# Digitalization in European schools

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December 2025

# 1 Introduction

# 2 Current State of Digitalization in European Schools

The European Union produced in 2019 a very complete description of the technology available and used in schools [2]. It divides schools in 3 levels: primary school, middle school and high school.

## 2.1 Hardware

There are in average 18 students per provided computer in primary schools, 7 for middle and high schools. However, the standard deviation is huge and highly depends on the country, as shown in the figure below.

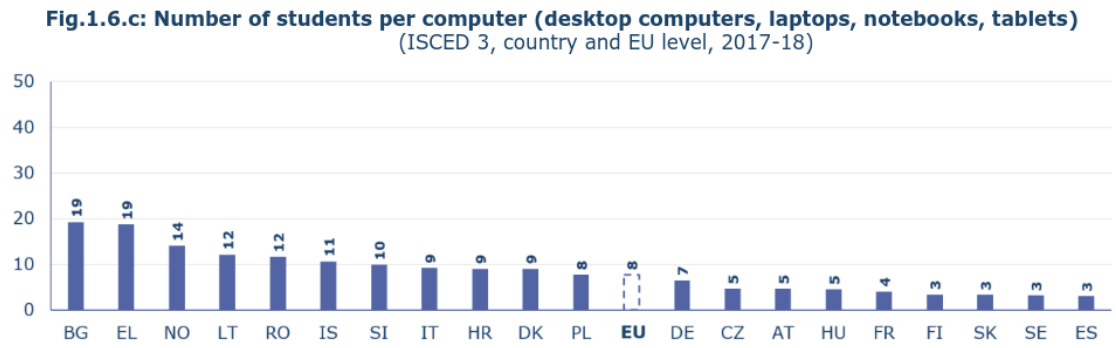



Figure 1: Caption

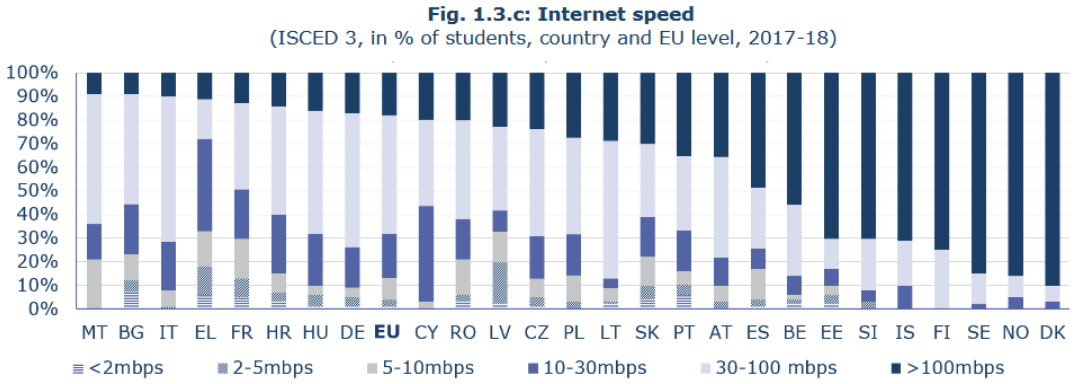
Teachers considered in 2019 that the number of computers and tablets represented an obstacle for proper teaching in ICT. It is interesting to note that they also considered allotted time and teacher's competences obstacles of identical importance.

### 2.1.1 Repairability

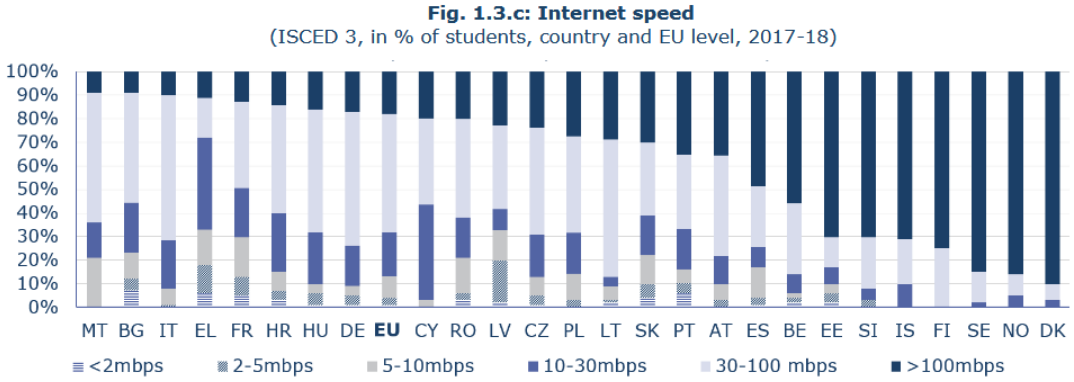
A very interesting finding is that a lot of hardware is broken in schools. In fact, a bit more than one third of students attend schools with less than 90% of functional equipment. This means that we can significantly improve the state of digitalization in schools, without having to buy new hardware with its social and environmental footprints.

## 2.2 Connectivity and Online tools

There are huge inequalities of connectivity among schools of EU countries. Indeed, on average, less than 1 out of 5 of European students has access to high speed Internet (>100 mbps).




However, 65% of ISCED3 students have acces to a Virutual Learning Environment (VLE) which consists of having an e-mail address, having access to online ressources and attending courses that feature digital devices.




## 2.3 Limitations

Limitations are perceived both by teachers and students but teachers seem more likely to feel it. They express 3 types of limitations :

1. Equipment-related : Lack of equipment, usable equipment, poor connectivity, out of date equipment.

2. Pedagogy-related : Insufficient online content, difficulty of integration in the curriculum, lack of pedagogical support for teachers.

3. Attitude-related : Resistance of parents; resistance of teachers; lack of interest of teachers; no or unclear benefit to use ICT for teaching.

# 3 Impact of introducing computers and Internet of Things (IoT) in class

In this section, we will focus on establishing wether introducing computers in class and at home, as well as Internet of Things, AI and Digital Classroom improves the quality of learning and reduces inequalities for students.

## 3.1 Introducing computers and digital technologies

In class, the computers are mostly used for text and photo editing as well as Internet searches. The students are getting acquainted with the use of ICT but it does not help much for leaning in the other subjects. About 10% of students also regularly use learning apps for other subjects. [2]

An OECD study from 2015 [17] found that the simple provision of ICT equipment is not sufficient, but that ICT is only linked to better student performance when, amongst others, computer software and Internet connections help to increase students study time and practice. The addition of technology is useless if not paired with some pedagogical improvements [11]. In fact, using computers only improves learning (in domains other than ICT) if they allow collective work and games. An online quizz in teams is the perfect example of a learning improvement via computers in class. Flipped classrooms are also proven more effective. The students read the course at home and practice with exercises in class. This is facilitated by students having a computer or tablet at home with access to an online platform. [5]

However, the presence of digital devices in classrooms and especially personal devices can negatively impact learning processes of students. They become more distracted during classes, using these tools to browse on the Internet, chat with friends or even play games. Surveys reported that 75% of student use digital devices for non-class related activities during lectures and 40% admit multitasking in every class [16]. Moreover, a meta analysis raised evidence on the fact that an intensive use of digital devices lead to a drop in students scholar performances, even though ICTs tend to increase them up to a optimal use (about several times a week) [22]. Another study [21] performed on an international level and over decades, also found that performances declined with the arrival of personal devices for students. This was also related to students' mental health, especially their social relationships. Devices increased the number of students feeling lonely to 5 percentage points.

## 3.2 Creating a Digital classroom and leading classes online

A Digital Classroom is defined by using electronic devices or platforms such as social media, multimedia, and mobile phones to teach students. This general usage enables the teachers to introduce many systems and new pedagogical tools.

They can for example create a Virtual Classroom which is defined as a virtual environment where a teacher can interact with students in real-time, share his resources, deliver his lecture, assess students' learning, collect feedback, and reply to their queries. [17] A digital classroom can also enhance access to educational resources. Indeed, thanks to the Internet and the rising level of connectivity in Europe, access to educational resources anytime is now possible seven days a week. Moreover, Teachers can use feedback loops to provide feedback depending on many factors such as student,

lesson, group, etc.

Digitization of education could also help students get involved in their work. But these advantages are determined by how students, parents, and teachers use technology to improve education. When technology is used effectively for instructional reasons, the educational experience improves, and students become interested.

However, the creation of a virtual classroom could encourage students to skip lectures or classes. Additionally, online classes and a very virtual learning environment tend to favour better students and increase inequalities. Studies also reported that pupils from primary and secondary school learning twice as fast with a teacher in person rather than a remote teacher.
The phenomenon of Screen Inferiority designates the lesser understanding of a text if read on a screen instead on paper. The effect will not diminish when students are more exposed to the technology. It can impact up to 20% of understanding on a text, depending on aggravating factors such as the need to scroll and a fixed screen. [4] It is hence important that students do not switch completely from printed handbooks to online versions on an online classroom. The schools can put in place some measures to reduce the weight of school bags such as lockers, sharing of books between students etc. while keeping printed material. Teachers should also avoid relying entirely on slides instead of written instructions or exercises.

## 3.3 Inequalities and Inclusivity

Concerning inequalities, the introduction of ICT in class can be helpful in many ways. For example, being introduced to computers already in K12 education with a regular usage diminished the fear for girls to pursue a career in ICT. [3] Of course, other societal factors could and should impact this fear such as better representation.

Computers and IoT can also allow disability aids. Currently, according to WHO, around 2 to 4% of students have significant learning difficulties. [23] For example, a student with dyslexia will more easily read and write on a computer with regular characters, an automatic corrector can make up for dysorthographia etc. A study found that students with learning difficulties report fewer negative emotions compared to their peers in virtual learning environments. [23] On the hardware part, Human-Computer Interaction (HCI) is a field of study which aims at creating computers adapted to everyone. Captors in IoT can help with the diming of light for students on the Autistic Spectrum, describe colors for students with daltonism etc. Of course, such technology also costs more and sufficient funding has to be provided.

This reducing of inequalities is however conditioned by the inclusivity of the digital content and hardware themselves.
Moreover, the access should also be as equal as possible for all students. If some student work is to be conducted on computers, a student who has access to a computer at home will be advantaged. Currently, around 80-90% of students have this advantage in the EU, which makes it even more difficult for the remaining students.

## 3.4 AI in education

AI growth in the recent years has led to the question of using such a tool in education, what could be its use and its impacts on learning processes of students.

The main use for AI in education is personalised learning. With this method, an AI model analyses students' data individually in order to find their strength and weakness, and propose educational material to reduce the gap with other students. For example, a personalised learning software has be used to teach maths and improve the results of students by 30% [10].

Another use of AI in education is chatbots. They can be implemented in order to create more interactive learning, help organise student work or administrative processes.

Some schools could also use AI to grade the students. This can reduce teachers' bias and save time. It can be used to give student almost instant feedback on their assignments and help them improve their work. However, studies show that AI model gave three different grades for the same exam when given three times [8]. Even if teacher grade of a exam can also vary depending on various factors.

But the use of AI in education raises several issues that cannot be omitted. The institutions must guarantee privacy and data protection as lot of sensible data is collected by AI models. The models also have to be trained with unbiased data and be fair, which means not discriminate student based on their gender, ethnic or beliefs. Finally, the models have to be accessible for every person with disabilities and be transparent about their system to teachers and students [10].

## 3.5 Environmental impacts

The digitalisation of education has a certain impact on the environment on many levels. However, studies are lacking on the specific case of digitalising the education. Therefore, we will discuss the environmental consequence of ICTs and digitalisation of other instances.

A systematic literature review on the use of ICTs for sustainability shows that research is focused on efficiency, which means reducing the relative energy and resources used to produce a good or a service. But it highlights the gap in research on possible use of ICTs for Consistency and Sufficiency, which respectively consist of creating a circular economy and reducing the "absolute level of resource and energy demand by way of rethinking needs or changing consumption and production habits or patterns" [20]. They emphasise the need to research these three fields equally, adding that efficiency creates a great number of rebound effects that limit the positive initial intent.

While we do not yet have studies on Consistency and Sufficiency, we already know some substantial direct effects of producing new hardware that have to be taken into account when discussing the cons of digitalizing education. The production and disposal of the ICT hardware currently impacts very negatively the environment and quality of life of countries like Ghana (huge toxic e-waste disposals [18] [7]), China (water pollution due to the hardware production [13]), Democratic Republic of Congo (extracting of cobalt and other rare-earth minerals under armed group and child labour [15]).

Via hardware and use, the ICT sector is already responsible to 5% of the world Greenhouse Gases emissions. Digitalization of schools would imply more direct usage. Students would also graduate with digitalization as a part of their way of thinking and researching, which would speed up the digitalization of the whole society.

As an example, let us examine the impact of providing every Slovenian student with a computer for school. This example does not cover all of the infrastructure and hardware needed behind, and only encompasses one aspect of digitalization.
In France, the computers provided to students are of low quality, which is especially bad for the environment as students will buy a second, better computer for personal use. Moreover, the devices will be thrown away after a few years. Let us consider here that solid laptops are bought each year to 15 000 students entering the ninth grade. Each computer will amount to 286.1 kg CO2eq emissions throughout its lifetime. [6] 10 500 tons of materials would have to be extracted to produce these laptops. [14] However, one could argue that the students would have acquired a laptop on their own if the schools had not provided one. Some would have had the money to buy better ones while others not. In this way, the state providing this hardware reduces inequality between students. Yet if students are getting the computers themselves, they can make sustainable choices, i.e. getting the device that an older sibling who was going to throw it away, buy second-hand etc. In fact, in Europe, 56% of laptops are bought second-hand [1]. The number is probably even higher in students because of their limited financial resources.
If the state wants a neutral carbon impact when furnishing computers, it needs to go with refurbished computers. It also needs to only give computers to students who don't already have one. Of course, this is a challenge because second-hand devices are not standardized and it would be difficult to provide the same quality to everyone.

# 4 Guidelines

The aim of this section is to provide guidelines for developing digitalisation in eduction in the more sustainable way:

- Include every stakeholder in the decisions, especially teachers and students. Additionally, schools should provide formations for teachers and students that have limited digital knowledge.
- Use digital devices that are repairable and easy to maintain. Try to repair broken devices first and try to buy refurbished devices if necessary.
- Focus the use of digital to learn about ICTs as it is less effective for other topics.
- The use of digital devices in primary and secondary school is not the most beneficial so its use can be limited to a common access such as an IT room or computer available in the library.
- High school students may need a personal device to do research at home. The school could provide such devices only for students that do not own a personal computer already.

# Conclusion

In conclusion, ICT in class is mainly useful to learn about the ICT domain itself, which is nowadays present in most jobs and important as an educational subject. However, it does not by itself improve the quality of learning in other domains. Some improvements are still seen with ICT usage on the short term because it facilitates certain ways of teaching that work best on students: games, collective and active learning etc. ICT can moreover be useful to include students with special needs, by providing personalized content, allowing to study more easily in specific environments, or allowing an interface such as a vocal reader.
However, when students own personal devices, these devices take up a bigger place in their lives than pedagogical games at school. They create distractions and cause loneliness, causing in the long-term a drop in academic performances.
The digitalization of the education sector would have a non-negligible environmental impact. While there is no specific study yet on the subject, new hardware (especially IoT) would have to be produced and the energy consumption would grow.

Througout this paper, we have seen that the education digitalization impacts the SDG Goal of Reduced inequalities. If hardware and software are designed in an inclusive way, it can help disabled students. However, if the technology is financially difficult to access and not designed in an inclusive way, it also has the potential to increase inequalities.
The goal of Quality Education is poorly influenced by the digitalization in all domains except for ICT itself. However, certain uses of ICT have showed the importance of including games and collective work for students.
As discussed in the Environmental impacts section, the production of hardware and increase of energy usage implied by the digitalization would have a negative impact on the goals :
- Clean Water and Sanitation in other parts of the world.
- Life on Land
- Life below water
- Climate action
- Sustainable cities and communities
- Responsible consumption and production
- Good health and well-being
- Peace,justice and strong institutions.

Some compromises have to be made to take into account all of the goals. Our guidelines aim for the best course of action to take all of the SDGs into account.

[9] [12]

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# 5 Annex: Methodology

In order to write our subject proposal, we read the conclusions of a lot of papers, especially from this literature review. [19] This allowed us to find some documented measures we wanted to investigate and divide our work, as written in the proposal.
For our first milestone, we read the EU documents on European schools' state of digitalization. We both read the reports, then Eléonore wrote about Hardware and Repairability while Adrien wrote about Connectivity and Online Tools.
This first milestone passed, we focused on the four measures we meant to assess:
– Introducing IoT in class and giving personal devices to students (Eléonore) – Conducting classes online (Eléonore) – Creating a Digital classroom and giving students access to online resources (Adrien) – Introducing latest technologies in the classroom such as AI, blockchain or robots (Adrien) When reading the papers entirely, and a lot of new papers, we realised how difficult it was going to be to separate the effects of these measures. We had a problem of identifiability. We started writing our conclusions altogether. Then, Adrien organized them in different categories. We ended up with two big categories instead of four: "Introducing computers and digital technologies", and "Creating a digital classroom and leading classes online". It made sense because this is how the measures were most often paired in reality, so their effects were measured together. Eléonore deepened the research on Inequalities, since they were not yet addressed by the general papers about digitalization in details.
When presenting our second project update, our teacher gave us some new insights and resources, and recommended that we now dive into the environmental impacts.
Adrien focused on the bigger picture: tackling the effects of digitalization in other fields and in general. Eléonore tried to find some data on the sector of education (it is non-existent) and did the simulation with computers.
After that, Adrien wrote some guidelines that we both agree on.
Our conclusion existed from the begining and we added our most important findings along the way. We rephrased it a bit for fluidity but did not have to change it much.
Eléonore identified all of the SDG goals that we had come across in our research.
Our next step is mainly the poster, and adapting to our teacher's next feedback.