP for higher education is the highest among OECD countries, the system was described as inefficient. The report aimed to combine know-how with equality and efficiency, and claimed that small nations need to focus their resources on niches where they can be internationally competitive. By 2030, higher education should be available for all and at least 50 per-cent of 25- to 34-year-olds would have a higher education. The vision also embraced flexible and individual educational tracks and a renewal of education through digitalization.³⁴ The report did not attempt to resolve the apparent contradiction between an individualized, flexible, student-centered education and the perceived need for a national focus.

Planning education and adapting curricula

Educational planning in Sweden, Norway, and Finland highlights the need for the school system to adapt to technological development. The Finnish report *Uusi oppiminen* (2013) was ambivalent towards the country's success in the PISA tests.³⁵ It should not be a source of contentment but 'obliges us to develop teaching by investing in new environments and models for learning'. The success proved that Finland had high-quality teacher education, but it was still necessary to renew pedagogical practices and integrate technology in everyday education. Such a development could in time form the foundation of a significant educational export. Finland might educate the teachers and children of the world, the report claimed.³⁶

The Swedish educational strategy (2017) for growth and equality claims that technology and digitalization will change society and the labor market. The school must adapt by acquiring technical infrastructure and raising the teachers' digital competence. For example, programming should become an ingredient of many subjects in comprehensive schools.³⁷

The Norwegian *Fremtidens skole* claims that digital competencies are crucial for future innovation and technological development in the private and public sectors. Technological development and complex problem-solving demand creativity and inventiveness, which will be of great importance to Norway's economic development and competitiveness.³⁸

The guidelines in recent national curricula on how to prepare students for the future labor market are strikingly similar. The current Finnish curriculum for the comprehensive school (2014) emphasize digital aids and competencies. The general part mentions seven competencies, of which 'digital competencies' are number five and 'work life competencies and entrepreneurship' number six. Innovation is mentioned as part of competency one, 'ability to think and learn'. In the subject-specific part of the curriculum, innovation is only mentioned in connection to traditional handicrafts, *sloyd*, where it occurs no less than seven times.³⁹ Apparently, proponents of *sloyd*, which disappeared from US schools in the early 1900s but still lives on in the Nordic countries, have embraced innovation in order to legitimize the subject's future existence. However, the Finnish comprehensive school curriculum is dominated by digitalization, which is mentioned in connection with all subjects except physical education, 162 times in total.

At the time of writing, the Swedish curricula for the comprehensive schools and upper secondary schools date from 2011. However, as of July 1, 2018, these curricula were revised to include digital competencies. The revisions concerned the general aims of education as well as the particular goals of individual subjects such as mathematics, history, languages, and technology. The word 'digital' was inserted 13 times in the general curriculum for the upper secondary school, seven in a single paragraph. This paragraph, which stresses the importance of entrepreneurship and innovation for the students' future in the labor market, was significantly expanded. While digitalization was not

mentioned at all in the original paragraph, the revision made digitalization its main theme.⁴⁰ Thereby, the curricula clearly states that the key to future employment is digital competencies.

In Norway, a major revision of national curricula is currently pursued. The general goals of education were revised in 2017, but, unlike Sweden and Finland, none of them are directly related to the demands of the labor market. However, the core elements of each subject are developed by work groups, which should include persons having experience with digital tools, entrepreneurship, and innovation.⁴¹ The new curricula were gradually introduced from August 2020.

Thus, in all three countries, students are expected to find future employment by mastering entrepreneurship, innovation, and, primarily, digitalization. The focus on digitalization in the late 2010s turned out to be timely, as the corona virus outbreak in 2020 led the three countries to temporarily replace traditional schooling with distance education.

Conclusions

The term ‘the fourth industrial revolution’ is found only in sources dating from after its breakthrough at the 2016 WEF. It was used by Norway’s minister of finance in 2016 and in the Finnish Visio2030 report of 2017.⁴² It is associated with a belief in an imminent radical shift in technological development, and this technology optimism is prominent also in earlier Finnish reports, especially *100 Opportunities for Finland and the World*. The Swedish *Långtidsutredningen*, which sees future development as a continuation of present trends at the current pace, does not use the concept but is instead referring to skill-biased technological change. Technology-pessimist circles also dominate the Norwegian *Produktivitetsskommissjonen*. Optimists and pessimists alike are trying to predict the future, but with different research methods and narrative traditions. While the pessimists write in academic style and rely on mathematics and statistical extrapolation from current trends, the optimists write in management-literature style and produce lists of innovations that they claim are on the brink of causing a revolution. Although *100 Opportunities for Finland and the World* (2013/2014) is unusually long with a hundred items, it is similar to WEF’s list of 23 technologies from 2016 or Citibank’s six from 2015.⁴³ In Sweden, Stefan Fölster at the market-oriented think tank Reforminstitutet has written two technology optimist books that include lists of technologies.⁴⁴ *Digitaliseringskommissionen* partly based its assumption of 35–53 percent job loss in two decades on Fölster’s research.⁴⁵ Although technology optimism is an international discourse with similar manifestations all over the world, Finland stands out in the degree of influence that optimists assert over government long-term planning.

This might be explained in part by the institutional framework of government planning. Traditionally, in all three Nordic countries public planning was done by government-appointed committees that published reports in official series.⁴⁶ This practice still exists in Sweden and Norway, while in Finland the

committee report system was abandoned in 2002. The continuity is especially apparent in Sweden, where *Långtidsutredningen* (2015) is the twentieth report by that name since 1948. Such deep institutional roots lend a historical perspective to forecasting, which might contribute to a more gradual image of future development. In Finland, since no central committee report series exist, smaller reports are written by ministries, or, as *100 Opportunities for Finland and the World*, by the Committee for the Future, appointed directly by parliament. The rupture with the traditional committee system might have made it easier for new groups to assert influence over the planning process.

A decade of economic recession in Finland has made successive governments suggest a number of reforms intended to improve Finland's economic competitiveness. However, they have met strong resistance from certain professions, civil servants, the academic community, and labor unions. Traditionally, these groups were represented in the committees responsible for long-term planning. By circumventing broad interest groups and putting planning in the hands of a small group of technology optimists, hopes are that a faster planning process not bogged down by vested interests can be achieved. However, the inclusion of interest groups in committees meant that when a report was finally published they were more likely to support the proposed reforms, since they had been able to influence them. Today, the most extreme technology optimist visions of the Finnish school are destined to meet fierce resistance from the teaching profession.

In Norway, technological development is seen as a way to counteract structural problems caused by the resource-based economy. Hopes are tied to raising productivity in the service sector, which has swelled due to petroleum revenues. Thus, Norway put more emphasis on adapting and utilizing technology than on developing and selling it. Use of technology in the public sector is discussed in Finland, but as a means of stimulating tech companies or overcoming labor shortages, while the idea is not discussed at all in Swedish reports.

The main focus in Sweden and Finland is on developing and exporting high-tech products. All three countries encourage the use of technology in education, modes of learning that stimulate creativity and adaptability, as well as life-long learning. These ideas are not new and have circulated for at least half a century.

However, there are also important differences between the countries' description of educational challenges. While Norway fears that its system of higher education lacks international competitiveness, Swedish reports are content with the system of higher education but are concerned with the basic skills of non-graduates, which have been highlighted by poor results in international comparisons. The erosion of basic skills is perceived as a threat to the positive economic development that Sweden has experienced for decades. Finland's comprehensive school system is renowned for a good and egalitarian distribution of skills, but since Finland, in spite of its well-functioning traditional education system, has experienced a long recession, good basic skills cannot be prescribed as a recipe for future success. This has opened the field for visions

about a high-tech revolution of the Finnish educational system, where no educational traditions or institutions are taken for granted. Perhaps it is not surprising that hopes of a future revolutionary transformation are highest in societies where current economic development is least satisfactory. The problems in Finland's system of higher education have only recently caught the attention of government reports.

While technological change is mainly seen as an opportunity in Finland and Norway, in Sweden the threat of skill-biased technological change is discussed more thoroughly. However, it is believed that Sweden can avoid skill-biased polarization and instead achieve upgrading, for example by raising the educational level of immigrants and reeducating males for traditionally female work.

The school system has been described as modeled on the factory of the first industrial revolution: a mass production facility for uniform knowledge transmission. In theory, a school modeled on the tailor-made manufacturing of the fourth industrial revolution should be able to achieve the individualized learning that has been long dreamt of among educationalists. However, although such a fundamental transformation of the school organization is envisioned by some long-term future forecasts, especially in Finland, it is absent from direct educational planning. Recent curricula are focused on transmitting digital competencies through the old educational structure rather than on using digitalization to reform it.

Notes

- 1 Crouzet 1996, 45.
- 2 OECD 2013, 51.
- 3 Brynjolfsson, Rock & Syversson 2017, 33.
- 4 Streeck 2016, 35 f.
- 5 Autor, Katz & Kearney 2006, 2008.
- 6 Acemoglu 2015.
- 7 Goldin & Katz 2008, 119–121.
- 8 Ibid., 87.
- 9 Goos, Manning & Salomons 2009, 61.
- 10 Federal Ministry of Economic Affairs and Energy homepage, 'Industrie 4.0'.
- 11 Schwab 2017, WEF Homepage, 'The fourth industrial revolution: what it means and how to respond'.
- 12 WEF Homepage, 'Ways to close the inequality gap in the fourth industrial revolution'.
- 13 Peters 2017, 4f.
- 14 Frey & Osborne 2015, 90f.
- 15 Brynjolfsson & McAfee 2016 (2014), 208–214.
- 16 NOU 2016:3, 6.
- 17 Jensen 2016, NOU 2015:1, 9, *Nasjonal kompetansepolitisk strategi 2017–2021*, 2017, 12, NOU 2016:3, 6.
- 18 Edgerton 2008 (2006).
- 19 SOU 2015:104, 85, 195, 201f, 213f, 312f.
- 20 Ibid., 201f.
- 21 Ibid., 174–184, 236f.
- 22 SOU 2016:89, 104–107.
- 23 Ibid., 171–175.

- 24 SOU 2015:104, 295–298.
- 25 The ‘agile applier’ is described as an ‘agile developer’ in the figure on page 20 in the English version of the report. However, in the Finnish original *ketterä soveltaja* is used in both places, and it is best translated as agile applier. Ailisto, Mäntylä & Seppälä (eds.) 2015, 20f.
- 26 Ailisto, Mäntylä & Seppälä (eds.) 2015, 26–30.
- 27 Opetus ja kulttuuriministeriö 2015:14, 12f.
- 28 Martin & Thelen 2007, 13.
- 29 Linturi, Kuusi & Ahlqvist 2014, 28f.
- 30 Linturi, Kuusi & Ahlqvist 2013, 27f, 2014, 28f (Quote).
- 31 Linturi & Kuusi 2018, 150, 2019, 175.
- 32 *Uusi oppiminen* 2013, 3f, Raatikainen & Tarvainen 2013, quote on 87, Tiihonen & Hietanen (eds.), 2014, 7, *Koulutusvienti kartalle* 2015, 30, Opetus ja kulttuuriministeriö 2016, 7.
- 33 Opetus ja kulttuuriministeriö 2015:11, 9, 73.
- 34 Opetus ja kulttuuriministeriö 2017, 13ff, 19, 22.
- 35 The PISA test is an international student assessment conducted by the OECD.
- 36 *Uusi oppiminen* 2013, 3f ‘velvoittaa meitä kehittämään kouluopetusta investoimalla uusiin oppimisympäristöihin ja oppimismalleihin’, 6.
- 37 SOU 2017:35, 96f.
- 38 NOU 2015:8, 26, 31.
- 39 Gfgu 2014, 21–23.
- 40 Gy11 2018, 3.
- 41 Utdanningsdirektoratet, Kjerneelementer.
- 42 Jensen 2016, Opetus ja kulttuuriministeriö 2017, 7.
- 43 Schwab 2017, Frey & Osborne 2015, 23–56.
- 44 Fölster 2016, Sanandaji & Fölster 2016, Reforminstitutet homepage.
- 45 SOU 2016:89, 104.
- 46 Statens offentliga utredningar (SOU) in Sweden, Norges offentlige utredninger (NOU) in Norway, and until 2002 Valtion komiteamietinnöt in Finland.

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