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DEIFDC framework: Evaluation of Digital Education deployment in Peru in the midst of the Covid-19 pandemic

Marco DEIFDC: Evaluación del despliegue de la Educación Digital en Perú en plena pandemia de Covid-19

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Abstract: Digital Education is a key factor to bring developing countries up to speed so they are able to compete under the new rules of the Digital Economy. The Covid-19 pandemic crisis has made more evident the need to implement a global educational strategy where all children can be prepared to learn in a digital environment independently of their country and birth condition. In this research, a Digital Education Index for Developing Countries (DEIFDC) has been defined and applied for the Peruvian case. The construction of the index is based on relevant variables organized in three levers to determine Peru's capacity to better prepare current primary school children to acquire the competences needed in a 21st century workforce. The results show good development on pedagogical capabilities and students' readiness but only adequate maturity on the development of schools' infrastructure. Peru's slow digital development, in comparison to other countries in the region, is distressing the availability of high-skilled labour, digital GDP growth and digital services productivity hence major efforts will need to be undertaken to guarantee Peruvians upgrade to a digital prepared society.

Keywords: Digital education, Developing countries, Digital economy, Digital index, Social impact.

Resumen: La Educación Digital es un factor clave para que los países en vías de desarrollo puedan competir bajo las nuevas reglas de la Economía Digital. La crisis de la pandemia Covid-19 ha hecho más evidente la necesidad de implementar una estrategia educativa global donde todos los niños puedan estar preparados para aprender en un entorno digital independientemente de su país y condición de nacimiento. En esta investigación se ha definido y aplicado un Índice de Educación Digital para Países en Desarrollo (DEIFDC) para el caso peruano. La construcción del índice se basa en variables relevantes organizadas en tres palancas para determinar la capacidad del Perú para preparar mejor a los actuales niños de primaria para adquirir las competencias necesarias en una fuerza laboral del siglo XXI. Los resultados muestran un buen desarrollo en las capacidades pedagógicas y la preparación de los estudiantes, pero sólo una madurez adecuada en el desarrollo de la infraestructura de las escuelas. El lento desarrollo digital de Perú, en comparación con otros países de la región, está poniendo en peligro la disponibilidad de mano de obra altamente cualificada, el crecimiento del PIB digital y la productividad de los servicios digitales, por lo que será necesario realizar grandes esfuerzos para garantizar que los peruanos se conviertan en una sociedad preparada para el mundo digital.

Palabras-Clave: Educación digital, Países en desarrollo, Economía digital, Índice digital, Impacto social.

1. Introduction

Education is a human right and one of the strongest instruments for development as it contributes to reduce poverty and improve health, equality and peace (United Nations, 1948). For individuals and societies, education promotes employment, poverty reduction, economic growth and social cohesion (World Bank, 2020).

The importance of Education has been reflected in the Agenda 2030 for Sustainable Development adopted by the United Nations General Assembly, where the specific development goal number 4 has been dedicated to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. Target 4.4, described as substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship, is directly related to Digital Education (United Nations General Assembly, 2015).

2020 was a year of profound changes at social, economic and educational levels due to the Covid-19 pandemic (Unesco, 2020). 1,5 billion children and youngsters were displaced out of school with diverse consequences in terms of their learning progress, nutrition support and subsequent enrolment continuity. Specifically, in Latin America and the Caribbean more than 165 million children have lost an average of 158 school days during 2020 hindering in-person instruction (Petri C. et al. 2021). In vulnerable environments, the current digital divide made evident that those with less technical resources were unable to keep up with their standard learning process (Unicef et al., 2020) and have lost at least one year of educational development.

However, as important as Digital Education has demonstrated to be during the pandemic crisis, it should not be considered as a backup instrument to respond in case of school closure but as a means to prepare children at early stages of education to acquire the competences that will be needed in a new Digital Economy (Riviello, R., 2020). In this sense, Digital Education prepares children for the Industry 4.0 revolution (Kask. M. et al., 2021) as well as it enhances their learning experience by introducing innovative, collaborative tools and new social experiences (Luckin et al., 2012); moreover, it prepares children for advanced STEM education, increasing the number of children who will develop a career in programming, data analysis, cybersecurity or cloud management.

In developing countries, Digital Education is even more relevant because it can improve the teaching and learning processes and introduce the basis necessary for producing a technologically proficient workforce that might transform in the next 10-15 years the composition of the labour market (Kalolo, J.F., 2018). In Latin America, the expansion of education has been very significant in recent decades, but the degree of inequality remains relevant, as the creation of human capital is still dependent on the socio-economic origin of the families and education is not contributing as an equaliser factor, especially in Peru where the GDP growth has been very relevant in the last twenty years (Figueroa, A., 2008). Additionally, in the scenery of developing countries, globally, it has been calculated that there is a 9% increase in hourly earnings for one extra year of schooling (Psacharopoulos, G. et al., 2018).

The recent pandemic crisis had shown that only those with jobs adopted to the current digital economy could introduce massively home working; in Latin America, lower-income economies have a lower share of jobs that can be done at home (Dingel, J. I. et al., 2020). Also, at a micro-level, workers from developing regions and lower wages had a more challenging time continuing to work during the pandemic, increasing overall economic vulnerability and worsening inequality in lower-income households (López-Calva, L.F., 2020).

In a new Digital Economy, developing countries must aim to become not only countries of manufacturing outsourcing but also move into high skilled services with customer call centres, data entry facilities and higher-skilled professional jobs ranging from engineering to artificial intelligence (Lieberman, J. I., 2004). It is therefore relevant for developing economies, not only to ensure economic growth but also to build a more resilient and inclusive economy, focusing on how Digital Education is preparing future adults of the next generation to acquire the required Digital Competences to enter the labour market prepared with sufficient ICT skills.

More developed economies are focusing on the learning process at schools and on lifelong learning opportunities at university or on how to upscale the current workforce (Beblavý et al., 2019). At the same time, systematic research has been developed in order to provide trend analysis and country comparisons of their digital performance (Foley et al., 2018).

However, there is lack of information on the overall deployment and evolution of Digital Education in developing countries and this research tries to contribute to close this knowledge gap. Inspired by the mentioned studies and to determine the state of readiness of a particular country in terms of Digital Education acquisition at early stages of schooling, a Digital Education Index for Developing Countries (DEIFDC) has been defined. For this characterization, three specific levers relevant at low levels of education have been considered, mainly for primary schools where the impact has demonstrated to be higher (Heckman, 2007).

The selection and weighting of levers and variables have been carried out based on the detailed overview of supporting literature, mainly professional journals, expert think-pieces, case studies, interviews, systematic reviews, comparative studies and policy statements.

In order to apply the DEIFDC to the specific Peru case, detailed research of the education system has been conducted, as well as a revision of the different policies and programs that have been undertaken on Digital Education in Peru in the past 20 years that are directly impacting the variables that compose the index. In this sense, the DEIFDC will assess the current deployment of Digital Education in the midst of the Covid-19 pandemic, but it will not measure the social, political or cultural implications that might be affecting the index construction.

2. Methodology

2.1. Relevance of Digital Education

In the context of a new Digital Era, Digital Education is considered as a key factor to link schooling and the future of a Digital Society. Investments in education are critical for developing the human capital that will end extreme poverty (United Nations Development Program, 2019) and priority should be given to the lower levels of education in countries that have not yet achieved universal primary education (Psacharopoulos, G. et al., 2018). Although there are several definitions for Digital Education that can be applied depending on the stage and purpose of education, i.e., early childhood, K-12, professional, university and life-long learning, for the purpose of this research, Digital Education has been defined as the process of teaching and learning in schools that is facilitated by Digital Technologies.

Digital Technologies have been progressively introduced in most Education systems, even if traditional textbooks and chalk and board were also used. Nowadays, and due to the workarounds originated due to the school closures during the pandemic, many education world leaders agree that technology is no longer a supplementary tool and that it should be fully integrated into all Education Systems (Gianini, S., 2020).

Digital Education is striking as it prepares children to acquire the digital competencies needed in a 21st century workforce like digital literacy and computational thinking (World Economic Forum, 2020). Nevertheless, these skills cannot be considered isolated, and it is necessary to use a holistic approach in which the new ways of teaching and learning will also help children to acquire a series of soft skills that have been described in several frameworks, such as the four C's (Ruhl, J., 2015): critical thinking, creativity, communication and collaboration, the ABCs, adapt, be resilient and communicate (Wilson-Body, P. 2020) or the four Pillars of Education: learn to know, learn to do, learn to live and learn to be (Unesco, 2015). Recent studies (Ganimian, A.J. et al., 2020) suggest four different ways to realise the potential of education technology to accelerate student learning and focus on potential uses of technology that play to its comparative advantages: scaling up quality instruction, facilitating differentiated instruction, expanding opportunities to practice and increasing learner engagement through videos and games.

For the purpose of this research and focusing on primary schools, Digital Education has been approached into two different areas depending on their potential use, individual and collective education technologies as they will help the children to develop the required 21st-century competences. Individual learning tools are mainly based on the usage of educational resources on computers, tablets or mobile phones to speed up the learning process by giving each student access to different content available from the Internet or previously downloaded and made available offline. This way of working is differential for three reasons:

a) Knowledge boundaries: It extends the boundaries of knowledge of the traditional textbooks, especially if the children are able to connect to the internet and explore further than what it is written in the books just with a device, this process can be thought to be similar to have access to an infinite

library where thousands of books are available, and children are capable of conducting their own research (Mitra, S., 2014).

b) Adaptive learning: It introduces the concept of learning personalization and the ability of the educational resources to adapt to the current capacities and abilities depending on the student level, its achievements and misconceptions (Luckin, R. et al., 2016).

c) Evaluation and assessment: It facilitates evaluation and assessment as different types of tests and questionnaires can be applied to verify students' levels at different stages of the learning process, at the same time as it simplifies the individual certification or warranty of proficiency in certain subjects or matters than can be used to access higher education or specialized jobs (Beblavý et al., 2019).

The collective learning digital tools bring a new way of working soft skills that allow teachers to introduce complementary forms of interaction among students. It changes the way of interaction in a classroom from a teacher-centred approach to a student-centred approach (Ruhl, J., 2018). These tools can be interactive white-boards (IWB) (Lopez, O.S., 2010) or projectors, but also more advanced systems such as Virtual Learning Environments (VLE) or Learning Management Systems (LMS) deployed either locally or connected to the Internet (Light, D., 2016):

- Teamwork and collaboration: The students can be grouped in smaller clusters to develop different subjects, research together or complete tasks that involved thinking out of the ordinary (Scheuer, O. et al., 2010).

- Peer evaluation: The software deployed in tablets or computers allows the students to assess their peers' work and help them create a collaborative environment where everyone learns from both producing and revising the work of others.

- Gamification: It helps to motivate the students with the creation of avatars and game-related content that can be used to deeply study a specific matter; the children will get higher scores depending on how they dominate the subjects (Freitas, S., 2011).

2.2. Research model

The Digital Education Index for Developing Countries (DEIFDC) is a geometric mean of nine different variables that have been grouped into levers and assigned a different weight based on the implications to deploy Digital Education in primary schools of Developing Countries. The index composition is based on the most relevant categories considered to assess Digital Education readiness: Students' Readiness, IT Infrastructure Development and Pedagogical Capabilities. The literature reviewed suggests that each of these levers provide relevant insight into a particular aspect of Digital Education. The justification of each lever and its corresponding variables and assigned weights will be described in the following subsections.

Students' readiness

One of the main challenges to apply Digital Education in developing countries is that enrolment (weight: 30%) in certain areas is still a challenge; without school attendance and continuous guidance, the benefits of introducing 21st-century skills in primary schools can be reduced. It is also indispensable that children stay in primary school and keep on studying until last grade (weight: 30%), this is beneficial in terms of individuals but also in terms of society as additional years of schooling have proved to be central for employment, poverty reduction, economic growth and social cohesion.

At the same time, evidence on the importance of early environments on a spectrum of health, labour market, and behavioural outcomes suggests that focus must be put at early education stages (Heckman, 2007) rather than on secondary or lifelong learning opportunities.

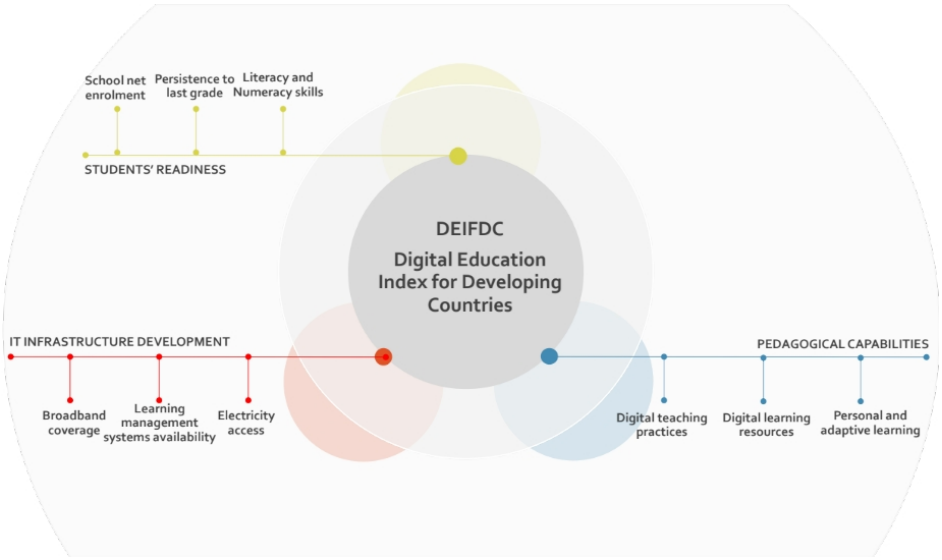

Figure 1. Digital Education Index for Developing Countries Schema. Source: Authors' elaboration.

Among the benefits of introducing Digital Education at an early stage is the reduction of learning poverty (World Bank, 2019) that is mainly measured by the students' capacity to read and write and solve mathematics problems related to daily life (40%). Although several countries have been measuring education's impact, the most extended analysis is based on PISA, the Program for International Student Assessment, developed by the OECD to measure 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges (Ministerio de Educación de la República del Perú, 2021).

Early Digital Education brings, as a result, the interest of students in pursuing advanced STEM education, the new professions of the future (World Economic Forum, 2020) require the professional labour to adapt to reality in the new Digital Era. This means that children in primary schools must acquire the basics to be ready to pursue this specific knowledge but not that every student must be a data analyst or an engineer.

IT Infrastructure Development

The adequate deployment of infrastructure is critical to ensure that children can receive the initial instruction required in developing countries schools, as family support that is usually the first step of Digital Education introduction in developed countries, cannot be ensured. Electricity access (weight: 40%) has been given the most relevant load as it is crucial that the ICT equipment (computers, tablets, routers or projectors) is appropriately charged. When no standard electricity access is possible due to geographic or economic conditions, there are other ways to ensure batteries can last during the school day, and several deployments have been proved successful such as solar panels or solar chargers for specific equipment; however, normally, their capacity is conditioned to weather circumstances and the quality of the equipment provided. Other renewable energy technologies like wind turbines, small-scale hydroelectric projects and other forms of self-sufficient energy can provide rural communities in the developing world with the electricity they need to power schools (Solar Energy International, 2018). Even if educational resources can be made available and previously uploaded, internet access (weight: 30%) ensures that broad knowledge and content can be used in the classrooms (International Telecommunication Union, 2013). This is particularly relevant in contexts where advanced individual or collective learning tools are being introduced, such as adaptive learning and gamification (Internet Society, 2017).

Although it seems Digital Education deployments should start with the delivery of a laptop or tablet to children in school for individual use, the standard approach that has been carried out in more advanced Education Systems is through the usage of Interactive White Boards, Learning Management Systems and projectors in the classroom (weight: 30%). This introduction allows the Primary Education teachers to expose content and familiarise the children with Digital Education. Particularly, educators can use IWBs to empower students with 21st-century skills and create exciting new learning opportunities for promoting STEM education, problem-solving, critical thinking, and collaboration skills among their students (Yinghui, S., 2012).

Pedagogical Capabilities

Within this section, the variable with the greatest importance is the training of teachers (weight: 40%), as it is considered critical to the success of introducing Digital Education in the schools (Panagiotis, K. et al., 2015). In this sense, it is not only necessary to teach them how to use the new ICT tools but also to provide pedagogical support and continuous professional development to ensure they can apply innovative methodologies in the school and work on the competencies that Digital Education facilitates as it has been proposed by several frameworks.

The second variable in terms of importance is the availability of adequate content (weight: 35%). Advanced digital content has traditionally been exploited by EdTech companies that made the content available through web access, applications and different types of licences. However, new regulations on Open Educational Resources (Unesco, 2019) have made plenty of digital content available, especially after the Covid-19 crisis and to students and teachers with an internet connection. Although this is a progression that can make a difference in developing countries, it is necessary to adapt it to each environment's specific curricula (Trucano M., 2010), local languages,

contexts without an internet connection or specific devices different from laptops like mobile phones.

Electronic devices' penetration per student (weight: 25%) has been considered of less relative relevance as it has been proven that deployment of ICT labs and equipment sharing is also a good practice to introduce Digital Education in the education process.

However, it is essential to ensure unique login to identify students' sessions and relevant to apply some of the advantages that Digital Education provides in terms of personalisation (Luckin, R., 2016), gaming, evaluation and certification.

Procedure

The equations defined to calculate the DEIFDC are as follows, where each variable will be given a 0-1 scale:

$$L_1 = 0.3V_{1.1} + 0.3V_{1.2} + 0.4V_{1.3}$$

$$L_2 = 0.4V_{2.1} + 0.3V_{2.2} + 0.3V_{2.3}$$

$$L_3 = 0.4V_{3.1} + 0.35V_{3.2} + 0.25V_{3.3}$$

This will result in an index calculated on the geometric mean of the three different levers previously constructed:

$$\text{DEIFDC} = \sqrt[3]{L_1 . L_2 . L_3}$$

Depending on the Index result, the different countries understudy will be grouped according to one of the following categories (Table 1).

Table 1. DEIFDC Weight variables. Source: Author's elaboration.

Lever/variable	Assigned weight
Students' Readiness (L_1)	
School net enrolment	30%
Persistence to last grade	30%
Literacy and Numeracy skills	40%
IT Infrastructure Deployment (L_2)	
Electricity access	40%
Broadband coverage	30%
LMS availability	30%
Pedagogical Capabilities (L_3)	
Digitally teaching practices	40%
Digital learning resources	35%
Personal and adaptive learning	25%

Table 2. DEIFDC and Levers Distribution. Source: Author's elaboration.

A. Excellent	0.9-1
B. Good	0.8-0.9
C. Adequate	0.6-0.8
D. Insufficient	0-0.6

2.3. Research context

Peru is located in South America, bordering Bolivia, Chile, Ecuador, Colombia, Brasil and the South Pacific Ocean. It has a vast diversity, both cultural and geographical, that are

often linked, drawing significant national differences between the coastal areas, the Amazonian regions and the Andean mountains. Although Spanish is the most common official language, there are other 47 indigenous languages, mainly Quechua and Aymara, that conform an important diversity in terms of cultural differences (Ministerio de Educación de la República del Perú, 2013).

Peru's economy has been one of the most prominent performers in Latin America in the last 25 years averaging 5.3 per cent growth since 2001, besides, its economy is one of the largest in Latin America and the Caribbean. However, there are great differences between the coastline regions and the Andean and Amazonian ones; for example, the Lima area accounts for one-third of Peru's population and one half of its GDP (World Bank Group, 2017).

Peru ranks 82 in the Human Development Index with an IDH of 0,759 considered within the high group of Human Development (UNDP, 2019). However, the indicators of Peru in social and infrastructure metrics show that Peru is lagging behind its structural peers in almost all indicators such as electricity, sanitation, water, access to mobile phones and internet users, paved roads, stunting, secondary school degrees, social insurance and pensions (World Bank Group, 2017). This particularly affects 7.6 million indigenous people, around a quarter of Peru's 32 million population, where the higher poverty ratios are found. The higher poverty incidence among indigenous people is often driven by the fact that they live in rural areas rather than by their ethnicity (World Bank Group, 2017).

The main economic sectors in Peru are services, construction and mining. It is a wealthy country in terms of natural resources such as gold, silver and copper that drive substantial foreign investments; however, according to the World Bank, the lack of investments in innovation and more productive digital technologies is constraining growth: low productivity, slow technology adoption, lack of export diversification that are all closely related, describing an equilibrium of weak labour demand for productive, well-paid jobs. In this aspect, the impact of Digital Education will be profoundly analysed at early stages of schooling and the conformation of a digital high productive and high waged labour.

The key areas prioritised for action to ensure sustainable development are closely interrelated with the raising of human capital (World Bank, 2017) and also involve the improvement of connecting infrastructure and public services, government coordination, law enforcement and reduction of environmental risks, among others.

According to the INEI, in 2018 there were 567,347 teachers, 113,069 schools and 8,815,800 students in the Peruvian Education System organized following the procedures of the General Education Law (Ministerio de Educación de la República del Perú, 2003). The education system has been structured in stages, levels, modalities, cycles and programs, these terms will be explicitly referred within the Peruvian context:

- The stages are the progressive periods in which the educational system is structured according to each student's learning needs.

- The levels are the periods within the educational stages.

– The modalities are educational alternatives organised according to the specific characteristics of students

– The cycles are developed based on learning achievements.

– The programs are sets of educational actions developed to meet specific demands

As we can see in figure 2, the Peruvian Educational System comprises the following two stages: (a) Basic Education, as a means to acquire fundamental competencies, promote the students' integral development and the development of capacities, knowledge, attitudes, and values to act and live in society adequately. It also attends from an inclusive point of view, children and adults with special educational needs or learning difficulties. (b) Higher Education, which is focused on specialisation and the acquisition of specific competences like high-level professional skills in accordance with the la-bour skills demanded by society.

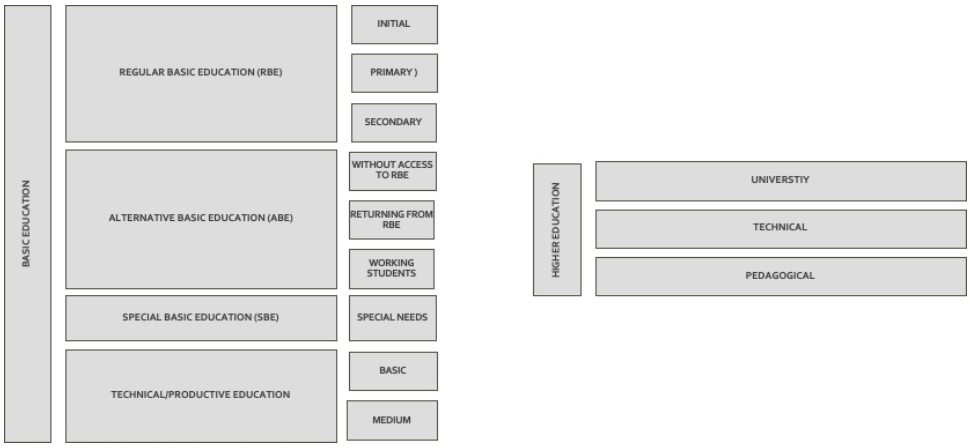

Figure 2. Peruvian Education System. Source: Author's elaboration with data from the General Education Law (Ministerio de Educación de la República del Perú, 2003).

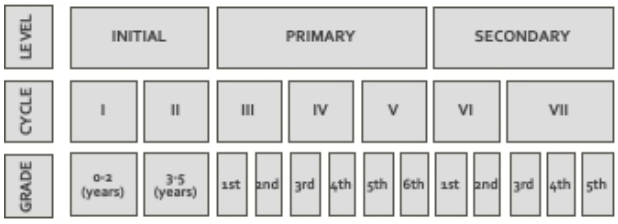

Figure 3. Basic Regular Education. Source: Author's elaboration with data from the Basic Education Curriculum (2016)

As we can see in figure 3, Regular Basic Education is divided into seven cycles that correspond to the central and more extended educational modality in Peru. It takes care of children and adolescents that adequately go through the educational process according to their physical and cognitive evolution.

For this study's purpose, only the schools within the Regular Basic Education have been considered leaving potential further research for the deployment of Digital Education in Alternative Basic Education, Special Basic Education, Technical Education and Higher Education. Additionally, special attention has been paid to the cycles that belong to primary education bearing in mind the importance of the last year of initial education compulsory in Peru to the first cycle of secondary education where the main competences acquired during Primary years are evaluated.

It is worth pointing out that the general education law considers as the main objectives of Basic Education not only the learning processes in the traditional fields of science, humanities, culture, art, physical education and sports, but also those that will allow the students to make good use and enjoyment of new technologies.

The Basic Education Curriculum (Ministerio de Education de la República del Perú, 2016) defines 29 general competences that children must have achieved by the end of the 6th grade. Specially dedicated to Digital Education are:

- Competence 22: Design and build technological solutions to solve problems, justifying the scope of the technological problem and its alternative solutions based on scientific knowledge.

- Competence 28: Proved capabilities in virtual ICT environments; it contemplates the creation of digital materials such as videos, presentations, designs, documents and the proficient usage of applications, the internet and social networks to integrate all its acquired knowledge.

The Peruvian government has progressively introduced ICT at different stages of education since 1996. Even if the first programs were deployed at a shallow scale, there has indeed been relevant knowledge acquired during the last 25 years, and that has positioned Peru as one of the countries with better digital response during the Covid-19 pandemic (Unesco, 2020). The main programs ordered by initiation date are:

1) Infoescuela (1996-2001): Teachers were trained in the Logo programming language and to use LEGO kits. The program was evaluated by MIT (Linares, J., 2016) and supported by Seymour Papert himself (Papert, 1993). Its deployment was remarkably reduced, and in 2001 there were only 360 active schools (Marcone, 2010).

2) Edured (1996-2001): It aimed to provide schools with an internet connection to improve the quality of learning and modernise high schools (Salas-Pilco et al., 2014). In 2001, there were 345 high schools implemented with internet access, but only 74 of them had the project in operation (Marcone, 2010).

3) Huascaran Project (2001-2007): This project tried to introduce ICT in Peruvian schools at a large scale compared to the previous projects that could be considered more like pilots. It developed a whole program that included not only the computer lab equipment and the internet access in the schools but also the training of teachers and the appointment of an ICT teacher

specialist per school (Marcone, 2004). In 2001 there were 3,000 schools equipped, but most of them were urban schools as the rural schools required antennae to provide an internet connection.

4) One Laptop per Child (2007-2011): The OLPC implementation is one of the most well-known deployments of the program in the world and has been largely analysed. More than 800.000 XO laptops (Rivoir, A., 2016) were either handed over to students in rural areas or as a part of a Digital Lab in a second phase due to budget restrictions. The program had a formal evaluation using randomised control from the InterAmerican Development Bank, and it was found that even though there was no improvement noticed in literacy and numeracy competences, children and their families had a positive perception of the program and increased competence in the usage of ICT tools (Santiago A. et al., 2010). Also, it was found that it had impact on cognitive skills, although much effort had to be dedicated to teacher's qualification (Cristiá, J. P. et al., 2012)

5) PeruEduca (2011-now): This project tries to create a community for teachers where they can access online MOOC training and certification and digital resources to use in their classrooms. It also allows them to publish in blogs and forums and create specialised groups.

6) Aprendo en Casa (2020-now): In 2020, during the Covid-19 crisis, all schools were closed for the whole school year, but there were several initiatives based on digital capabilities already installed that ensured that up to 93% of the students could follow on with their learning (Semáforo Escuela, 2002). The project is aimed at Basic Education (Ministerio de Educación de la República del Perú, 2020), and it is very innovative as it is not only based on access to the internet but also broadcasted by television and radio. In the short term, it has been used during the pandemic crisis, but in the long term, it will try to reduce the educative gap between urban and rural zones in Peru.

7) Tablet distribution and virtual/presential hybrid approach (2020-2023): The plans of the current government in order to keep on responding to the pandemic crisis in Peru consist of ensuring quality infrastructure in schools, provide access to digital tools, distribute more than 1 million tablets (Ministerio de Educación de la República del Perú, 2020) and increase internet coverage in rural regions. There will be three ways to provide lectures, and it would be possible to combine virtual and presential lessons in schools and a complete virtual education model depending on the necessity and region. With an increase of 2.83% in the public budget allocated to Education (Ministerio de Economía y Finanzas de la República del Perú, 2020), it will be possible to prioritize essential literacy and numeracy, emotional aspects and digital competences (Fundación Santillana, 2020). The tablets acquired count with more than 35 applications and 3,000 educational resources that will be used by children in the last cycle of Primary Education and Secondary Education of rural areas and will be delivered to 90,000 teachers (Ministerio de Educación de la República del Perú, 2020). In a zone with internet coverage, the tablet will have a data chip to provide internet access for both children and teachers, and if there is no internet coverage, the content will be uploaded previously in the tablet so it can be available offline. Also, a solar

charger will be provided to be used in those areas with no access to current electricity. It has also been considered of great importance that the teachers in the program count with specific training on digital literacy and competences with preuploaded training resources in the tablets (Ministerio de Economía y Finanzas de la República del Perú, 2020).

Peru has been having an outstanding performance in terms of GDP growth, the best of the region during the last two decades (World Bank Group, 2017). This growth helped reduce poverty for each percentage point increase in GDP growth and poverty fell by 1.4 percentage points. Thus, from 2004 until 2015, 9.3 million Peruvians escaped poverty, moderate poverty fell by more than half, from 58 to 22 per cent, and extreme poverty fell from 16 to 4 per cent. In Peru's case, GDP growth has been based on natural resources and has attracted foreign investments in mining and enabled growth based on fast capital accumulation, although with few gains in productivity and negligible export diversification (World Bank Group, 2017). This GDP growth is based on the measurement of the monetary value of all final goods produced in an economy (Brynjolfsson, E. et al., 2019), but it does not include digital offerings as free digital goods are consumed at no cost, which is relevant as it increases the gap related to the Digital Economy that has not been taken into account.

Overall, Peru has a very slow digital development and ranks below its regional peers on digitisation (BBVA, 2017; Sethi, A. et al., 2020), largely because it falls short in infrastructure as it has low internet usage compared to other Latin American countries in terms of private and public sectors and personal use. Only 45% of Peruvians use the internet, but in urban areas, the rate is 54%, whereas, in rural areas, it is only 14%. Geographically, there is also a significant difference: over 63% of the population in Lima's province use the internet, whereas, in Cajamarca, Huancavelica and Amazonas, this rate is around 20%. Young people and those with a medium-to-high education level use the internet most, having a considerable impact on qualified job opportunities and participation in the digital economy. The internet is mainly used for communicating, obtaining information, and entertainment, but the usage for interaction with the public sector, electronic banking, buy or sell product and services or training is residual. The evolution has been very positive with recent analysis in 2019 situating on 57,1% the percentage of the Peruvian population that uses the internet, an increase of 10 points in only two years (Instituto Nacional de Estadística e Informática, 2019).

76% of private companies use the internet, nevertheless, only around one-third of them have all their employees using it due to the internet connection speed. Companies in Peru are too slow in the adoption of new technologies. Only 7 per cent of firms have licensed technology from abroad, compared to 14 per cent in the Latin-American region as a whole. They also lag in the adoption of new digital technologies; for instance, less than 20 per cent of formal sector retail firms sell their products online, despite the significant opportunities to enhance their scale and productivity through online trade. This is among the lowest online shares for retail firms in Latin America as in Mexico, Colombia, and Chile, between 50 to 80 per cent of all sector retailers offer online sales (World Bank Group, 2017). There has been progress in government digitisation in Peru over recent years thanks to the effort of the SeGDi (Secretaría de Gobierno Digital) that is in charge of developing internet policies, national plans, standards, guidelines and strategies in e-government and IT matters. However,

although it has developed several applications and web services, the government's online services and their perceived benefits still lag its peers in Latin America.

3. Results

3.1. Data Analysis

The existing data suitable for constructing the DEIFDC was obtained from reputable available national and international sources through desk research. Data sources include global databases like the UIS Unesco Database and the World Development Indicators from the World Bank, as well as local Peruvian sources like Semáforo Escuela and standard PISA (Programme for International Student Assessment evaluations) results of 2018. The use of international databases will be useful to build a base for comparison among other developing countries where the DEIFDC will be applied. However, we still encounter other limitations like the availability of annual data to determine future evolution and the monitorisation of SDG 4 targets at a sufficient disaggregation level that will allow deep dive into a particular social (gender, castes, disabled) or geographic (rural/ urban, coastal/mountain) group.

3.2. DEIFDC Scores

The analysis and application of the DEIFDC came with relevant insights on the development of Digital Education in Peru. Overall, with a result of 0,711 is situated within the countries with Good Digital Education deployment. In terms of Students' Readiness (figure 4), the Peruvian context has considerable room for improvement. Even if net enrolment and persistence to the last grade of primary schools are reaching levels of high-income countries, 96.91% and 93.09%, respectively, the PISA evaluation levels are still deficient (42.46%), almost matching the levels of learning poverty, especially in mathematics (39.66%). This factor is very relevant because it demonstrates that even if all efforts are made in a good direction, the instruments that are put in place also need to focus on the basic literacy and mathematics competencies.

This lack of basic competences then translates into a subsequent variable resulting in only 31.70% of students applying on STEM superior education that will lead to scarce fulfilment of digital job positions. This lever brings an important point related to Digital Education and the fact that the introduction of ICT in the education systems does not help improve the learning process's efficiency, and it only aims to acquire complementary competences like research, organisation, problem-solving, collaboration, teamwork and project development (Marcone S., 2010).

Further research will need to determine the current effects of Digital Education on future evaluations of basic competences, so far increased levels of school attendance, decrease in dropout rates, students and teachers producing and sharing information, improvements in educational management and teachers' training have been demonstrated but impacts behind in the improvement of reading, writing and math skills are yet to be analysed (Cardim, J. et al., 2021).

As we can see in figure 5, in terms of infrastructure, the Peruvian government has made plenty of effort to ensure schools count with electricity by standard means or with other renewable energy sources reaching almost 79.93% of the schools. However,

only 40.77% of schools had an internet connection, making it challenging to introduce online learning individual and collective tools. Even though there is no data available on the deployment of LMS, IWB or projectors in schools, during 2020, at least 66.9% of teachers were using Aprendo en Casa, which is a very high penetration and demonstrates an outstanding response throughout the school closure originated during the school year. With a total of 0,634 the School Infrastructure Development is adequate, however, additional effort needs to be made in terms of inter-net connection and usage of LMS, IWB and projectors to ensure the basic infrastructure is deployed both in rural and urban environments.

As we can see in figure 6, the pedagogical capabilities lever represents the highest score of the three levers that compose the DEIFDC. Teachers in Peru are receiving Digital Education instruction both in their initial capacitation programs and as part of their lifelong learning to enrich their curricula. In this sense, the PeruEduca portal is a centrepiece to ensure the acquisition of these abilities.

The availability of digital learning resources has also boosted during the pandemic crisis when it was necessary to reach children in their homes; in this sense, it is essential to consider that most of these resources are online and mainly in Spanish, leaving behind those rural areas where the mother tongue is an indigenous language, and the internet connection is not a reality. In terms of penetration, the last data available from the UIS database regarding the number of schools with access to computers for pedagogical purposes was 78.31%, almost 80%. However, this data does not consider the latest distribution of tablets started by the Peruvian government (Ministerio de Educación de la República del Perú, 2020).

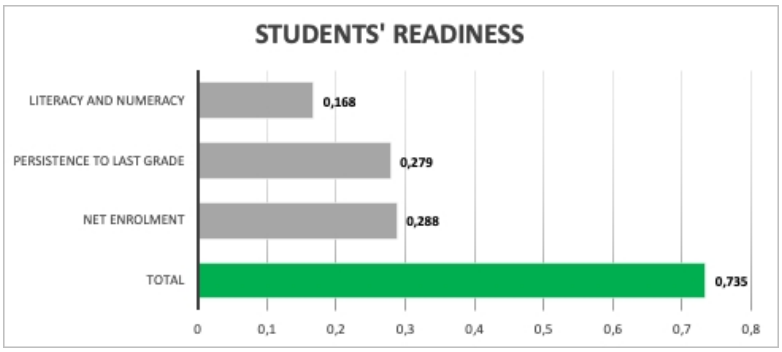

Figure 4. Students' Readiness. Source: Authors' elaboration with data from World Development Indicators (World Bank) and PISA 2018.

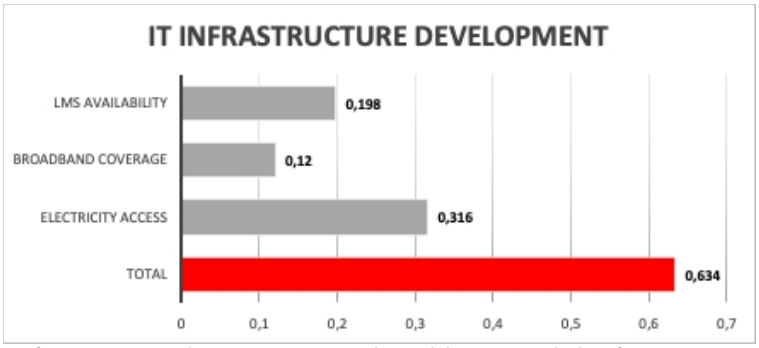

Figure 5. IT Infrastructure Development. Source: Authors' elaboration with data from UIS Unesco Database and Semáforo Escuela.

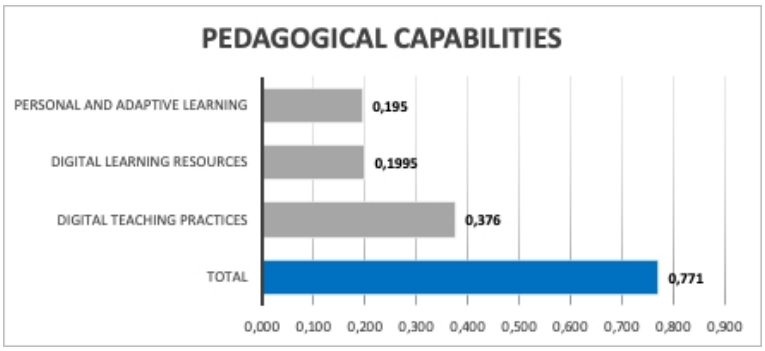

Figure 6. Pedagogical Capabilities. Source: Authors' elaboration with data from UIS Unesco Database and Semáforo Escuela

4. Conclusion

Success in the Digital Age requires Digital Skills (Internet Society, 2017). As primary school children will enter the labour market in ten years' time, they will need to have acquired the basic competences of Digital Literacy: use of computers and digital equipment, ability to use online applications, find and qualify online information and make use of it in daily life. Building these skills is crucial for developing countries and should be included in the curricula and assessed in the same manner as other basic competences like reading, writing and mathematics.

In Peru, the composition of the labour market needs to upgrade to be able to respond to the demands of the new digital economy. The existing digital divide and the lack of infrastructure, especially in terms of internet connection in rural areas, is causing that developing countries lag behind in digital dividends. This situation makes them incapable of benefiting from the broader development benefits of using digital technologies (World Bank, 2016) that go beyond the traditional sectors that have been responsible for GDP growth in the last twenty years.

Several programs have tried to integrate Digital Education into the learning process by introducing different components in a linked way at different stages of education, and digital competences have been included as part of the Peruvian

national curriculum. However, still plenty of effort needs to be put in place in terms of education policies to ensure all variables affecting the three different levers of the DEIFDC work in a coordinated manner.

In the application of the DEIFDC for the Peruvian case, the results show good results on Pedagogical Capabilities and Students' Readiness but only adequate IT Infrastructure Development. The Covid-19 response has been a major boost in terms of upgrading the usage of digital educational resources and digitally train the teachers in order to be able to keep up with the lessons during the school closure. However, important differences are still very relevant in terms of rural and geographical development, which greatly affect indigenous people, due to some factors such as their mother tongue but also due to the locations where their homes are based, normally rural, rather than by their ethnicity.

The current data available from several studies that follow up the state of digital readiness of the labour market in Peru show that currently, the country has tremendous room for improvement in terms of digitalisation of the personal, enterprise and government processes. As a result, the GDP growth will flatly grow during the following years if no adequate digital development takes place.

Proposed further research will need to explore both the evolution of DEIFDC at different periods of time, its disaggregation based on gender (male-female), social origin (indigenous children, disability status and conflict-affected) or detailed geographic distribution (rural-urban, coastal-Andean-Amazonian), its possible application in higher education (secondary, technical and university) and its impact on the country's composition of the digital workforce, GDP growth, overseas attractiveness and index of digitalisation, as well as the comparison with other countries of similar economic development.

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