The importance of basic education in Brazil, in the context of the fourth industrial revolution

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Submitted on: 05/06/2023. Approved on: 11/07/2023. Published on: 03/04/2024.

ABSTRACT

Based on the analysis of the main factors driving the Fourth Industrial Revolution and its current stage of evolution, and considering the possible social and economic impacts, particularly regarding the elimination of traditional jobs and the creation of new occupations, this article examines the importance of Basic Education, with a focus on the necessary adaptation of teaching methodologies, as ways of facing the challenges and taking advantage of new the opportunities that arise.

Keywords: basic education; teaching methodologies; 4th industrial revolution; digital transformation. automation; jobs; unemployment; professional requalification.

1. INTRODUCTION

This study aims to provide an analysis on the importance, role and transformations necessary for Basic Education, in the context of the 4th Industrial Revolution, which has among its main characteristics the use and integration of advanced technologies such as Artificial Intelligence, Big Data, Web 3.0, Virtual Reality, Augmented Reality, Internet of Things, robotics, 5G, low orbit satellite internet[2], Biotechnology, Genetic Engineering, *blockchain*, cryptocurrencies, among others, which allows for the creation of applications such as smart *chatbots*, harvesters and autonomous vehicles, and countless other innovations that seemed like science fiction only a few decades ago. The integration of these technologies allows the automation of activities and work processes, applied in different sectors of the economy, whether in offices, industries, agribusiness or space exploration.

In educational terms, in a broad sense, such characteristics of the 4th Industrial Revolution imply the need for a new type of education, with an emphasis on teaching skills and abilities required to thrive in a technology-driven digital economy. It is agreed that to be successful in this new era, individuals will need to have a solid foundation of technology knowledge and digital skills necessary to effectively use digital tools, as well as the ability to adapt and learn new skills, quickly and autonomously.

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[2] According to Gartner, a technology research and consulting company, by 2027 the network of low Earth orbit satellites should be considered "critical infrastructure" by the governments of the United States and China (Wiles, 2022).

The ability to acquire new knowledge and adapt to an ever-changing world, as well as critical thinking skills, solving complex problems, working collaboratively, self-management and ease of communication, now have greater weight in employment and job retention than previous knowledge and professional experience.

To meet these current needs, educational systems will need to adapt, focusing on providing students with practical and experiential learning opportunities that allow them to apply knowledge gained in class to real-world environments and situations. In summary, education in the 4th Industrial Revolution should prioritize the development of interpersonal skills, such as critical thinking, communication, self-management, teamwork and problem solving, while also providing students with a solid foundation in technology and digital skills.

2. METHODS

The methodological approach proposed for this article includes exploratory theoretical transdisciplinary research based on the examination of ongoing transformations and short and medium-term trends, considering the global and national scope. Its aim is to analyze the importance, role and adaptations and changes necessary to education, whether in the scope of basic or professional training, so that the premises imposed by the 4th Industrial Revolution are met. The technical procedure adopted in this work is bibliographic.

The analysis in question considers economic, social, political, pedagogical and psychological perspectives, as well as corporate factors that directly impact the formation of specialized labor to meet new market demands.

The structure of this work was conceived as follows: the next section describes the current context of the 4th Industrial Revolution and its impacts in terms of the elimination of jobs and the creation of new positions, with demands for new training, qualifications and skills. Next, section four is dedicated to issues related to core education, covering the characteristics, mechanisms and new forms of teaching that must be considered and implemented to provide the adequate training of citizens for this new digital era. Section five presents the results and conclusions of the analyses and data previously made available. Section six concludes this work with due final considerations.

3. CONTEXTUALIZATION

The history of the last 200 years, starting with the First and Second Industrial Revolutions, teaches us that periods of transition in social and economic models can mean times of great difficulty for workers and for certain economic sectors and social classes. This difficulty is higher the more intense the break with previous models and the faster the transition occurs.

Several studies produced between 2018 and 2019 by researchers from Coppe[3], Ipea[4], Forrester, McKinsey Global Institute, WEF[5] (Albuquerque *et al*., 2019; Forrester, 2019; Lima *et al*., 2019; Lund *et al*., 2021; Lund; Manyika, 2017; Manyika *et al*., 2017a; 2017b; 2017c; Schwab, 2016; World Economic Forum, 2018; 2019a; 2019b; 2020), suggest that the changes currently underway in the 4th Industrial Revolution take place in waves, more quickly, with greater scope and with greater impact than previous industrial and technological revolutions, also reaching a higher number of people than on previous occasions. Furthermore, the covid-19 pandemic, starting in 2020, brought an urgency scenario for the automation of work processes and digital transformation, plunging much of the planet into a vortex of technological expansion and changes in business models and employment contracts, further accelerating the impacts and scope of the 4th Industrial Revolution.

In a scenario in which global economic systems are interconnected like never before, the world undergoes a period of accelerated disruption of traditional systems and models, in the political, social and economic spheres. A multipolar world, with different centers of political, economic and military power, where complex decentralized economic systems (DeFi) are established. Part of this scenario, the current digital transformation wave, with unprecedented speed and breadth in history, carries the real potential for harsh social and economic impacts, such as a significant increase in unemployment in the medium and short term, and, consequently, economic inequalities and social vulnerabilities. As a result of the ongoing technological revolution, a 2016 study by the World Bank highlighted the risk of increasing income concentration and social inequality (World Bank Group, 2016, 2019). Not preparing society, or a country, for such changes can mean unacceptable cost in terms of future prospects, especially for those who are more adversely affected.

French economist and writer Thomas Piketty drew attention to the issue of income concentration and the increase in social inequality, back in 2013:

> De certa maneira, estamos, neste início de século XXI, na mesma situação que os observadores do século XIX: somos testemunhas de transformações impressionantes, e é muito difícil saber até onde elas podem ir e qual rumo a distribuição da riqueza tomará nas próximas décadas, tanto em escala internacional quanto dentro de cada país (Piketty, 2013, p. 22)[6].

[3] Coppe – Alberto Luiz Coimbra Institute for Postgraduate Studies and Engineering Research, at Universidade Federal do Rio de Janeiro.
[4] Ipea – Institute of Applied Economic Research.
[5] WEF – World Economic Forum.
[6] Translation: “In a way, we are, at the beginning of the 21st century, in the same position as that of the observers of the 19th century: we are witnesses of impressive transformations, and it is very difficult to know how far they can go and what direction the distribution of wealth will take in the coming decades, both on an international scale and within each country” (Piketty, 2013, p. 22, editorial translation).

The potential for social and economic disruption caused by hyperautomation is a serious concern for many governments, businesspeople, economists and scholars on the subject. The global economy may be dominated by a small group of countries, while developing countries may interrupt their economic growth, have stagnant economies, face recession and long social, economic and political crises (Lee, 2019) during the period of transition.

In Brazil, the cruel side of this ongoing transition period can be evidenced by the significant percentage of young people between the ages of 18 and 24 who can neither find a job nor continue their studies – the so-called "nem-nem" ("neither-nor", neither do they study, nor work). According to the Organization for Economic Cooperation and Development (OECD, 2022), Brazil has the second highest proportion of such young people, corresponding to 35.9% of the population, ranking below South Africa (46.2%) only, and has more than double the average among the 45 countries analyzed, of which the Netherlands appears with the lowest percentage, at just 4.6%. According to the previous edition of the same study (OECD, 2021), this scenario has worsened year after year in Brazil, where the percentage of young people who did not study nor work rose from 29.3% in 2019, to 34.1% in 2020, exceeding the percentage of young adults who are undertaking academic or professional activities.

Supporting the trend towards the automation of tasks and work processes, and the predictable increase in social inequalities, studies by the World Economic Forum, presented in report *Future of Jobs Survey* 2020 (World Economic Forum, 2020), indicate that after the start of the covid-19 pandemic, a significant amount of entrepreneurs are preparing to accelerate their automation agenda:

> Entre os líderes empresariais pesquisados, pouco mais de 80% relatam que estão acelerando a automação de seus processos de trabalho e expandindo o uso do trabalho remoto. Um significativo percentual de 50% desses mesmos empresários também indicam que estão preparados para acelerar a automação de postos de trabalho em suas empresas. (World Economic Forum, 2020, p. 13, our translation)[7].

During the First and Second Industrial Revolutions, businesses that were based and thrived on older technologies that had become obsolete gave way to new forms of work, harnessing the power of steam, coal and the industrial production line. Such changes have created a demand for professionals with skills and abilities compatible with new technologies and ways of working. Once again we are facing a similar situation. As can be seen below, preparing society for the transformations underway necessarily involves reviewing teaching methods, in order to prioritize education that is less content-based and more focused on facing real-life problems, by means of the preparation and training of young people and adults for the new global scenario that is imposed.

[7] Original: "Among the business leaders surveyed, just over 80% report that they are accelerating the automation of their work processes and expanding their use of remote work. A significant 50% also indicate that they are set to accelerate the automation of jobs in their companies." (World Economic Forum, 2020 p. 13)

Also according to report *Future of Jobs* 2020, the lower the level of education, the greater the risk of one losing their job, of not being able to make a career transition or of not relocating (World Economic Forum, 2020). However, according to studies carried out by Universidade de Brasília together with Ipea (Albuquerque *et al*., 2019), automation should reach not only professionals in activities that require lower professional qualifications, but also professionals who undertake intellectual activities along with higher-education professionals, and is able to automate around 49% of accountants' activities and 54% of legal advisors' activities. Considered low friction, these accountant and legal advisor activities can be automated using cloud-based *software*, which is updated or maintained remotely. For some professions, part of their activities will be automated, however, in extreme cases, entire professions may be extinguished.

Updated forecasts (World Economic Forum, 2023) indicate, for the specific set of countries analyzed, totaling 673 million jobs, the creation of around 69 million new job opportunities, against 83 million jobs to be eliminated by automation, between 2023 and 2027, projecting a deficit of 14 million jobs. Additionally, according to report *The future of work after covid-19* (Lund *et al*., 2021), the increase in new job opportunities should be highly associated with high-skilled jobs, for example, in industries such as health, medical sciences, technology, engineering and mathematics (STEM[8]), while low and medium-skilled jobs such as food service or office support roles will see a progressive decline. At the present time, however, there is a reduction in new hires and an accelerated elimination of jobs.

Other factors such as the war between Russia and Ukraine, population reduction and the pace of economic growth in China, forecasts of economic recession in the United States and Europe, have further stimulated the acceleration in employee layoff. According to information available on Layoffs.fyi[9]platform, which monitors the termination of employment contracts in technology companies, this situation is corroborated by the significant mass layoffs by North American *big techs* (*Amazon, Google, Meta* and *Microsoft)*, in addition to Twitter, which, together, in the last two months of 2022 and the beginning of 2023 laid off around 74 thousand people in just six months[5]. Other large companies such as IBM, Salesforce, Cisco, Philips, Ericsson, PayPal and Dell increased the number of layoffs in the same period[10]. The reactivation of jobs eliminated by the companies mentioned is unlikely, even if there is an economic recovery at a global level. In addition to the *big techs*, massive layoffs have also been observed in *startups* that reached unicorn status, but that have not managed to reach a financial balance

[8] STEM – Science, Technology, Engineering and Mathematics.

[9] Website: https://layoffs.fyi/

[10] Digital payments company PayPal announced on 02/01/2023 that it will lay off 7% of its workforce, totaling around 2 thousand employees (https://newsroom.paypal-corp.com/2023-01-31-Update-on-Our-Transformation), on 02/06/2023 it was Dell's turn to announce that it was laying off 6,650 employees, corresponding to 5% of its workers (https://layoffs.fyi/). According to Layoff.fyi, on 05/31/2023, the previously mentioned numbers were added to the other layoffs taken place from October 2022 onwards: 3,000 at Seagate, 3,300 at SAP, 3,900 at IBM, 4,100 at Cisco, 8,500 at Ericson, 9,000 at Salesforce, 21,000 at Meta, 10,000 at Microsoft, 10,000 at Philips, 12,000 at Google (Alphabet), 27,000 at Amazon, and 3,940 at Twitter (https://layoffs.fyi/).

This retraction in technology companies is also a reality in Brazil, for example in the PagSeguro/PagBank group, which announced a reduction of 500 jobs, around 7% of its workforce, a few days after the beginning of 2023. Moreover, according to Layoffs.fyi, in 2022, 158,951 employees were laid off from 1,035 technology companies, while by the end of May 2023, over 200,000 layoffs had already been made in 718 of these companies. Possibly, this wave of layoffs will continue for the next few months.

Threat to jobs is arising much faster than most experts predicted, and it will not discriminate by the level of specialization of positions, but will instead hit both the highly trained and those with a low education level (Lee, 2019).

An additional factor for the reduced supply of jobs will possibly be the demise of companies that are unable to update their operational processes and adapt to new technologies and business models, as are the countless examples of recent decades, emblematized by icons such as Kodak, Xerox, Blockbuster, Palm, RIM (read BlackBerry), Nokia and Sears, among many others.

Many factors influence the socioeconomic consequences of the use of new technologies and automation, some of which are presented above and that, together, point to future trends, also presented throughout this work (Fernandes, 2020). Such factors may be of a technological, political, economic, social, cultural, ethical, regulatory or environmental nature. Due to the large number of variables that can determine unexpected changes in course, accelerating or slowing down the evolution of the 4th Industrial Revolution, as was the case with the 2008 financial crisis, covid-19 and the war in Ukraine, as well as the environmental and energy crises, such trends may undergo abrupt changes and must be monitored and updated periodically.

Regarding the factors of technological nature, one must consider Amara´s law, coined by North American researcher and futurist Roy Amara (1925-2007), according to which “tendemos a superestimar o efeito de uma tecnologia no curto prazo e subestimar o efeito no longo prazo.” (Ratcliffe, 2016, n.p, our translation)[11]. Amara’s Law applies, especially, to the emergence of new technologies and applications that can enable hyperautomation and destabilize the balance that measures the elimination of jobs in contrast to the creation of new job opportunities, such as the case of Generative AI and its most prodigious son, the recently launched ChatGPT (*Chat Generative Pre-trained Transformer*)[12] of North American company OpenAI, its competitor from Google, *chatbot Bard*[13] , or other applications that use Generative AI technology, such as the prestigious Dall-E[14], also of OpenAI, or Midjourney[15].

[11] Original: “We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run.” (RATCLIFFE, 2016, n.p).
[12] Website: https://chat.openai.com/.
[13] Website: https://bard.google.com/.
[14] Website: https://openai.com/dall-e-2.
[15] Website: https://www.midjourney.com/.

As a special category of machine learning models, trained on huge databases, called LLM (*Large Language Models*), Generative AI offers as a result the generation of content in the form of texts, images, audios, and even the coding of computer programs, largely indistinguishable from what would be produced by human beings. Therefore, the potential to worsen the crisis in the labor market of an intellectual nature is attributed to this LLM technology, which is still in the process of maturing, with a significant impact on higher education workers in the marketing industry, writers, musicians, programmers and lawyers, among others.

Another point to be weighed is the fact that, while the reduction of jobs due to the automation of activities and work processes is guaranteed, the occupation of possible new job opportunities depends heavily on the availability of qualified personnel with the skills needed for these new positions. Considered an important employability factor, soft skills have gained status of equal or greater importance than that of hard skills and professional experience. According to the publication of the most recent *The Future of Jobs Report 2023* (World Economic Forum, 2023), based on the perspectives of 803 companies, from 27 different economic activity areas, from 45 countries from all regions of the globe, among the 26 main personal skills and competencies, from an employability point of view, 4 are technical (hard skills), 3 are managerial, 2 are motor skills, and the remaining 17 are soft skills. The list below presents the top eleven personal skills listed as the most important:

i. Analytical thinking
ii. Creative thinking
iii. Resilience, flexibility and agility
iv. Motivation and self-knowledge
v. Curiosity and active learning for life
vi. Technological literacy
vii. Reliability and attention to detail
viii. Empathy and active listening
ix. Leadership and social influence
x. Quality control
xi. Systems thinking (World Economic Forum, 2023)

From a business perspective, the unavailability of qualified labor represents the main challenge to be faced, from 2023 to 2027. According to the *Future of Jobs Survey 2023*, the organizations surveyed identify skills gaps and the inability to attract talent as the main barriers hindering the digital transformation of businesses and company growth (World Economic Forum, 2023).

Due to the low availability of qualified labor, studies already indicated, in 2018 (World Economic Forum, 2018), the tendency for companies to move to different regions or countries in search of available qualified labor. Report *Future of Jobs Survey* 2018, from the World Economic Forum (World Economic Forum, 2018), highlighted the availability of talent as the main criterion for choosing the location of organizations, far exceeding labor costs, and local production and operating costs. This data already signaled a migration process both for companies, looking for cities with talent availability, and for professionals, looking for job opportunities. However, the covid-19 pandemic, when *lockdowns* were implemented in different parts of the globe and at repeated times, introduced an additional component to this equation, stimulating an intense effort to implement hybrid or fully remote models for a significant part of the workforce. This movement culminated in the direct hiring of specialized labor in any part of the globe, with companies paying for these resources in the currency and country of best tax convenience. It also became feasible to establish and have a local presence of companies in countries and regions in which it did not operate directly, with a large part of the operation working remotely, thus also allowing them to choose the most convenient locations for collecting taxes on operation and profits. According to 2020 estimates (World Economic Forum, 2020), it is likely that around 44% of the workforce will implement remote work.

While, not long ago, protectionist policies were imposed on local populations in various economic activities, in addition to difficulties for specialized professionals to change countries, we reached the point where organizations were seeking qualified labor for other countries, on Linkedin, totaling hundreds of thousands of vacancies per year, also offering facilities for moving.

Thus, making any city, region or country a hub for a given economic sector, as a countermeasure for the process of geographic mobility of talents and companies, attracting and retaining both, necessarily involves the training and retention of qualified labor, as well as appropriate tax and incentive policies. In this sense, in October 2022, Portugal enacted legislation to facilitate the application for and obtaining of visas for remote workers, who mainly work for foreign companies from their territory. In December 2022, the Spanish government followed the same path as Portugal, increasing the list of countries with this type of arrangement.

Reinforcing the workforce qualification needs described previously, the Automation Paradox (Bainbridge, 1983) states that the greater the level of automation and criticality of a system, the smaller the team required for its operation, however, the more important the contribution human development of developers, operators and support, demanding better levels of qualification.

Companies estimate that half of all employees will need professional retraining in order to reduce the risk of losing their positions, and of this percentage, 40% will need courses lasting six months or less. This need for requalification considers a period of five years, indicating that the window of opportunity to requalify and improve workers has become shorter. In terms of Brazil, considering a workforce of 64% of the working age population, totaling 87.4 million active workers, the percentages above indicate a group of almost 44 million potential trainees for requalification courses (World Economic Forum, 2020). A not inconsiderable opportunity for training and consulting companies.

The reality that presents itself, of strong transformation in business and work models, driven by a convergence of rapidly evolving technologies, brings with it the imposition that learning must be a priority to be maintained throughout life. Learning, one of the main means of fighting social inequality, has become continuous. Ignoring this reality will mean taking personal risks of placing one outside of the labor market, wasting the emerging business and job opportunities. For innovation to provide not only increased efficiency, but also social inclusion, focusing on learning and professional qualification becomes of paramount importance.

Investments in education have proven to be the option with the best return in terms of growth in national GDP and GDP per capita and, consequently, as an instrument for reducing social inequalities. As examples, we have the results achieved in recent years by several countries, such as China, Estonia, Japan, South Korea, Denmark, Finland, Norway, Sweden, Netherlands, Canada, among many others. Brazil, despite having a significant percentage of GDP invested in education every year, around 5.6%, has usually occupied the bottom 20% in terms of quality of educational systems, among the countries analyzed by the OECD (OECD, 2019). Recent performance results of Brazilian students in tests conducted by organizations such as the Program for International Student Assessment (PISA) suggest inefficiency issues related to the public administration of education in the country.

4. EDUCATION 4.0

Let us imagine a doctor's office or hospital from two hundred years ago, the furniture, instruments, exams from that time and, mainly, the knowledge available then, as well as the medical protocols and procedures used. Let us compare this scenario with current medical facilities, instruments, exams and procedures. Let us do the same with an accounting office from the same period, with poorly lit rooms, dark furniture, a large number of closely spaced desks, piles of paper on desks and furniture and the uninterrupted sound of countless typewriters, with modern well-lit rooms, with a clean style, with basically a monitor and a keyboard on the desks, and the almost absence of papers.

If there were the possibility of entering an environment like the ones described above, from 200 years ago, in full operation, we would certainly have the impression to have traveled in time, returning to the past, which seems very distant from current reality. This must be the sensation experienced daily by most teachers and students when entering their classrooms: the return to a distant past, frozen in time. Current classrooms and teaching methods hardly differed during this time. It suffices to browse the internet for such images.

Schools, while they remain stagnant in the past, do not belong to the present world of students or teachers. Upon entering the classrooms, one returns to the past, to the 19th century. The school environment today brings about a strangeness effect, disassociation with reality, lack of emotional bonds, lack of engagement and interest, apathy. The traditional learning process is tiring, tedious and discouraging.

Today, in accordance with Moore's Law, any smartphone has processing and storage power millions of times greater than the main computers used by Nasa to send astronauts to the Moon, on Apollo 11, in 1969. The internet brought about an explosion of digital data of different formats, continuously created and stored, with the most diverse objectives: texts, images, videos, clicks, tweets, social network posts, purchases, payments, video conferences, etc. Most students, whether from public or private schools, have personal or family-use smartphones, allowing daily access to the digital world. The mismatch between the technologies used in the students' daily lives and in the teaching environment makes it difficult to maintain focus on studies, whether inside or outside the classroom, with so many distractions which are much more appealing than the teaching material that is commonly made available.

The schools and teaching methods of the 19th century, and even much of the 20th century, prepared students for the reality and needs of such time. Choosing a profession, in general, meant a lifelong decision. The knowledge acquired in schools and used in professional life did not evolve so quickly, sometimes remaining stagnant for decades, requiring little or no updating during one's professional life. This scenario has radically changed. People will probably pursue several different professions throughout their lives. Technical knowledge, and even entire professions, have become volatile, evolving very quickly and sometimes simply ceasing to be needed, and disappearing. Formal learning, whether at a basic, technical or higher level, needs to adapt to new market demands and needs. Reducing the gap currently existing between the academic training provided by our schools and universities and the qualification requirements of the different sectors of the economy is of paramount importance.

Several pedagogical challenges are presented to make possible technological-professional training and the acquisition of skills required for a large number of people, both for new entrants into the labor market and for those in need of professional requalification, suitable for new professions and job opportunities.

The educational system itself and teaching methodologies need to be reconsidered. The teaching methods that were effective in the 19th and 20th centuries, strongly favoring the purpose of preparing students for entrance into a university and the traditional labor market, no longer meet the demands of the 21st century. It is necessary to prepare citizens for this brave new world.

Therefore, it becomes imperative and urgent to implement new teaching methodologies, starting with Basic Education, which must be adapted to the reality of *screenagers,* considering their individual characteristics:

→ Students have their own interests and preferences and wish to learn about different topics, which are distributed and compartmentalized across multiple school subjects. The enormous amount of material and teaching content to study makes it difficult for students to know what should be prioritized and, above all, meet their personal interests;

→ Overcoming the compartmentalization of knowledge has become an urgent need. According to Edgar Morin (Morin; Ciurana; Motta, 2003), transdisciplinarity is a fundamental principle for overcoming the fragmentation of knowledge;

→ Not everyone learns in the same way, with rhythms, personal factors and other characteristics of the learning processes that are particular to each student or groups of students;

→ Traditional education does not connect with the profiles and interests of young people or with the needs of the labor market, as anticipated by North American educator, philosopher and political activist John Dewey (1859-1952) (Lemos et al., 2022);

John Dewey raised much criticism of the so-called traditional school, highlighting the passivity of students and the uncritical teachers, the imposition of validated content *a priori*, the mere transmission of content, the lack of encouragement for the students' autonomy, among others (Lemos *et al*., 2022).

In his view, teachers can no longer maintain an authoritarian stance, as owners of the knowledge that will be transmitted to learners. It is the responsibility of teachers to guide and moderate the teaching and learning processes, encouraging school activities and the spirit of democracy (Lemos *et al*., 2022). The biggest challenge teachers have, in this proposal, is to offer support to learners, presenting the reality of the world, however, allowing them to carry on independently.

THE BASIC EDUCATION STRUCTURE IN BRAZIL[16]

In terms of Brazil, Basic Education is divided into three stages: Early Childhood Education, Elementary Education and Secondary Education.

Early Childhood Education is aimed at children aged between zero and five years of age, and should focus on the development of aspects of a physical, motor, psychological, cultural and social nature, working on imagination and creativity by means of playful activities, in addition to encouraging interaction and collaboration among classmates.

Elementary Education, with a duration of nine years, is divided into two stages:

→ Elementary I, aimed at children aged six and above, and consists of five grades. This is where the literacy process begins, focusing on the development of languages and cognitive, motor and social skills. At this stage, student groups are usually attended by a single teacher, with the exception of complementary activities and subjects. It has a minimum workload of 800 hours per year, with daily working hours of at least 4 hours, spread over at least 200 school days;

→ Elementary II, with four grades, is ideally aimed at children aged between 11 and 14. In this stage there is an increase in the repertoire of knowledge and content offered to students, in addition to more complex learning challenges. Each class is attended by several teachers, specialized in the subjects planned for this Elementary School stage, with the same annual workload, daily working hours and number of school days as Elementary I.

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[16] Basic education in Brazil includes early childhood education, basic education and secondary education.
In the United States, Brazil's equivalent of basic education is generally called K-12 education (meaning Kindergarten through 12th grade), referring to the years starting at preschool to the end of high school.
Here is a detailed explanation:
- Kindergarten (K): It corresponds to the last year of preschool, attended by children around 5 years of age.
- Elementary School: This includes the years from 1st to 5th grade, corresponding approximately to the initial years of basic education in Brazil.
- Middle School or Junior High School: These are the years from 6th to 8th grade, generally attended by students aged between 11 and 14.
- High School: This comprises the years from 9th to 12th grade, corresponding to secondary education in Brazil. Students generally graduate from high school at around 17 or 18 years of age.
Therefore, basic education in Brazil is comparable to the K-12 education system in the United States.
In the United Kingdom, Brazil's equivalent of basic education is generally divided into two main stages - basic education and secondary education - as detailed below:
- Basic Education: It corresponds to the first stage of basic education and is attended by children aged 5 to 11 years old. During primary education, students study a range of core subjects such as mathematics, English, science, history, geography, art and physical education.
- Secondary Education: This is the second stage of basic education and is divided into two parts:
a. Key Stage 3: It comprises years 7 to 9 and is equivalent to the final years of basic education in Brazil. During this time, students study a wide range of subjects, including mathematics, English, science, foreign languages, humanities, art, technology and physical education.
b. Key Stage 4: It corresponds to years 10 and 11 and is equivalent to secondary education in Brazil. During this time, students often prepare for important final exams, such as the GCSE (General Certificate of Secondary Education) or similar exams, which are essential for advancing their education or entering the labor market.
Thus, basic education in Brazil is comparable to Primary Education and Secondary Education in the United Kingdom.

Secondary Education, as it is more strongly linked to preparing students for the current landscape of digital transformation, technological revolution and hyperautomation in the labor market, will be treated in this study with greater emphasis than Early Childhood and Elementary Education. We highlight, however, the importance of good quality Elementary Education, as a condition for Secondary Education to achieve its goals.

THE PNE, BNCC AND THE SECONDARY EDUCATION REFORM

The Federal Constitution of 1988 (Brazil, 1988), the National Education Bases and Guidelines Law (LDB), of 1996 (Brazil, 1996), and the National Common Core Curriculum (BNCC), approved and ratified in 2018 (MEC, 2018a) regulate educational guidelines, emphasizing the need to adapt to the great transformations of the contemporary world and a social equity policy.

As it recognizes education as one of the main factors for the economic and social development of nations, in 2014 (MEC, 2014), the Ministry of Education established the National Education Plan (PNE) in compliance with the provisions of article 214 of the Federal Constitution, and of the BNCC guidelines, with the aim of universalizing, democratizing and raising the quality of Basic Education in Brazil. Additionally, it instituted the Secondary Education Reform in 2017 (MEC, 2018b).

The National Education Plan (PNE) determines guidelines, goals and strategies for the educational policy for the 2014-2024 period (MEC, 2014). Together with the Secondary Education Reform and the New BNCC, the PNE foresees profound changes in teaching methodologies, changing the traditional content-driven model to a model aimed at developing capabilities and skills oriented to current educational needs, as described in the previous sections. Such changes, in addition to adherence to some of the UN SDGs (Sustainable Development Goals) and requirements for joining the OECD, set goals to be applied to Basic Education.

The following are teaching universalization and democratization goals set out in the PNE (MEC, 2014):

→ extending access to quality education to the majority of students by ensuring, by 2016, early childhood education in pre-school for all children aged 4 to 5 years and expanding the provision of early childhood education in daycare centers in order to meet, at least, 50% of children aged up to 3 years, by 2024;

→ universalizing 9-year elementary education for the entire population aged 6 to 14 and ensuring that at least 95% of students complete this stage at the recommended age, by the last year of validity of this PNE;

→ universalizing, by 2016, school attendance for the entire population aged 15 to 17 and increasing, by the end of the period of validity of this PNE, the net enrollment rate in secondary education to 85%;

→ offering full-time education in at least 50% of the public schools, in order to serve at least 25% of basic education students;

→ tripling enrollment in secondary-level technical professional education, ensuring this offer to at least 50% of the expansion in the public segment;

→ promoting the quality of basic education at all stages and modalities, improving school flow and learning. All students must have access to education with the same quality.

The BNCC (MEC, 2018a) goals for personalizing teaching (adaptive learning) are:

→ respecting the distinct desires, expectations and interests, socio-emotional specificities, behaviors and prior knowledge of each student, within a process of personal and dynamic development of their individual skills and abilities, outlining unique and personalized combinations of training itineraries and learning paths;

→ selecting and applying diverse didactic-pedagogical methodologies and strategies, using different rhythms and complementary content, to work on the needs of different groups of students, their families and culture of origin, their communities, their socialization groups, etc.;

→ creating and implementing situations and procedures to motivate and engage students in learning activities;

→ selecting, producing, applying and evaluating teaching and technological resources to support the teaching and learning process.

The goals for individualizing teaching[17] set out in the PNE (MEC, 2014) are:

→ identifying, treating and adapting teaching to the possible biopsychosocial characteristics of each student, which may affect learning;

→ universalizing, for the population aged 4 to 17 years with disabilities, pervasive developmental disorders and high abilities or giftedness, access to basic education and specialized educational assistance, preferably in the regular school system, with the guarantee of an inclusive educational system, of multifunctional resource rooms, specialized classes, schools or services, whether public or contracted.

→ ensuring specialized educational assistance in multifunctional resource rooms, specialized classes, schools or services, public or contracted, in complementary and supplementary manners, to all students with disabilities, pervasive developmental disorders and high abilities or giftedness, enrolled in the public basic education network, according to the need identified through assessment, having the family and the student been heard;

[17] While personalization aims to address deficiencies and meet each student's interests and potential, within an adaptive learning proposal, the individualization of education aims to foster equity and inclusion, considering the physical, intellectual, cognitive, emotional characteristics and social aspects of the students.

→ encouraging research aimed at developing methodologies, teaching materials, equipment and assistive technology resources, with a view to promoting teaching and learning, as well as accessibility conditions for students with disabilities, global developmental disorders and high abilities or giftedness.

Additionally, Basic Education schools must adopt teaching and learning mechanisms and processes, aiming to address the following issues (MEC, 2014):

→ maintaining student engagement in teaching and learning processes at high levels, respecting their interests, expectations and particular objectives, aiming to improve academic performance and reduce or eliminate school dropouts;

→ implementing new assessment methods: test and assignment grades are poor indicators for assessing the quality of teaching, being insufficient for measuring how much students are learning and developing their skills and abilities.

In order to meet the goals and objectives described above, the PNE's twentieth and last goal is to "increase public investment in public education in order to reach, at least, 7% of the Gross Domestic Product - GDP of the country on the 5th year of validity of this Law and, at least, the equivalent of 10% of the GDP by the end of the ten-year period." (MEC, 2014, *online*).

SECONDARY EDUCATION

To meet the current needs for basic training, the LDB underwent changes, established by Law No. 13.415/2017, determining changes in the structure of Secondary Education. In addition to increasing the minimum school hours from 800 to 1,000 hours per year, a new curricular organization was defined, which is more flexible and adheres to the BNCC and which includes "the offering of different possibilities of choices to students, training itineraries, with a focus on areas of knowledge and technical and professional training" (MEC, 2018a). This change aims to improve the quality of education, making it compatible with the new demands and complexities of the world of work and life in society, by bringing schools closer to the students' reality.

The New Secondary Education (MEC, 2018b) establishes a curriculum composed of the ten general skills of Basic Education, common to all students, and training itineraries, defined in the BNCC (MEC, 2018a), which must be organized through the provision of different curricular arrangements, depending on the profile and interests of students and the capacity of education systems to offer such itineraries.

Among the 3,000 hours set out for the 3 years of this stage of Basic Education, as a minimum workload, 1,800 of such hours must be dedicated to the general skills of Basic Education, while the remaining 1,200 hours must be allocated to the specific skills of the training itineraries.

The training itineraries, making the curricular organization of Secondary Education more flexible and providing options for students to choose from, according to different prior skills, abilities, desires, interests and personality profiles, can be structured with a focus on a specific area of knowledge, in technical and professional training, or even the combination of two training itineraries, forming integrated itineraries, which allow the mobilization of skills and abilities from different areas. There are 5 possibilities for training itineraries, namely (MEC, 2018a):

i. languages and their technologies: covering vernacular, foreign, classical and indigenous languages, Brazilian Sign Language (LIBRAS), arts, design, digital languages, corporeality, performing arts, scripts and literary productions;
ii. mathematics and its technologies;
iii. natural sciences and their technologies;
iv. applied human and social sciences;
v. technical and professional training.

The skills, as seen previously, can be classified as general and specific. In short, skills are the units resulting from the way BNCC divides the areas of knowledge. The MEC (2018a, *online*) defines skill “as the mobilization of knowledge (concepts and procedures), skills (practical, cognitive and socio-emotional), attitudes and values to resolve complex demands of everyday life, the full exercise of citizenship and world of work”, adding that: by adopting this approach, the BNCC indicates that pedagogical decisions must be oriented towards the development of skills. By clearly indicating what students should “know” (considering the constitution of knowledge, abilities, attitudes and values) and, above all, what they should “know how to do” (considering the mobilization of these knowledge, abilities, attitudes and values to resolve complex demands of everyday life, the full exercise of citizenship and the world of work), conception of curricular knowledge contextualized by the local, social and individual reality of the school and its students (MEC, 2018a).

Each skill is assigned a set of abilities to be developed throughout the stages of Basic Education, expressing the essential learning that must be assured to students, in different sociocultural contexts. These abilities, in turn, are related to different objects of knowledge, understood as content, concepts and processes that, ultimately, are organized into thematic units.

TEACHING METHODOLOGIES AND STRATEGIES SUITABLE FOR THE NEW SECONDARY EDUCATION AND BNCC

In order for the results desired by the PNE, BNCC and New Secondary Education to be effectively achieved, it is necessary to adopt appropriate methodologies and strategies, among which we highlight: active learning, adaptive learning, multidimensional education, playfulness, gamification, *edutainment*, entrepreneurship, flipped classroom, hybrid teaching, *maker* spaces. Some of the methodologies mentioned will be briefly discussed below.

Active methodologies constitute pedagogical teaching and learning strategies that prioritize student action, such as: project-based and problem-based learning, which prioritize learning through practical challenges involving investigation, research, the development of hypotheses, to seek problem solving by addressing the principles of protagonism, innovation, stimulation of creativity, contextualization, problematization and critical thinking (Lemos *et al*., 2022).

Edutainment, word formed by the combination of education and entertainment, refers to an educational strategy that makes use of entertainment elements, as a way of obtaining high levels of playfulness and student engagement. Heavily based on digital technologies and audiovisual resources, it uses entertainment tools such as games, films, metaverse, augmented reality and virtual reality. Having multidimensional education as its central concept, with the use of engaging narratives and in different formats than the usual, *edutainment* aims to produce more appealing pedagogical content with greater retention power.

Gamification presents itself as a relevant teaching strategy, linked to the concept of *edutainment*, with the use of multiple media. Making use of game elements, aimed at solving practical or historical tourism problems, among other possibilities, it operates as a playful instrument, meeting the objectives of active learning. It awakens students' interest in acquiring knowledge, promotes protagonism and autonomy to decide on their actions in the games and encourages student engagement in classes. Additionally, it stimulates soft skill development, such as creativity, initiative, flexibility, resilience and tolerance to stress , in addition to reasoning skills for problem solving and the ideation of solutions (Medeiros, 2022).

The teaching and learning process, to obtain the proper retention of knowledge and the ability to use it, has emotion as one of its main pillars, and must stimulate certain feelings, such as engagement, belonging, curiosity, motivation and creativity. The teaching methodologies and instruments mentioned in this section are facilitators to meet such demands of the educational process.

Together, active learning methodologies supported by technological tools and appropriate strategies, such as gamification, inserted in the concept of *edutainment,* become powerful pedagogical resources for teaching both the general and elective skills provided for in the BNCC, as well as the soft skills necessary for contemporary life: critical thinking, entrepreneurship, collaborative work, time management, financial education, creativity, autonomy, socio-emotional learning, emotional intelligence, communication, negotiation, cognitive flexibility, complex problem solving.

In a complementary way, active methodologies also favor the development of entrepreneurial skills. In addition to the restricted purpose of opening a business or company, entrepreneurship is currently treated as the creation of value, be it financial, cultural or social. In this sense, developing entrepreneurial education presupposes the use of new teaching strategies that encourage students to collaborate and obtain solutions to problems and that allow them to deal with complex situations.

Finally, in the current scenario of dissemination of synthetic realities, teaching methodologies and strategies, including the development of abilities and *soft skills*, must prepare students to fight the dissemination of misinformation, "[…] through scientific, digital and humanistic literacy" (Unesco, 2022, p. xiv).

TECHNOLOGIES APPLIED TO EDUCATION

Today, public and private educational institutions dedicated to Basic Education are facing difficult adaptation to the (PNE), the Secondary Education Reform and the new BNCC. The insufficient number of teachers, school counselors, educational managers and content producers, combined with the need for training these professionals, and the costs of hiring and training additional professionals, represent critical challenges to be overcome.

While a significant percentage of public schools are unable to have a complete set of teachers for core subjects, how can we promote the personalization and individualization of teaching, providing the additional attention required for each student by means of these practices, while maintaining the same number of employees? In the case of private educational institutions, even if it were possible to obtain additional educational professionals with the appropriate qualifications, necessary to face the challenges described above, how can the significant increase in expenses be made compatible with the monthly tuition?

An alternative to mitigate the difficulties and challenges that arise for the effective implementation of the personalization and individualization of teaching by public and private schools would be to use technologies, platforms, software tools and virtual assistants.

Education professionals can currently rely on a wide range of possibilities for using technologies applied to educational processes, which enable the use of differentiated teaching strategies, for the production of content, facilitation of communication, mapping of profiles, monitoring of performance, suggested learning paths, school management, among other resources.

Education Mediated by Technology (EMT) presents itself as an indisputable reality, enabling hybrid education strategies, with online, live and interactive classes, transmitted on the internet, in its various modalities (broadband, satellite, 4G or 5G), simultaneously facilitating the universalization and democratization of teaching.

LMS (Learning Management System) platforms , based on the regular collection of individual data, ranging from grades, performance assessments by area of knowledge, attendance in classes and other information from academic records, facilitate school management and allow teachers to monitor the individual performance of students, identifying the potential and needs of each student, and recognizing possible trajectories and paths most suited to the success of the educational process. By means of a continuous analysis of information about the teaching and learning process, such platforms also help educators to regulate and adjust the evaluation process, facilitating the planning of future pedagogical interventions. Additionally, it helps to outline adaptive education strategies, in an automated or semi-automated way, comprising the definition of training itineraries, learning paths and personalized content paths for individual students or homogeneous groups of students, and of life plan, allowing the effective personalization and individualization of teaching.

Software platforms for the automated application of tests and mapping of personality profiles, including the identification of skills, abilities, propensities and interests, giftedness, and socio-emotional specificities of each student, can be used as tools for planning and monitoring personal development. By making it easier for educators to recognize students' personal characteristics and needs, it allows them to create courses of study adaptable to the students' uniqueness, especially regarding issues related to training itineraries, life plan and definition of elective skills for learning paths.

In addition to the principles of universalization, democratization, personalization and individualization of teaching, together with the technology platforms and tools described above, they facilitate the identification of individual potential and needs, favoring the use of appropriate methodologies and the development of strategies that expand possibilities of success and the achievement of the learning objectives set out in the LDB, PNE and BNCC, they address the principle of equity in an incisive manner.

Equity refers to the sense of justice, impartiality, exemption and neutrality in relational spaces. In the educational sphere, equity implies recognizing the uniqueness and plurality of students in their learning and development processes.

Alongside the equal right to education is the right to difference in the learning process, inviting the guarantee of equal learning opportunities and the recognition of cultural, social and personal diversities that permeate the school universe (Lemos *et al*., 2022).

The use of the metaverse and social networks of school communities for educational purposes fosters student engagement, a sense of belonging, and motivation, necessary for the teaching and learning processes.

The use of OTT (Over the Top) platforms, similar to streaming networks such as Netflix or Prime Video, to broadcast educational content complementary to that provided by the BNCC, chosen by students to meet their personal interests, encourages the development and deepening of skills beyond what schools would normally be able to provide.

The development of educational content using cutting-edge technologies such as augmented reality, virtual reality, whether in the form of games or for the exhibition of materials in a playful and immersive way, takes the 19th century school to contemporary times, also favoring student and teacher engagement, motivation and interest.

It is important to highlight that all the technology resources mentioned above presuppose the presence of educators as mediators, who, using these different tools, identify weaknesses and promote the potential of students, actively fostering their integral development, in addition to mobilizing to ensure the quality of the teaching and learning process. In a way, the use of modern technologies for educational purposes, linked to the concept of *Edutainment,* will allow teachers to become influencers and YouTubers for their students. In this sense, the Unesco report (2022, p. xiv)[18] 'Reimagining our Futures Together' highlights that

> […] o ensino deve ser profissionalizado ainda mais como um esforço colaborativo, com os professores sendo reconhecidos por seu trabalho como produtores de conhecimento e figuras fundamentais na transformação educacional e social.

As a facilitating body for the adoption of technologies that depend on internet connectivity, the RNP (National Education and Research Network) began, in December 2022, the execution of the pilot project of the Internet Brasil Program, an initiative of the Ministry of Communications in partnership with the Ministry of Education for digital inclusion, which provides for the free distribution of mobile sim cards to public school students (RNP, 2022; 2023).

[18] Translation: "[…] teaching must be further professionalized as a collaborative effort, with teachers recognized for their work as producers of knowledge and as key figures in educational and social transformation" (Unesco, 2022, p. xiv, editorial translation).

In compliance with Law No. 14.351/2022 (Brazil, 2022), the distribution and maintenance program will provide its beneficiaries with 700 thousand sim cards, with a 20 GB data plan, renewed monthly and automatically. It is expected that by the end of 2025, all 22 million basic education students in public education networks will be served. This program will enable hybrid teaching, allowing any place to become a learning space.

5. RESULTS

Professional retraining presents itself as an ongoing long-term strategy for mitigating the potential risk of unemployment among the active workforce, resulting from ongoing automation processes. Faced with the enormous challenge of serving millions of workers in a short space of time, unless we see significant intervention and proactive efforts from various government bodies and the business community, it is likely that social inequality will be exacerbated in the near future.

For those entering the labor market, productive inclusion policies and actions become paramount, in which case the provision of quality Basic Education is of utmost importance, aligned with the contemporary needs, meeting the principles of universalization, democratization, personalization and individualization of teaching.

6. FINAL CONSIDERATIONS

Developing and improving human capabilities and skills through education and professional qualification are among the main drivers for well-being, individual economic success and the reduction of social inequalities. However, in addition to preparing for the labor market, education must contribute to the integral and multidimensional training of individuals, in their intellectual, cognitive, physical and emotional aspects.

REFERENCES

ALBUQUERQUE, Pedro Henrique Melo; SAAVEDRA, Cayan Atreio Portela Bárcena; MORAIS, Rafael Lima de; ALVES, Patrick Franco; YAOHAO, Peng. *Na era das máquinas, o emprego é de quem*? Estimação da probabilidade de automação de ocupações no Brasil. Rio de Janeiro: Instituto de Pesquisa Econômica Aplicada (IPEA), mar. 2019. ISSN 1415-4765. Available at: http://www.ipea.gov.br/portal/images/stories/PDFs/TDs/190329_td_2457.pdf. Access on: 11 dez. 2019.

BAINBRIDGE, Lisanne. *Ironies of Automation*. Automatica (Journal of IFAC), v. 19, n. 6, p. 775-779, Nov. 1983. DOI 10.1016/0005-1098/83. Available at: https://www.ise.ncsu.edu/wp-content/uploads/2017/02/Bainbridge_1983_Automatica.pdf?utm_source=forrester_pdf&utm_medium=web&utm_campaign=futureofwork&utm_content=link. Access on: 11 dez. 2019.

BRASIL. *Constituição da República Federativa do Brasil*. Brasília, DF: Senado Federal, 1988. Available at: http://www.planalto.gov.br/ccivil_03/constituicao/constituicaocompilado.htm. Access on: 31 maio 2023.

BRASIL. *Lei de diretrizes e bases da educação nacional – LDB*. Brasília, DF: Casa Civil da Presidência da República, 1996. Available at: http://www.planalto.gov.br/ccivil_03/Leis/L9394.htm. Access on: 31 maio 2023.

BRASIL. *Lei nº 14.351/2022*. Brasília, DF: Presidência da República, 2022. Available at: https://www.in.gov.br/en/web/dou/-/lei-n-14.351-de-25-de-maio-de-2022-403313208. Access on: 31 maio 2023.

FERNANDES, Gilberto Lourenço. Transformação digital e quarta revolução industrial: impactos sociais e econômicos. *Revista Lift Papers,* Brasília, v. 2, n. 2, p. 415-427, maio 2020. ISSN 2675-2859. Available at: https://www.liftlab.com.br/docs/lift_Red.pdf. Access on: 23 jan 2023.

FORRESTER. Forrester: The future of work is dynamic and adaptive. *Forrester Research*, Cambridge, Mass., June 2019. Available at: https://go.forrester.com/press-newsroom/future-of-work/. Access on: 11 dez. 2019.

LEE, Kai-Fu. *Inteligência artificial*. Rio de Janeiro: Globo Livros, 2019.

LEMOS, Claudia Farache; CASTRO, Janine Mattar; DUSI, Miriam Lúcia Masotti, PEREIRA, Sandra Maria Borba. *Princípios e Estratégias Educacionais*: bases teóricas. Brasília: iNuTech, 2022.

LIMA, Yuri de Oliveira; STRAUCH, Julia Celia Mercedes; ESTEVES, Maria Gilda Pimentel; SOUZA, Jano Moreira de; CHAVES, Miriam Barbuda Fernandes; GOMES, Daniel Takata. *O Futuro do Emprego no Brasil*: Estimando o Impacto da Automação. Rio de Janeiro: Laboratório do Futuro - UFRJ, 2019. Available at: http://labfuturo.cos.ufrj.br/wp-content/uploads/2019/08/O-impacto-da-automação-no-Brasil.pdf. Access on: 11 dez. 2019.

LUND, Susan; MADGAVKAR, Anu; MANYIKA, James; SMIT, Sven; ELLINGRUD, Kweilin; ROBINSON, Olivia. The future of work after covid-19. *McKinsey & Company*, Feb. 2021. [McKinsey Global Institute]. Available at: https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19. Access on: 27 jan. 2023.

LUND, Susan; MANYIKA, James. Five lessons from history on AI, automation, and employment. *McKinsey & Company*, Nov. 2017. McKinsey Global Institute. Available at: https://www.mckinsey.com/featured-insights/future-of-work/five-lessons-from-history-on-ai-automation-and-employment. Access on: 14 jan. 2019.

MANYIKA, James; CHUI, Michael; MIREMADI, Mehdi; BUGHIN, Jacques; GEORGE, Katy; WILLMOTT, Paul; DEWHURST, Martin. A future that works: automation, employment, and productivity. *McKinsey & Company*, Jan. 2017a. McKinsey Global Institute. Available at: https://www.mckinsey.com/~/media/mckinsey/featured%20insights/Digital%20Disruption/Harnessing%20automation%20for%20a%20future%20that%20works/MGI-A-future-that-works-Executive-summary.ashx. Access on: 07 jan. 2019.

MANYIKA, James; LUND, Susan; CHUI, Michael; BUGHIN, Jacques; WOETZEL, Jonathan; BATRA, Parul; KO, Ryan; SANGHVI, Saurabh. Jobs lost, jobs gained: workforce transitions in a time of automation. *McKinsey & Company*, Nov. 2017b. McKinsey Global Institute. Available at: https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages. Access on: 07 jan. 2019.

MANYIKA, James; LUND, Susan; CHUI, Michael; BUGHIN, Jacques; WOETZEL, Jonathan; BATRA, Parul; KO, Ryan; SANGHVI, Saurabh. O futuro do mercado de trabalho: impacto em empregos, habilidades e salários. *McKinsey & Company*, nov. 2017c. McKinsey Global Institute. Available at: https://www.mckinsey.com/featured-insights/future-of-work/jobs-lost-jobs-gained-what-the-future-of-work-will-mean-for-jobs-skills-and-wages/pt-br#part%201. Acesso em 07 jan. 2019.

MEC - Ministério da Educação. *Base nacional comum curricular*. [*S. l.*:*s. n.*], 600 p., 2018a. Available at: http://basenacionalcomum.mec.gov.br/images/BNCC_EI_EF_110518_versaofinal_site.pdf. Access on: 20 jan. 2023.

MEC - Ministério da Educação. *Novo ensino médio - perguntas e respostas*. [Brasília]: Educação do campo, 2018b. Available at: http://portal.mec.gov.br/publicacoes-para-professores/30000-uncategorised/40361-novo-ensino-medio-duvidas. Access on: 20 jan. 2023.

MEC - Ministério da Educação. *Plano nacional de educação – lei n° 13.005/2014*. [*S. l.*:*s. n.*], 2014. Available at: https://pne.mec.gov.br/18-planos-subnacionais-de-educacao/543-plano-nacional-de-educacao-lei-n-13-005-2014. Access on: 27 jan. 2023.

MEDEIROS, Maria Aparecida Silva de. Jogos, brincadeiras, gamificação e cultura maker no processo de educação e aprendizagem. *Brazilian Journal of Science*, Rio Verde, GO, v. 1, n. 1, p. 23-32, 2022. ISSN: 2764-3417.

MORIN, Edgar; CIURANA, Emilio-Roger; MOTTA, Raúl Domingo. *Educar na era planetária*: o pensamento complexo como meta de aprendizagem pelo erro e incerteza humana. Tradução de Sandra Trabucco Valezuela. Revisão técnica da tradução de Edgard de Assis Carvalho. São Paulo: Cortez Editora, 2003. ISBN: 85-249-0937-4.

OCDE. *Education at a Glance 2021*: OECD Indicators. Paris: OECD Publishing, Sept. 2021. DOI 10.1787/b35a14e5-en. Available at: https://www.oecd-ilibrary.org/education/education-at-a-glance-2021_b35a14e5-en. Access on: 31 maio 2023.

OCDE. *Education at a Glance 2022*: OECD Indicators. Paris: OECD Publishing, Dec. 2022. ISBN 978-92-64-58258-

3. Available at: https://www.oecd-ilibrary.org/deliver/3197152b-en.pdf?itemId=/content/publication/3197152b-en&mimeType=pdf. Access on: 27 jan. 2023.

OCDE. *PISA 2018 Results*: Combined Executive Summaries Volume I, II & III. [*S. l.*]: OCDE Publishing, 2019. Available at: www.oecd.org/pisa/Combined_Executive_Summaries_PISA_2018.pdf. Access on: 26 jan. 2023.

PIKETTY, Thomas. *O capital no século XXI*. Tradução de Monica Baumgarten de Bolle. Rio de Janeiro: Editora Intrínseca, 2013.

RATCLIFFE, Susan (ed.). *Oxford essential quotations*. 4. ed. Oxford Univesity Press, Oxford, 2016. DOI 10.1093/acref/9780191826719.001.0001. Available at: https://www.oxfordreference.com/view/10.1093/acref/9780191826719.001.0001/acref-9780191826719. Access on: 31 maio 2023.

RNP. Programa Internet Brasil. [*S. l.:s. n.*], 2022. Available at: https://www.rnp.br/projetos/internet-brasil. Access on: 31 maio 2023.

RNP. Termo de Referência: Conexão de internet para as escolas, chamada adc/ 11452/2022. Relatório Anual da Gai 2020, Gerência De Atendimento Integrado, [*S. l*], 2023. Available at: https://www.rnp.br/arquivos/documents/ADC%2011452_2022_TR_Chamada_2_ERRATA_v.2.pdf?0cEOxmjBJFDe8PH5LX4iT5d9aXCBxj2B=. Access on: 31 maio 2023.

SCHWAB, Klaus. The fourth industrial revolution: what it means, how to respond. [S. l.], *World Economic Forum*, Jan. 2016. Available at: https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/. Access on: 11 dez. 2019.

UNESCO. *Reimaginar nossos futuros juntos*: um novo contrato social para a educação. Brasília: Comissão Internacional sobre os Futuros da Educação, UNESCO; Boadilla del Monte: Fundación SM, 2022. 186 p. ISBN: 978-65-86603-23-1 (digital). Available at: https://unesdoc.unesco.org/ark:/48223/pf0000381115. Access on: 27 jan. 2023.