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Interim report of the Commission expert group on quality investment in education and training

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Expert group on quality investment in education and training

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1. Executive Summary

Education and training are the foundation for personal development and well-being, and their benefits go well beyond the individual, affecting the whole society. Investing in high quality education and training for all is a key priority for the European Union. Educational systems, however, are currently facing a particularly challenging situation. The COVID-19 pandemic has led to school closures and learning disruptions that exacerbates educational inequalities. At the same time, education and training systems have to prepare for the challenges of the 21st century and transform themselves to enable children, youth and adults to actively participate in modern economies and societies.

For all these reasons, promoting quality investment in education and training is a key political priority for the EU and the Member States. In a situation where more EU resources than ever are mobilised for education and training through Next Generation EU and the new Multi-annual Financial Framework to support the recovery after the COVID-19 crisis, it becomes fundamental to ensure that every single euro is spent properly. All member States have included education and skills measures in their National Recovery and Resilience Plans. All levels and sectors of education are covered and investments, notably in digital learning and infrastructure, as well as green and modern physical infrastructure but also in teachers' training, skills development, account for around 12% of total planned spending.

Investing in high quality education and training necessitates the identification of effective and efficient investments. An expert group on quality investment in education and training has been created at the EU level to help the Commission and the Member States identify those education and training policies that have the potential to boost education outcomes, promote inclusion and equity, ensure pupils' well-being and improve the efficiency of spending. This report is meant to present the work carried out by this group between May and December 2021, and discuss its main findings and policy conclusions with Member States' representatives and key stakeholders.

One of the reasons why education and training systems are characterised as complex systems is that while policy evaluations can show that a particular programme has been successful in improving outcomes in some contexts, the results are often not transferable when applied in a different context. Therefore, it is extremely difficult to distinguish what defines a quality investment in education and training in general. Nevertheless, this interim report tries to draw some preliminary conclusions based on robust evidence on the effectiveness and efficiency of different education and training policies.

The analysis has been organised around four focus areas, and notably: i) teachers and trainers; ii) digital learning; iii) management, infrastructure and learning environments; and iv) equity and inclusion. Moreover, part of the work has been dedicated to two important aspects of policy evaluation that may help design innovative and effective education policies: impact evaluation analysis and cost-benefit analysis.

Teachers and trainers

Teachers and trainers play a key role in students' achievement and life chances and their salaries represent the largest budgetary element at all levels of education. Research shows a positive link between teacher quality and student performance. Most EU countries, however, face teacher supply challenges, such as shortages - particularly in high-demand subjects and hard-to-staff schools and areas – or

difficulties in attracting new candidates to the profession. Key messages from the literature review give some indications on the policies that show promise in this area:

- Financial incentives matter for recruiting and attracting teachers, as teacher remuneration needs to be competitive with comparable occupations. Research also shows promise in targeting financial incentives to bring teachers to work in hard-to-staff schools and areas, or for teachers with skills in high demand. Available evidence suggests that recruitment incentives aimed at attracting talents work best when coupled with an obligation to stay in the school or area for a predetermined time.
- Non-monetary elements also crucially matter to attract and retain teachers. Supporting working conditions, in particular those that relate to leadership and collegiality are key aspects that matter for teachers, and even more so in disadvantaged areas. There is a high financial burden on public budgets due to turnover and sickness absence imposed by prevalence of work-related stress.
- Reducing class size is a costly policy, but it seems to be effective in schools/areas with a high percentage of students from lower socio-economic background or with special education needs. Nevertheless, equipping teachers with appropriate competences and training to implement effective pedagogical approaches which are adapted to a smaller class size is also fundamental for the success of such policy.
- Appropriate support in the form of mentoring, personalised support, access to continuing professional development and career opportunities, is also an important aspect to ensure quality teaching and training. In this regard, raising teachers' pedagogical digital competences seems to be a priority area for future research, as it may improve student outcomes and help teachers feel more prepared to teach remotely in particular situations, such as the recent COVID-19 crisis.

Digital learning

Education and training are sectors that could be drastically affected by emerging technologies. The increased use of digital technologies may help teachers and trainers to efficiently provide quality education, including the possibility to open up to a more diverse cohort of learners, increase flexibility, personalisation and inclusion, and offer more interactive and engaging forms of cooperation and communication. At the same time, digital technologies bring challenges as they may also exacerbate inequalities, due to a differential access to these technologies. The COVID-19 pandemic, which has forced teachers and schools to increase the use of digital technologies but has widened the educational gap, illustrates the promises and limits of the use of such tools in education. The results of available research on the *effectiveness of digital learning* in primary, secondary and higher education shows the necessity to take into account both efficiency and equity aspects.

- Positive effects of the use of digital technologies in classrooms on student outcomes can be identified in the literature. However, the opposite seems to be a matter of concern for students from lower socio-economic backgrounds. The impact of digital learning on student attainment depends to a considerable extent on which technologies are selected for use and on how they are implemented in the classroom. Teachers and trainers need to master the digital environment to design high quality and engaging learning experiences and learners need to be equipped with the right skills to use the technology, in order for the use of such technologies to efficiently foster knowledge acquisition.

- In addition, the literature review tends to reinforce the expectation that online/digital learning may be more effective if combined with face-to-face learning, not only in primary and secondary education, but also in higher education. In other words, blended learning appears more promising than digital-only learning.
- There is a potential to leverage digital technologies to help better connect families, students and schools and to develop compensatory programmes that could be more intensive at a lower cost or reach more students, using computed assisted learning or online mentoring.
- Given the importance of the topic, additional research on the efficiency of the use of digital tools in and out of the classroom, as well as the collection of data for cost assessment is a prerequisite for better investment in digital technologies. More robust evidence from European countries will help better assess the cost-effectiveness of investment in digital learning, and define minimum standards for infrastructure, equipment and software.

Management, infrastrucuture and learning environments

Digital tools are part of a broader learning environment, defined as the physical spaces in which learners, teachers, content, equipment, and technologies interact. Physical learning environments represent a significant part of educational investments. They are an influential element in the complex education process as they affect the interactions among learners and educators. Good architectural and educational design – and their proper combinations - may lead to good teaching practices and be the catalyst for innovative pedagogies. Moreover, educational buildings represent 17% of non-residential buildings in Europe and they are a valuable public asset that should be used, built and managed in an efficient and effective way, during and after school hours. A large part of the stock needs to be renovated, to make it more energy efficient and ease the implementation of innovative and digital teaching practices. Despite the high interest and need for understanding the impact of the physical learning environment and its design on learning outcomes to ensure effectiveness and efficiency of education spending, the report has identified that robust empirical evidence is still very limited.

- A growing strand of research focuses on the design of physical learning environments, exploring factors such as light, thermal comfort, acoustics, quality of air, hygiene and cleanliness, as well as other factors such as flexible and adaptable use of space, furniture and equipment, safety, or energy efficiency. Most of the evidence tends to warn of the negative effects of a poor environment, and research into the effect of the physical environment demonstrates few direct impacts on student learning, but suggests many indirect effects achieved via both learning and teaching processes.
- Given the limited available studies, large potential gains from additional knowledge can be expected by gathering more empirical evidence specifically linking design elements of learning spaces to student outcomes. Data on costs would also help better relate the potentially substantial costs to the benefits of different designs. Additional evidence of the benefits of using schools after operating hours would also help integrate this aspect in the design of school buildings.
- Moreover, in the context of the green transition, a significant amount of public money will be spent on renovating public buildings, including educational facilities. It is therefore necessary to understand which management practices

for the construction, renovation, and day-to-day use of facilities, can lead to a cost-effective, energy-efficient improvement of physical learning space.

Equity and inclusion

Education and training play an important role in making European societies fairer and more inclusive. However, socio-economic background continues to be a strong determinant of student attainment. The COVID-19 crisis has reinforced the case for improving equity in education as the shift to distance learning and the loss of teaching time have brought increased challenges for disadvantaged students and are likely to compound existing inequalities. The interim report has focused on a specific set of policies aimed at increasing education equity: desegregation policies, tracking and ability grouping, priority education policies and access and persistence in higher education. Other policies, including early childhood education and care, compensatory policies for socioeconomic disadvantage and special education, will be included in the final report.

- Research suggests that reducing school segregation brings benefits both in terms of equity and quality of education. However, desegregation policies have not been widely implemented in European countries, as they are considered as controversial policies altering the interests of different stakeholders.
- There is also evidence that tracking policies, either between tracks (academic, vocational) or between schools, reduce education equity, and they have mixed effects on efficiency. This suggests that delaying tracking to later ages may promote the equality of educational opportunities. On the other hand, ability grouping within the same class or school seems a more promising policy to increase educational achievement for all students, which deserves further research.
- The evidence on the impact of priority education policies, which provide some disadvantaged subpopulation in a specific school or area with additional resources, is at best mixed for students' outcomes. The wide variation across programmes in the magnitude of the additional expenditure and the way in which such funding is allocated may explain the discrepancy in results. Some studies also point to sorting effects and growing segregation. This suggests that replacing school-based policies with individual-based ones might be more promising in order to prevent the creation of negative school stigma.
- At the higher education level, reducing the gap in access to higher education between students from high and low socio-economic background is an important challenge in all types of systems. While the scarce existing evidence on tuition fees is mixed, research shows that need-based grants lead to improvements when they provide enough money to cover unmet needs and/or include an early commitment during high school. On the other hand, merit-based grants seem to improve the outcomes of disadvantaged students only rarely. In addition, evidence on outreach policies suggest that they are broadly effective in increasing access for disadvantaged students when they include active counselling, but not when they only provide general information on higher education.

Impact evaluation analysis and cost-benefit analysis

Overall, on the methodological side, some general findings emerge from the review of all the topics covered in the interim report:

- A large body of robust evidence comes from the US and UK, less from European countries. In addition, not all topics have been equally studied. For some areas, such as digital education, and even more so for physical learning environments, more evidence would really help improve the efficiency in investment.
- There is even more limited evidence of evaluations that provide cost-benefit analysis. This is partly due to the lack of data related to the costs of specific investments in education.

The development of an expertise for evaluation and dissemination of findings at the European level could help to fill this gap and support the design of effective education policies in European countries. The development of a framework for evaluation would be useful to estimate ex-ante, and evaluate ex-post the impact of a policy, together with cost-benefit analysis. Research in social science has progressed considerably and developed methods that can be used to perform rigorous evaluations, combined with qualitative analysis, to provide a comprehensive assessment of the effect of a policy. The implementation of such methods necessitates the careful design of data infrastructure with the creation of indicators on costs and outcomes. Cost-benefit analysis and evaluation can indeed only be performed when the expected impacts of a policy are clearly identified and measured, and when costs are properly recorded.

The development of rigorous impact evaluation and cost benefit analysis of educational policies in EU countries can bring three main benefits:

- First, while the experience of successful policies implemented in other contexts is very useful to design future policies, the actual effectiveness of a given policy may depend on the specific context where it is implemented. It is therefore necessary to conduct robust impact evaluation when a policy is implemented in a new setting, in order to adapt it to the specificities of each country and level of education.
- Second, investing in quality education and training for future generations necessitates innovating with policies that have never been implemented before. Policy designs that allow for experimentation and evaluation can help conceive educational policies for the future.
- Third, gathering more evidence of policy impacts from different settings allows a better understanding of the mechanisms that explain why some policies might work in some contexts and be less effective in others. It is therefore very useful to gather knowledge from multiple evaluations in different countries and contexts in an easily accessible and comparable way.

2. Introduction

The Strategic Agenda for the EU for 2019–2024 adopted by the European Council in June 2019 stresses that Member States "*must step up investment in people's skills and education*".[1] At the same time, at their first-ever joint policy debate in November 2019 under the Finnish Presidency of the Council of Ministers, Ministers of Education and Ministers of Finance have agreed that investing in education, skills and competences is a necessity for all Member States, and it should be a strategic priority for the EU. These commitments have become even more relevant since COVID-19 has harshly hit the EU's economies and societies. The pandemic has revealed large inequalities in access to and quality of education, and these issues require proper attention.

The Commission Communication on Achieving the European Education Area by 2025 clearly states that: *"The Commission will help intensify work on investment as part of the European Education Area. This will include fostering debate at high-level political fora, such as joint exchanges between EU finance ministers and EU education ministers, as well as with other institutions, such as the European Investment Bank and the European Parliament. At technical level, an expert group on quality investment in education and training will support this process, helping to maintain focus on national and regional investment. The Commission will also provide specific support to local, regional and national authorities to facilitate mutual learning, analysis and sharing of good practices on investment in education infrastructure."*[2]

The Council endorsed the proposal to intensify the work on investment in the Council Resolution on a strategic framework for European cooperation in education and training towards the European Education Area and beyond.[3] The Council has agreed that *"While respecting the principle of subsidiarity, intensified work on investment has a potential to aid the recovery from the current crisis and contribute to the green and digital transitions of the education and training sector",* and invited the Commission to *"work with the Member States and provide specific support to local, regional and national authorities to facilitate mutual learning, analysis and sharing of good practices on investment in education infrastructure".*

Therefore, a Commission Expert Group on Quality Investment in Education and Training was launched in May 2021.[4] The group is made up of 15 independent experts from all over the EU. The work of this expert group is of high relevance in a context of increased political priority given to education and training in the recovery phase, where the need to invest effectively and efficiently, and not just to invest more, has become key. In this document, 'effectiveness' refers to the ability to provide high-quality educational outcomes, by making the most of the available human and physical resources, while 'efficiency' adds a financial dimension to the analysis of effectiveness and refers to the ability to provide the desired educational outcomes at the lowest possible cost.

The group's overall mission is to carry out an evidence-based evaluation of education and training policies to identify those that allow boosting education outcomes and inclusiveness, while improving the efficiency of public spending. The group should provide robust evidence on the expected costs and benefits of selected education and training policies, on the challenges associated with their implementation and the

[1] https://www.consilium.europa.eu/media/39914/a-new-strategic-agenda-2019-2024.pdf

[2] COM(2020) 625 final

[3] OJ 2021/C 66/01.

[4] Register of Commission expert groups and other similar entities (europa.eu)

methodology for their evaluation. The group has focused its analysis on those areas that represent the bulk of education and training expenditure, and that may have a huge impact on education outcomes, notably: teachers and trainers; management of education infrastructure and related physical and human resources; and digital learning, both in terms of infrastructure and competence development.

More specifically, following the mandate given by the European Commission, the group has decided to divide the analyses presented in the report into the following four focus areas:

Table 1: Report's focus areas

Focus area 1	Focus area 2	Focus area 3	Focus area 4
Teachers and trainers	**Digital learning**	**Management, infrastructure and learning environment**	**Equity and inclusion**
Includes issues related to teacher and trainer quality and quantity, in particular teacher shortages, teacher pay and working conditions, professional development including digital competencies, class size	Includes issues related to ICT in education (digital equipment, use of digital software in and out of the classroom, distance learning in higher education)	Includes issues related to the quality of physical and digital environments (both for new schools and renovations), management of school resources and infrastructure, use of school infrastructure after school operating hours	Includes issues related to the equity of the educational system, including school tracking and school desegregation policies, priority education policies, access and persistence in higher education

Focus areas 1 to 3 are directly related to key components of the efficiency of educational systems, while focus area 4 is related to policies that are tackling inequalities in education. Within each main focus area, the choice of different topics has been made based on the expertise of the expert group with the objective to identify areas for which academic literature may help assess the efficiency of the policy. More precisely, for each topic, a careful search of the academic literature was conducted, with the aim to identify:

- Policies that have already been evaluated, for which there is solid empirical evidence and that allows meaningful policy conclusions.
- Areas where evidence is lacking and future research is needed.

For each topic, experts have focused on the most recent existing academic evidence, published in peer-reviewed social science reviews, with the aim of providing an overall picture of knowledge on the subject. Whenever possible, the experts have selected studies providing a robust evaluation of a given policy, linking policy intervention to clear outcomes. Given the very large scope of the report, a choice of topics had to be made, based on experts' knowledge of the literature. This interim report covers a limited set of policies, and it focuses mainly on school education and, to a lesser extent, higher education. Early years education, vocational education and training (VET) and adult learning will be covered in the final report. Additional topics will be covered in the final report, in order to provide a broader picture of the efficiency and effectiveness of different education policies and will include all stages of the educational system. The detailed list of topics that the group is planning to analyse in 2022 is presented at the end of this report.

The main outcome of the whole exercise will be an evidence-based guidance document for Member States that provides robust evidence on the impact, cost, and challenges in the implementation of key education and training policies. This final report is expected by September 2022.

This interim report aims to present the preliminary outcomes of the analytical work carried out by the experts since May 2021, and to steer the discussion with the Member States and key education and training stakeholders. All feedback received by those actors will be taken into consideration in the preparation of the final report.

Please note that the policy conclusions presented in this report do not represent the official position of the European Commission. This document reflects the views only of the authors, and the European Commission is not liable for any consequence stemming from the reuse of this publication.

3. Focus areas: detailed analysis

3.1. Teachers and trainers

Key policy conclusions:

- *Financial incentives aiming to attract talented teachers need to be targeted more precisely.* Available evidence suggests that recruitment incentives work best when coupled with an obligation to stay in a specific school or area for a predetermined time.
- The *selectivity of initial teacher education programmes affects the decision to become a teacher*. There is a need to strike a balance between selective criteria that can help in recruiting high-potential individuals into teaching and alternative criteria that can build a more diverse pool of teachers, addressing shortages and improving social mobility.
- *Alternative routes to full teacher qualifications* can be effective ways to attract and retain teachers if underpinned by appropriate support in the form of induction, mentoring, professional development and career opportunities, as well as supportive working conditions.
- *A more balanced policy approach addressing both recruitment and retention* would be beneficial given the impact of demographic changes on the teaching population.
- *Reducing teachers' work-related stress* may diminish the current high financial burden on public budgets due to turnover and sickness absence.
- *Reducing class size* seems to be effective in schools/areas with high percentage of students from lower socio-economic background or with special education needs. Nevertheless, this is not enough. Equipping teachers with appropriate competences and training to implement effective pedagogical approaches that are adapted to a smaller class size is also fundamental.
- *Raising teachers' pedagogical digital competences may improve student outcomes* and support teachers' confidence to teach remotely in particular situations, such as the recent COVID-19 crisis.
- Overall, there is a need for *further rigorous evaluations of the policies* that aim to address teacher supply challenges, teacher certification (including competitions, probation periods, waiting lists) and teachers' digital competences because the evidence is still rather scarce.

EU policy framework for teachers and trainers

The 2019 Council Resolution on further developing the European Education Area to support future-oriented education and training systems[5] invites the Commission to *"Develop new means to train and support competent, motivated and highly qualified teachers, trainers, educators and school leaders, and promote their continuous professional development and high-quality, research-based teacher education."*

[5] https://data.consilium.europa.eu/doc/document/ST-13298-2019-INIT/en/pdf

The Council Conclusions on European Teacher and Trainers for the Future of May 2020[6] reiterate the role of teachers as cornerstones of the European Education Area and call for further support for teachers' career and competence development as well as well-being at all stages of their careers. The Conclusions stress the benefits of mobility of teachers and the need of embedding mobility as part of teachers' initial and continuous education. Moreover, the Conclusions invite the Commission to support closer cooperation between teacher education providers within the continuum of teachers' professional development.

The 2020 Commission's Communication on Achieving the European Education Area by 2025[7] recognises the key role of teachers and trainers and sets the vision of having highly competent and motivated educators who can benefit from a range of support and professional development opportunities throughout their varied careers. It proposes a number of actions to address the challenges the teaching professions face today, including the plan to launch Erasmus+ Teacher Academies.

The Commission's Digital Education Action Plan (2021-2027)[8] stresses the need to ensure that all teachers and trainers have the confidence and competences to use technology effectively and creatively to engage and motivate their learners as well as to ensure that all learners develop their digital competences for learning, living and working in an ever more digitalised world.

The Council Resolution on a strategic framework for European cooperation in education and training towards the European Education Area and beyond (2021- 2030)[9] also recognises the key role of teachers as one of the key priorities. It refers for example to the potential of Erasmus+ Teacher Academies in facilitating networking, knowledge sharing and mobility among institutions providing teachers and trainers with learning opportunities at all phases of teachers' and trainers' careers.

The European Commission supports teachers and teaching professions as follows:

- The **Erasmus+ Teacher Academies** (E+TA), consisting in networks of teacher education institutions, will provide a joint learning offer for teachers, on digitalisation, inclusion, environmental sustainability, or improving gender equality. With these new courses and mobility as a regular feature, E+TA projects will also improve the attractiveness of the teaching profession. The target set in the EEA Communication is to have 25 Erasmus+ Teacher Academies by 2025.
- The Commission has started to work with Member States to develop guidance for the **development of national career frameworks** in order to diversify school education careers and improve recruitment, retention and professional development of teachers, trainers and school leaders.
- The Commission will develop a **policy framework for promoting teacher mobility** to embed mobility as an integral part of initial and continuous teacher education.
- In order to highlight and value high quality teaching and learning, the Commission has established a **European Innovative Teaching Award**,

[6] https://www.consilium.europa.eu/media/44115/st08269-en20.pdf

[7] Achieving the European Education Area by 2025 - Communication | Education and Training (europa.eu)

[8] Digital Education Action Plan (2021-2027) | Education and Training (europa.eu)

[9] https://www.consilium.europa.eu/media/48584/st06289-re01-en21.pdf

which highlights innovative Erasmus+ projects and complements existing European and national awards.

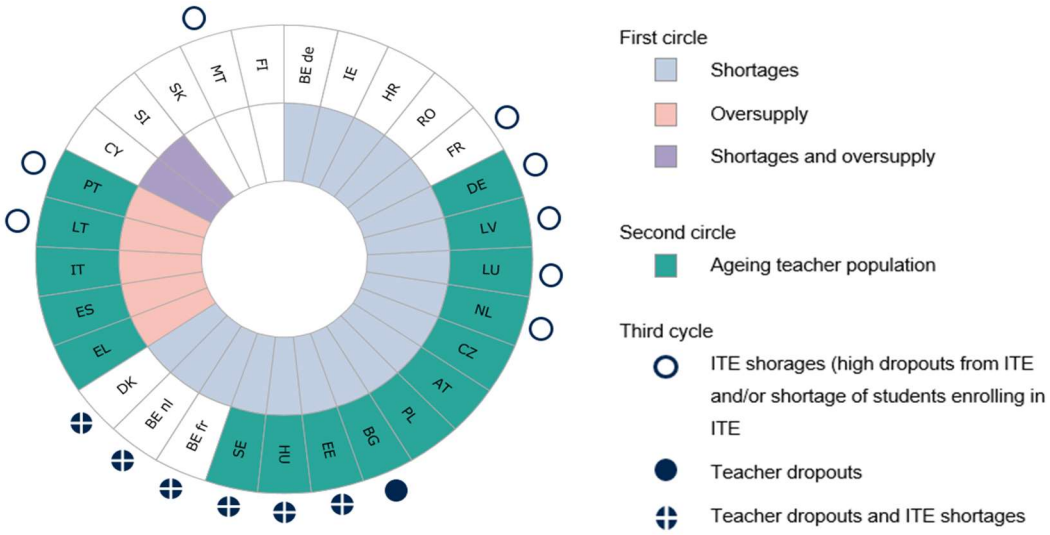
- To contribute to the development of digital competences, the Commission has developed a **SELFIE for teachers**. This tool accompanies the **SELFIE for schools** and it will help teachers to assess their digital competences and identify further learning needs.
- Finally, the support to teachers and their professional development is a core part of the proposal for a **Council Recommendation on blended learning in primary and secondary education** that was adopted in December 2021.

Setting the scene

Recruiting, training and retaining effective teachers is important because of the role that teachers play in student achievement and life chances. Teacher salaries also represent the largest budgetary element at all levels of education. Research shows a positive link between teacher quality and student performance (Hanushek, Schwerdt, Wiederhold et al., 2015; Chetty, Friedman & Rockoff, 2014). Consecutive years of effective teaching can offset learning gaps for disadvantaged students (Hanushek & Rivkin, 2010). Still, in practice, it is often the least experienced and least skilled teachers who are teaching the students with greater need, which contributes to academic achievement gaps based on students' socio-economic background (Boyd, Lankford & Loeb, 2003; OECD, 2019). For those students, class size also matters, as it can lead to better performance through closer interactions, both among students and between students and teachers. Moreover, teachers and trainers need to be equipped with the right skills, knowledge and competences to cope with a fast-changing learning environment (in particular in terms of digital tools) and be able to address properly students' need.

Recruiting effective teachers is a key policy concern for education authorities. It is all the more pressing given that most EU countries are faced with general teacher shortages, sometimes exacerbated by an unbalanced distribution across subjects and geographies, an ageing teaching force, as well as high attrition and low enrolment in initial teacher education (see Figure 1) (EC, 2021a). There are particular challenges in recruiting effective teachers in high demand subjects and hard-to staff schools.

Figure 1: Main challenges in teacher demand and supply in lower secondary education, 2019/20[10]



Source: European Commission/EACEA/Eurydice, 2021

The concept of teacher effectiveness has been thoroughly reviewed in research literature. In the simplest terms, teachers who are effective enable their students to learn. With the growth of standardised testing, teacher effectiveness has been operationalised as teacher's "value-added", meaning their ability to improve student learning as measured by student gains on standardised tests (Ballou, Sanders, & Wright, 2004) or ratings of teachers' performance through classroom observations (Hafen, Hamre & Allen et al., 2015). There is a debate whether teachers' impacts on students' test scores is an appropriate measure of their effectiveness and to what extent – and how - they can be used for accountability purposes.

Individual-level factors that influence the decision to become a teacher are related to identifying and selecting the options that provide the most favourable career opportunities. The decision to become a teacher is influenced by financial rewards and expectations on what the work entails in terms of working conditions, career opportunities, autonomy, social status and utility, as well as intrinsic motivations and self-efficacy.

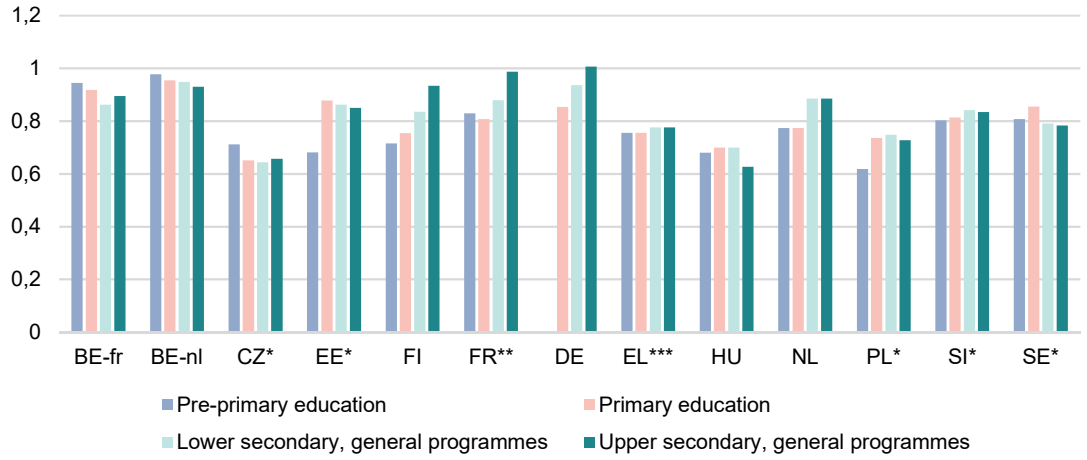
Competitive salaries that are at par with the remuneration paid to adults with similar education levels working in comparable occupations enhance the ability of school systems to attract and retain teachers (OECD, 2019). Currently the level of actual teacher salaries varies widely in EU countries (EC, 2021b)[11]. The optimal level of investment in relation to wages is country-specific and it has been defined in relation to the average GDP/capita. However, in almost a quarter of the European countries, the average teachers' salaries are below the GDP per capita: Czechia, Estonia, Ireland, Latvia, Hungary, Slovakia, Sweden, Iceland and Norway (EC, 2021b). There is no one-size-fits-all solution to the design of effective salary scales (OECD, 2019). Policy makers need to consider *'the specific challenges of their system and the characteristics of their local labour markets'*, such as the level of private sector wages

[10] The first circle of the graph relates to the categories 'Shortages', 'Oversupply' and the combination of these two. The second circle relates to the category 'Ageing teacher population'. The dots on the third circle relate to the categories 'ITE shortages' and/or 'Teacher dropouts'. Education systems without a colour corresponding to the related category mean that they do not report such challenge(s).

[11] The actual salaries refer to the average annual gross salary, including allowances and other additional payments that teachers receive on top of the statutory salary.

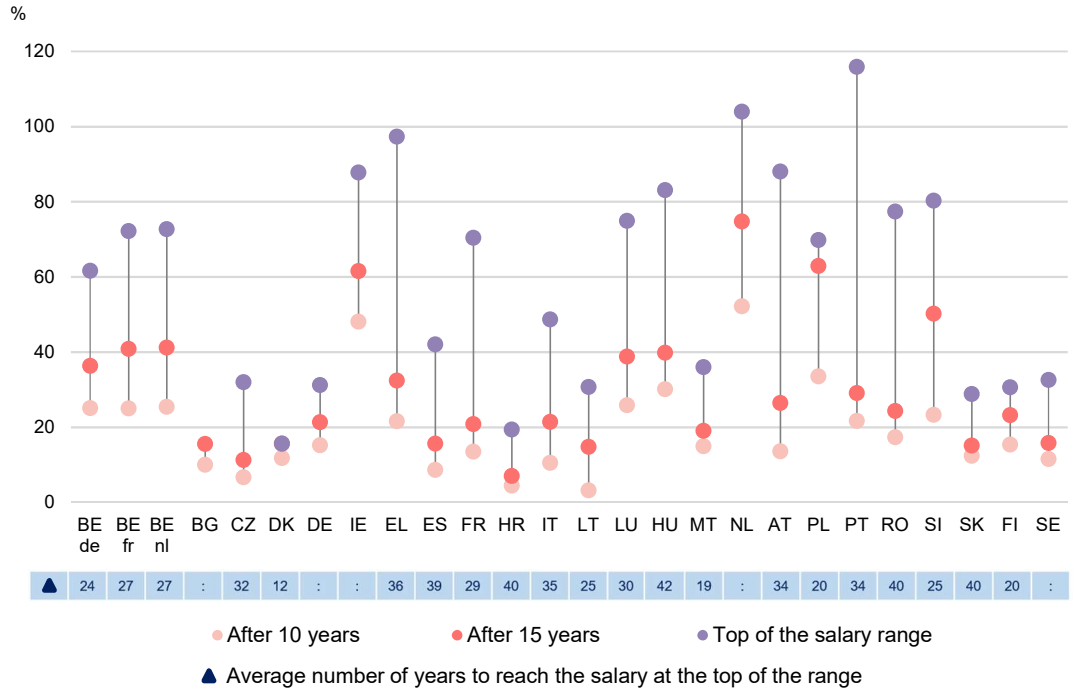
or unemployment rates when deciding on which point higher starting salaries can be an effective means to attract high-performing candidates into teaching (OECD, 2020).

Figure 2: Teachers' actual salaries relative to earnings for full-year similarly educated workers, 2019



Source: OECD, 2020. Notes: Data not available for remaining EU Member-States; * = Year of reference is 2018 for salaries of teachers; ** = Year of reference is 2017 for salaries of teachers; *** = At pre-primary and primary levels actual salaries refer to all teachers/ in those levels of education combined including special needs education. At lower and upper secondary levels, actual salaries refer to all teachers in those levels of education combined, including vocational and special needs education.

Figure 3: Percentage difference between the statutory starting salaries of lower secondary teachers and their salaries after 10 and 15 years' service, and at the top of the pay range, 2019/20



Source: European Commission/EACEA/Eurydice, 2021

Teacher working conditions are considered the (non)pecuniary elements of the workplace that affect teaching (Merrill, 2021; OECD, 2019, 2020c). They mainly refer to: (i) leadership; (ii) collegiality, professional learning and collaboration; (iii)

accountability systems; (iv) career advancement opportunities; (v) contractual arrangements and job security; and (vi) working hours and workload.

Research confirms that *"what appear to matter most to teachers about the context in which they work, are not the traditional working conditions policy makers often think of, such as modern facilities and well-equipped classrooms, but aspects that are difficult to observe and measure, such as the quality of relationships, collaboration among staff, the responsiveness of school administrators and the academic and behavioural expectations"* (Kraft and Papay, 2017: 20).

Teachers' working conditions have been reported as 'highly predictive' of teachers' stated intentions to remain in or leave their schools (Ladd, 2011; Barnett Berry et al., 2019). The evidence suggests that attrition from teaching is (i) not necessarily a 'healthy' turnover; (ii) more strongly moderated by characteristics of teachers' work conditions than previously noted; and (iii) a problem that can be addressed through policies (Borman and Dowling, 2008; Barnett et al., 2021). High turnover contributes to organisational instability and potentially reinforces a cycle of poor working conditions (Kraft and Papay, 2017; Education International Research, 2021). These findings apply to all levels of general education and are particularly strong for the 'hard to staff' schools where students are more disadvantaged.

One of the key aspects that affects teachers' working conditions is class size. Class size is a major determinant of the educational process as it relates directly to the educational expenditure and presumably education outcomes. Class size refers to the number of students in a group studying together in contrast to "student-teacher ratio" that refers to the number of students per teacher.

According to the most recent data from the OECD[12], in 2019 the average class size was 19.5 students in primary education (ISCED 1) and 20.9 students in lower secondary education (ISCED 2). Over the last decade (2010-2019) the class size has increased by 0.6 students in primary and decreased by 0.4 students in lower secondary education on average (OECD, 2021b). Different minimum or maximum class size rules are imposed at national level (EC, 2021c).

Recently, Leuven and Oosterbeek (2018) developed an analytical report on the studies exploring the link between class size and student outcomes in Europe. Around half of the studies under review show that smaller classes have a beneficial impact on education outcomes, mainly on mathematics and reading scores. The current review considers class size in primary, secondary and higher education.

Equipping teachers with appropriate competences and training to implement effective pedagogical approaches that are adapted to a smaller class size or new learning needs is also fundamental.

In this respect, an important development in education has been the increasing use of digital technologies. It is widely believed that digital technologies can facilitate high-quality teaching and enhance student learning (Wekerle & Kollar, 2021). Common beliefs are that digital (educational) technologies can enhance learning efficiency, facilitate a greater focus on students' professional future which will likely include the use of Information and Communication Technology (ICT), and foster personality development in a digital society (Seufert et al., 2021). Yet, several meta-analyses revealed that the use of digital technology leads to positive but not overwhelming effects on learning outcomes and that the magnitude of the effects appears to depend on contextual factors. Among those factors, teachers' pedagogical digital competences and their attitudes towards technology are important (Schmid et al., 2014; Tamin et al., 2011). In particular, various studies have showed that teachers

[12] Please note that only 22 EU Member States are also OECD members. Data on the average class size for the non-OECD members from the EU27 has not been reported.

who lag behind in the development of such competences and attitudes do not effectively integrate digital technologies into their teaching (Chen, 2010; Petko, 2012; Tondeur et al., 2019). Hence, there is a need to support teachers in developing their pedagogical digital competences. This need is even greater in light of the COVID-19 crisis and the resulting school closures, which elevated online learning from a bonus tool to the only option for education (OECD, 2020a), resulting in larger attainment deficits in education systems with low online pre-pandemic learning (Maldonado & De Witte, 2021; Gambi & De Witte, 2021) and significant post-pandemic investments in ICT-infrastructure (De Witte & Smet, 2021).

The concept of digital competence has been reviewed thoroughly in the literature, resulting in many operationalisations of the concept. From (2017) proposed using the concept of Pedagogical Digital Competence (PDC) which was defined as "*the ability to consistently apply the attitudes, knowledge, and skills required to plan and conduct, and to evaluate and revise on an ongoing basis, ICT-supported teaching, based on theory, current research, and proven experience with a view to supporting students' learning in the best possible way*" (p. 48).

Our literature review highlights the interconnected challenges within education systems concerning teacher recruitment, retention, working conditions and career development. Recruitment, retention and regeneration from initial teacher training through continuing professional development are all important.

This report focuses on the following topics. Unless otherwise indicated, our focus of analysis is on general education:

Topic 3.1.1	Recruiting effecting teachers
Topic 3.1.2	Improving working conditions and wage policies
Topic 3.1.3	Adapting the class size
Topic 3.1.4	Raising teachers' pedagogical digital competences

3.1.1. Recruiting effective teachers

What the evidence shows

There is rich research on individual-level factors that influence the decision to become a teacher, mainly based on surveys of existing teachers. International comparative studies provide evidence on the impact of competitive salaries in attracting people to teaching careers. Longitudinal studies show that trends in teacher recruitment are associated with labour market developments and the relative attractiveness of other occupations. Evidence suggests that teacher observable characteristics account for a negligible variation in teacher effectiveness, in contrast to selectivity to teacher education and early classroom experience.

Individual-level factors that influence the decision to become a teacher are related to identifying and selecting the options that provide the most favourable career opportunities. The decision is influenced by financial rewards and expectations on what the work entails (working conditions, career opportunities, autonomy, social status and utility), but also intrinsic motivations and self-efficacy. Based on PISA data, Han, Borgonovi and Guerriero (2017; 2020) find that salaries and job responsibility and respect are positively associated with teaching career expectations. They also show that men are more likely to work as teachers in countries with higher teacher salaries and more male teachers. A survey of teachers in Europe ranks salaries and social status, better working conditions and smaller class sizes as key factors for making teaching more attractive (EC, 2013, p. 72). Using longitudinal survey data, Savage et al. (2021) show that early decision-making in relation to becoming a teacher in Germany is motivated by social interests and parental influence.

Trends in teacher recruitment are associated with wider labour market developments and the relative attractiveness of different occupations (Dolton, 2006). More people enter the teaching profession during recessions: in particular, graduates are more likely to opt for teaching when teachers' relative pay is high and graduate employment low (Dolton, Tremayne & Chung, 2003). The wage effect on the supply of teachers is strongest for recent graduates and when teacher wages are relatively low (Chevalier, Dolton and McIntosh, 2007). Evidence also suggests that teachers entering the profession during recessions are more effective in raising student test scores (Nagler et al., 2015).

Consistent evidence from US-based studies suggests that years of education and degree qualifications etc. account for a negligible variation in teacher effectiveness (see, e.g., Hanushek & Woessmann, 2011). In contrast, selective processes to access initial teacher education or profession lead to higher quality teachers on average (Darling-Hammond et al., 2005). In primary education, countries with more selective teacher recruitment or structured training periods enhance student achievement in standardised tests in reading (Brage et al., 2019). Early classroom experience has a positive impact on teacher effectiveness in general education (Kane et al., 2006). Furthermore, mandatory practical training before (or immediately after) entering the profession generates higher student achievement in primary education (Brage et al., 2019).

What is missing

Causal evidence on the effectiveness of remuneration in attracting more talented teachers and improving student achievement is limited and should be further investigated. Higher salaries could expand the pool of potential teachers and reduce teacher turnover, but do not guarantee better quality teachers (Hanushek & Rivkin, 2004, Hanushek et al., 2015). Hoxby and Leigh (2004) show that pay compression contributed to the decline in the average aptitude of individuals entering the teaching profession, but the focus is on their SAT-results, rather than student achievement.

Evidence on the effectiveness of financial incentives in recruiting teachers in schools serving more disadvantaged populations is inconsistent. Some suggest that higher salaries – from 30 to 50% more – are needed to recruit teachers to work in such schools (Boyd, Lankford & Loeb, 2003). Others suggest that salary compensation has only a short-term effect (Bueno & Sass, 2016). There is limited robust evidence regarding the influence of non-financial incentives, such as induction and mentoring, or teacher education in high-need schools.

Causal research from the US on the effects of alternative entry routes shows no significant difference between the effectiveness of teachers who enter the profession through alternative routes and traditionally certified teachers, but suggests that their effectiveness depends on their design features and context-specific matters (Alfonso, Santiago & Bassi, 2010; Boyd et al., 2012). In Europe, causal research and rigorous cost-benefit analyses of teacher training routes are largely missing. To capture the related impact on teacher effectiveness such analysis would require access to information on applications made to each route, detailed information on the prior attainment and quality of each candidate, and the ability to measure retention and the effectiveness of the successful candidates in improving student achievement. These research questions should be factored into teacher policies. In line with evidence-based education, new policies should be tested through pilots before they are rolled out and generalised.

The effectiveness of different systems of recruiting and selecting individuals to initial teacher education programmes and the teaching profession and how these systems

influence the time-to-entry into profession and the associated costs would deserve further analysis[13]. The existing diverse approaches to teacher certification across European education systems, such as competition, probationary periods, or waiting lists, may cause delay in entry to the profession and exert varying costs to the public purse. There is a lack of research whether credentialing programmes provide useful training, and whether entry requirements prevent effective individuals from entering the profession.

It is equally difficult to identify evidence on how different types of employment contracts, from permanent/statutory contracts to temporary contracts, influence the attractiveness of the teaching profession and what impact they have on teacher effectiveness. Carefully designed contractual arrangements could make teaching more attractive, but this is difficult to study through experimental interventions and quasi-experimental approaches as career decisions are based on expectations for the future.

Finally, there is limited experience in Europe in implementing teacher value-added measures to capture teachers' impact on student achievement. Evidence from countries where value-added measures of student achievement are used suggests that they should be limited to low-stakes evaluations as part of an integrated analysis at school level and combined with other measures, such as classroom observations and improvements in working conditions, while high-stakes incentives should be avoided. For most countries, it could be more efficient to certify initial education and continuing professional development programmes and oblige all teachers to go through structured career development steps underpinned with salary incentives conditional to these steps.

Cost-effectiveness aspects

Cost-effectiveness analyses of teacher recruitment policies are rare and context specific. Most evidence is from the US. In the following, we present four studies of policies that have been implemented in the US and Norway with a causal or comparative design and robust measurement of recruitment and/or retention outcomes (See et al., 2020). In contrast to the Norwegian study, the three US studies address teacher effectiveness using value-added measures and include cost-effectiveness analysis.

First, Glazerman et al. (2013) evaluated the US Federal Government's Talent Transfer Initiative (TTI), which provided *bonuses to the best teachers with highest student achievement gains to move to and stay in low-performing schools* in seven US states. USD 20,000 was paid in instalments over a two-year period, while teachers already teaching in such schools received half this sum. TTI was found to be effective: 88% of vacancies were filled, student learning improved and TTI teachers had higher retention rates than their counterparts (93% vs. 70%), but the difference faded after the payments stopped. TTI saved the government USD 13,000 per grade per school compared with the cost of class-size reductions.

Second, Feng Li & Sass (2017) investigated the effects of the long-term, state-wide Florida Critical Teacher Shortage Programme (FCTSP) designed to *increase the supply of teachers in hard-to-staff subjects*. The FCTSP recipients were of higher quality than non-recipients. The loan forgiveness component was effective, reducing mean attrition rates for middle and high school maths and science teachers by 10.4%

[13] Eurydice (EC, 2018) shows that EU countries control the quality of teacher entrants in different ways and stages: in nearly half of EU education systems graduating from initial teacher education delivers full teaching qualifications, while in others, graduates must meet additional criteria such as a competitive examination, probation periods or confirmation of professional competency.

and 8.9%, respectively. Modest payments (USD 500-1,000 per year) helped reduce attrition. In special education, only payments of approximately USD 2,500 were effective. The cost-effectiveness was high given that a one-time retention bonus of USD 1,200 reduced teacher attrition by 25%, more than loan repayments of comparable magnitude.

Third, Hough & Loeb (2013) examined the effects of *financial incentives to teachers in shortage subjects in disadvantaged schools.* Under the Quality Teacher and Education Act (QTE) of 2008, 1,611 teachers in the San Francisco district received a pay rise (USD 500-6,300), a once-off bonus of USD 2,000 and a retention bonus. The pay rise improved the district's attractiveness in the local labour market and increased the quality of new-hires as measured by student achievement in English. There was no difference in the retention rates of QTE teachers and counterparts.[14]

Fourth, Falch et al. (2010; 2013) studied the centrally determined *wage premium for teachers* in Norway in the 1990s and early 2000s, identifying the wage effect *on schools with severe recruitment problems* in a specific region. The wage premium of about 10% increased recruitment by 30%, with responsiveness varying by age and gender. The study did not address cost-effectiveness or student achievement.

Table 2: Cost-effective ways to enhance teacher recruitment - financial incentives

Approach	Authors	Evidence base	Effectiveness	Costs
Federal government bonuses to the best teachers to move and stay in low-performing schools (US)	Glazerman et al., 2013	**High**	**High**	**Low**
State-level loan forgiveness, tuition reimbursement and retention bonuses for teachers in high-need subjects (US)	Feng Li & Sass, 2017	**High**	**High**	**Low**
District-level salary increases, bonuses and retention bonuses to teachers in shortage subjects in disadvantaged schools (US)	Hough & Loeb, 2013	**High**	**High**	**Low**
Increasing salaries: National wage premium for schools with teacher shortages (NO)	Falch, et al., 2010, Falch, 2013	**Medium**	**Medium**	**Medium**

[14] The reason could be the low level of incentives or the fact that the policy took place during the recession with low labour mobility.

3.1.2. Improving working conditions and wage policies

What the evidence shows

Leadership approach is the most important working condition shaping teachers' decisions to remain or to stay in their profession and is often more important than their salary (Ladd, 2011; Barnett Berry et al., 2019; Ingersoll et al., 2017). The 'shared/distributive leadership' model is better able to sustain teachers in the profession. This relationship is even stronger in the 'hard-to-staff schools' (Darling-Hammond et al., 2019). In particular, a collective sense of responsibility (shared/ distributed leadership) was considered essential when deciding whether to leave a school or not. Overall, compensating for the disadvantage of some schools by allocating additional teaching staff is insufficient to close the gap in student performance based on socio-economic status, as the quality of teachers also needs to be considered (OECD, 2018 cf. OECD, 2019). Moreover, there is evidence that a stronger focus on retention than on recruitment is cost-effective (Ingersoll and Smith, 2004; Doherty, 2020).

Inadequate working conditions undermine the professional status and make it difficult and costly to recruit new teachers (Ingersoll, 2001; Doherty, 2020). Moreover, increased recruitment is not likely to solve the turnover problem as many teachers are leaving schools because of poor leadership (ILO, 2021), their professional status, increased job expectations and the working environment being defined in social terms (Ingersoll, 2017; Sutcher, Darling-Hammond and Carver-Thomas, 2016; ILO, 2021). Recruitment and training are costly, reducing the budget otherwise available for improving teacher working conditions and thus, the retention of qualified teachers (Borman and Dowling, 2008). This explains the recent policy concern with increasing retention as a means of addressing the teacher supply crisis, especially for mathematics and the sciences (Ingersoll, 2017; Sibieta, 2018; Sutcher et al., 2016; Worth and De Lazzari, 2017). Although some education systems have a tradition of differentiating salaries based on the teaching subject, in order to reflect the opportunity costs of pursuing a teaching career, there is no evidence on the cost effectiveness of these policies (OECD, 2019).

Arguments around salaries are often accompanied by considerations related to non-monetary benefits, such as greater job stability, social benefits and overall higher work–family balance (ILO, 2021). However, the two types of benefits, monetary and non-monetary, should not be seen as mutually exclusive. As the process of reforming salaries in education can pose implementation challenges and a degree of uncertainty about the size and distribution of benefits, engagement with stakeholders is key (OECD, 2020c; Liebowitz et al., 2018).

On a different note, the evidence on the impact on bullying on performance and attrition in higher education is increasing. Women faculty members still encounter workplace harassment and gender-based discrimination in promotion. Preventing and addressing mobbing and sexual harassment at a structural level is cost-effective. Across all occupations, there is strong evidence that workplace mobbing has a stronger association with sickness absence than any other work-environmental factor and that it is a risk factor for sickness absence (Niedhammer et al. 2012; Verkuil, Atasay, and Molendijk 2015; Björklund et al., 2020). The financial implications of mobbing among staff members, although significant, have been only tentatively analysed for higher education.

What is missing

The working conditions that matter most are mainly *social* in nature and are strongly related to leadership and collegiality. However, these are difficult to operationalise and to replicate in research designs that are robust in informing policy making.

The high prevalence of work-related stress imposes a financial burden on the public budget in terms of turnover and sickness absence. Nevertheless, the most frequently evaluated interventions for the wellbeing of teachers are directed at the individual level, and so do not tackle the causes of stress at the workplace level. The quality of evidence on *organisational* interventions leading to improvements in teacher wellbeing and retention is low (Naghieh et al., 2015). Further evaluation of the effects of organisational interventions on teacher wellbeing, based on complex-interventions frameworks, using cluster-randomised designs on large samples would be beneficial.

Finally, there is no definitive evidence on the effectiveness of pay-per-performance schemes in general education, with some studies showing they fail to improve student outcomes and others reporting some positive effects (Ferra 2017).

Cost-effectiveness aspects

Overall, cost-effectiveness analyses are rare and context specific. They cannot be easily generalised or used as a base to inform policy choices. Therefore, further evaluations in that sense are needed.

Table 3: Cost-effective ways to improve working conditions

Approach	Evidence base	Effectiveness	Costs
Increasing the quality of administration by 'distributed' leadership approaches	High	High	Medium
Differentiating salaries based on the teaching subject	Medium	Low	Low
Bottom-up accountability systems in general education	Medium	High	Low
Allocating additional teaching staff in deprived schools	Medium	Low	Medium
Addressing bullying in higher education	Medium	High	Uncertain

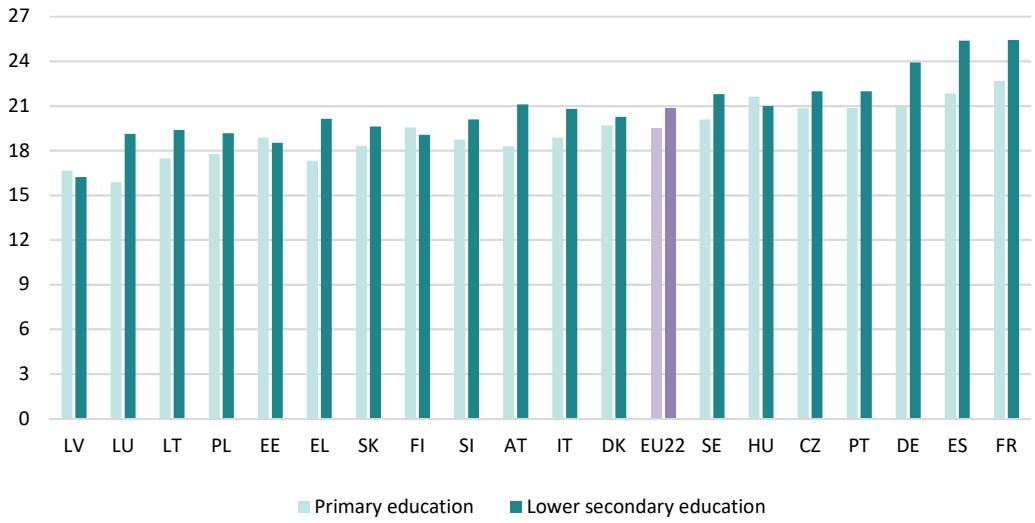
3.1.3. Adapting the class size

What the evidence shows

Although class size is one of the most debated topics nowadays, the bulk of relevant studies focus on the US. They explore predominantly the impact of the STAR (Student/Teacher Achievement Ratio) experiment in which students were randomly assigned into small classes from 13 to 17 students per teacher, regular classes from 22 to 25 students per teacher, and regular-with-aide classes with 22 to 25 students with a full-time teacher's aide. Overall, the empirical output indicates that a smaller class size has a beneficial short-term impact by significantly increasing performance on standardised tests in comparison with regular classes after one year of policy intervention (Krueger, 1999), along with a long-term effect on college completion, earnings, wages, etc. (Schanzenbach, 2014).

Looking at the EU, according to the most recent data for the OECD, in 2019 the average class size was 19.5 students in primary education (ISCED 1) and 20.9 students in lower secondary education (ISCED 2) as figure 4 shows.

Figure 4: Average class size, 2019[15]



Source: OECD, 2021. Notes: data for Luxembourg refers to year 2017; data is not available for Belgium, Ireland and the Netherlands; the EU average refers to the 22 EU Member States which are OECD members.

In Europe, the empirical evidence produces mixed results, as indicated by Leuven and Oosterbeek (2018) in their literature review. Half of the 30 studies under review show that smaller classes have a beneficial impact on education outcomes, mainly measured in terms of mathematics and reading scores. This includes studies in Denmark, France (for disadvantaged areas), Sweden, and Poland (6th graders). On the contrary, the effects of class size on academic performance are negligible or not significant according to studies on compulsory education in Italy, the UK, and Norway.

This following review summarises the latest findings of relevant studies focusing mainly on European countries since 2015. The majority of the studies are country specific and use a quasi-experimental design, which limits the validity of the results but improves their comparability.

In these studies on Europe, the average size of compulsory education classes being examined varies from 9 to 26 students. The evidence for compulsory education is mainly on the impact of class size on student performance measured by the results of standardised assessments such as PISA, TIMSS, PIRLS, and national exams. The effects on the drop-out rate and repetition rate have also been explored. Another strand of the literature focuses on the link between class size and teachers and teaching approaches.

Effects of class size on students' academic outcomes

Smaller classes improve academic performance for students from lower socio-economic backgrounds as well as those with special education needs (SEN) at different educational levels (Ecalle et al., 2019; Capucha et al., 2017; Kara et al. 2021; see, also Zyngler, 2014). Reduced primary-school classes of no more than 12 students in schools in zones with specific educational needs in France show higher

[15] The average class size in all private and public institutions.

performance in reading and spelling in comparison with the normal-sized classes of 20-25 students (Ecalle et al., 2019, Andreu et al., 2021). A reduced class size of 10.5 students on average in Grade 1 is found to increase literacy scores (Bressoux et al., 2019). However, one year in a small class does not lead to longer-term benefits. Bressoux (2017) points out that the positive effect of reduced classes is stronger for low achievers, for students from lower socio-economic backgrounds and those in priority educational areas. Fredriksson et al. (2014) examine upper primary school classes in Sweden with an average size ranging between 15 and 30 students. In larger classes disadvantaged students find it difficult to follow the teacher especially in the case of whole class teaching, owing to greater levels of home responsibilities, a greater likelihood of moving school, and less parental support relative to the children of high-income parents.

Student outcomes in multi-grade classes appear to depend on the class composition. Fifth graders exhibit poorer test scores in numeracy compared to their peers in single grade classrooms in Italy. According to the authors, this is probably due to their interaction with students from lower grades (Checchi and Paola, 2018). Lower grade students in Norwegian junior high schools gain from sharing the classroom with more mature peers from higher grades (Leuven and Ronning, 2014).

For regular compulsory education, the evidence on the impact of class size on student achievement is mixed, and generally no data is provided on class size for the schools under study. Overall, where a positive effect of reduced class size is found, it is generally small in size (Hattie, 2017; Jepsen, 2015). Li and Konstantopoulos (2016) indicate that a one-student reduction in 4th grade classes in Romania and Slovakia would increase student mathematics performance by about 4.5 points as measured by the TIMSS scale. Moreover, class size reductions have been associated with slightly increased mathematics achievement among 4th graders in Cyprus as well as in reading in Romania whereas for the other countries smaller classes make no difference (Konstantopoulos and Shen, 2016; Shen and Konstantopoulos, 2017). Smaller classes increase student retention but are also associated with lower performance in national high-stakes standardised assessments in Portugal, as a result of the Portuguese national educational policy “Programa Mais Sucesso Escolar” (PMSE) (Barata et al., 2015).

In Denmark, studies suggest that larger classes modestly reduce test scores at primary school level but not at the lower secondary level (Nandrup, 2016). The average class size is 21-22 students while the range is 14 to 28 students. Based on a review of 127 studies for 41 countries, Filges et al. (2018) conclude that in the non-STAR studies reduced class sizes have on average a small positive effect on achievement in reading but not in mathematics, at compulsory education levels.

Some studies suggest that it is possible to identify a class of optimal size in terms of student performance (Mazrekaj et al., 2021). The classroom which maximises the performance of Greek high school students, taking into account the associated costs, is found to have 22-23 students (Kedagni et al., 2021).

For higher education smaller classes increase student performance for STEM in contrast to non-STEM subjects (Kara et al., 2021), and for mandatory but not elective courses (Karas, 2021). However, as different academic programmes and subject fields have been examined, it becomes difficult to identify common trends and draw conclusions.

Effects of class size on teachers and teaching

Small classes allow for increased instructional time (owing to fewer disruptions and less classroom management time), more intensive teacher-student and student-student interactions, higher personal and academic support as well as better

emotional connections and identification of students with the class and the school community (Finn, 2019). However, smaller classes might not improve student performance if the teaching methods have not been tailored to the size of the class (Konstantopoulos and Shen, 2016) or students are taught by inexperienced teachers (Bressoux et al., 2019; Dieterle, 2015).

Larger classes might lead to poorer class management, instruction and teaching strategies among pre-service teachers and those with less than three years of experience (Maulana et al., 2017; Van der Pers and Helms-Lorenz, 2019), bigger or greater numbers of groups, as well as pressure on space and resources. Blatchford and Russel (2019) point out that larger groups resulting from bigger classes comprising at least 31 students in the UK might lead to reduced individual attention by the teacher, less differentiation of work and less work of lower quality. Where there is wide variation in students' characteristics and behaviour, teachers might experience difficulties in making their teaching decisions. There is a positive though small effect of classes of 21-25 students – compared to smaller classrooms of 15-19 students – on teachers' burnout measured by exhaustion and lack of accomplishment especially for primary subject teachers (Saloviita and Pakarinen, 2021). The number of students with special education needs and intensive support needs in the class, the school size, and the availability of teaching assistants are among the factors contributing to teacher burnout. Pedagogical approaches appropriate for larger classes in higher education include peer learning combined with technology usage (Bozzi et. al., 2021), collaborative learning using wikis (de Ariba, 2017), and experiential learning using performative pedagogy (Donovan and Hood, 2021). Other approaches identified in the research include student-centred instead of teacher-centred approaches and dividing students into smaller groups. Individual guidance and high student learning engagement could be achieved in primary classes with more than 20 students.

What is missing

Our systematic review of the relevant studies identified the following important areas where more robust evidence is needed for the EU Member States.

First, there is a need to evaluate the costs and benefits associated with class size reductions/increases. Existing studies focus predominantly on the link between class size changes and academic outcomes. However, it is important to consider that adapting class size might involve higher pressure on education spending than other policy options, such as improving teacher quality (Normore and Ilon, 2006). Moreover, current online education settings should be also considered in future analysis to evaluate the cost-effectiveness of reducing/increasing class size.

Second, while some studies suggest an optimal class size in compulsory education, there is still not enough evidence in this regard.

Third, the review shows that more evidence is needed on the impact of class size on student achievement, and teachers and teaching approaches across EU Member States in Central and Eastern Europe (2004).

Cost-effectiveness aspects

Our literature search resulted in only two studies presenting estimates of the monetary costs related to class size changes.

First, Kedagni et al. (2021) evaluated the monetary impact of decreasing and increasing class sizes in Greece, taking account of the costs of hiring and firing. They estimated that a rise in teacher wages of 50% would increase the optimal class size by two students whereas GPA would fall by 0.3 GPA points. Class size caps might be costly even if they are set well above the average level of the class size since schools

are expected to add a class before the cap is reached in the case of volatile enrolment and large adjustment costs.

Second, Mucharreira et al. (2019) estimated additional gross and net costs associated with the increasing number of classes and hence teaching hours in Portuguese public primary and secondary education in 2017/18. The total net costs reflecting both the additional expenditure and the associated additional benefits from direct and indirect tax contributions to the State budget are 30% lower than the gross costs.

On the basis of the available evidence, we estimate the cost effectiveness of the following four approaches to class size (table 4). A description of the main studies examining the impact of class size in primary and secondary education is presented in table 5.

Table 4: Cost-effective ways to adapting class size

Approach	Evidence base	Effectiveness	Costs
Reduced classes for disadvantaged students and SEN students (primary, secondary education)	High	High	High
Training teachers in effective pedagogical approaches according to the class size (primary, secondary, higher education)	Medium	High	Medium
Multigrade classes (primary, secondary education)	Low	Medium	Medium
Optimal class size for regular classes in compulsory education (20-23 students) (primary, secondary education)	Low	High	Medium

Table 5: Effectiveness and Efficiency of the Class Size (CS) Policy in Primary and Secondary Education in Europe in recent empirical studies

N	Study	Indicator for education quality	Average class size	Sample	Effect of class size
1	Bressoux, et al. (2019)	Rate of change in literacy score at grade 1 and 2	10.5 students in reduced class; range 8-12, 21.3 students in full class; range 15-27	France, schools in priority educational areas, 1st grade, 2002-2003, 81 reduced and 68 full-size classes	Small classes have better results in literacy skills. At the end Grade 1 a reduction in class size of one child increases the score by 2%. At the end of Grade 2, the effect has faded.
2	Ecalle et al. (2019)	Literacy skills (reading, spelling), numeracy	No more than 12 students in reduced class 20-25 students in full class	France, schools in zones with specific educational needs, 1st grade, 2002-03	Reduced classes show higher scores in reading and spelling. The effect is smaller in comparison with the high costs incurred for recruiting additional teachers in disadvantaged areas.
3	Li & Konstantopou-los (2016)	Mathematics achievement, TIMSS, 2011 results	from 19 (Austria) to 23 (Spain) students	4th grade students, 14 EU28 countries (Austria, Croatia, Czech Republic, Denmark, Germany, Hungary, Italy, Lithuania, Malta, Portugal, Romania, Slovakia, Slovenia, Spain)	Student achievement increases as the CS decreases in only two countries - Romania (av. CS 20) and the Slovak Republic (av. CS 19.7). A one-student class size reduction in 4th grade in Romania and Slovakia would increase student mathematics performance in TIMSS about 4.5 points.
4	Shen & Konstantopou los (2017)	Reading achievement, PIRLS, 2001, 2006, 2011 results	from 21 (Italy) to 24 (Hungary) students	4th grade students, 8 EU28 countries (Bulgaria, Germany, Hungary, Italy, Lithuania, Romania, Slovakia, and Slovenia)	The class size effects on reading achievement are not significant across countries and years. One exception was Romania (CS 22.3) in 2001 and 2011 when a one student reduction in CS increases reading performance in PIRLS by 5-7 points on average.

5	Konstantopoulos & Shen (2016)	Mathematics achievements, TIMSS, 2003 and 2007 results	22 students for 4th grade, 24-26 students for 8th grade	Cyprus, 4th grade and 8th grade students	No significant relationship between CS and mathematics achievement in the 8th grade. A one student decrease in CS increases the test score by 0.02 units in the 4th grade, driven mostly by males. Social background measures such as higher parental education and items in the home are beneficial and significant for performance.
6	Nandrup (2016)	Achievement in mathematics, physics, chemistry, reading, 2009/2010 and 2011/12	21-22 students mostly in range from 14 and 28 students	Denmark, students from 2nd to 8th grade	Students in grades 2 and 6 may benefit from small classes but the effect is small. Class size does not matter for 8th graders' achievement.
7	Barata et al. (2015)	Student achievements in the core subject areas (Mathematics, Portuguese, and English) and on external standardised measures; retention rate		Portugal, compulsory schooling (1st – 9th grade), 123 intervention schools and 252 comparison schools in the Portuguese national educational policy "Programa Mais Sucesso Escolar" (PMSE), 2009-2013	Retention increases by 5% in intervention schools in the first year but no significant differences on average in the second year. Performance on the 9th grade standardised assessment is 0.20% for mathematics and 0.17% for Portuguese lower for the students in the intervention schools. No significant differences in the 6th grade results.
8	Saloviita & Pakarinen (2021)	Teacher burnout	small CS 15-19 students, medium CS 20 students, large CS 21-25 students	Finland, primary education, 4567 primary school teachers, 2017	The teachers in the larger classes had higher rates of exhaustion than those in the smaller ones especially subject teachers. In general, the associations found in the study are rather small.
9	Mazrekaj et al. (2021)	Mathematics test score	19 students, range 1 – 32 students	Belgium, Flemish primary education 1st to 6th grade	A CS of 20 students minimises underachievement. In larger classes (over 20 students) a CS decrease reduces underachievement. In smaller classes (below 20) an increase in CS also decreases underachievement.

10	Kedagni et al. (2021)	Achievement measured by GPA points, 2001-2013	18 for rural and 23 for urban areas	Greece, 10th grade	A CS of 19 students maximszes attainment. When costs are considered, achievement is maximised at a CS of 22–23 students. It costs 54 435 EUR to drop a class and 58 531 EUR to add one.
11	Mucharreira et al. (2019)	Gross and net costs for additional teaching hours in case of CSR	17 (secondary vocational education); 25 (secondary general education); from 21 to 22 students in primary education	Portugal, public primary and secondary education	The total net costs reflecting both the additional expenditure and the associated additional benefits coming from direct and indirect tax contributions to the State budget are 30% lower than the gross costs.

3.1.4. Raising teachers' pedagogical digital competences

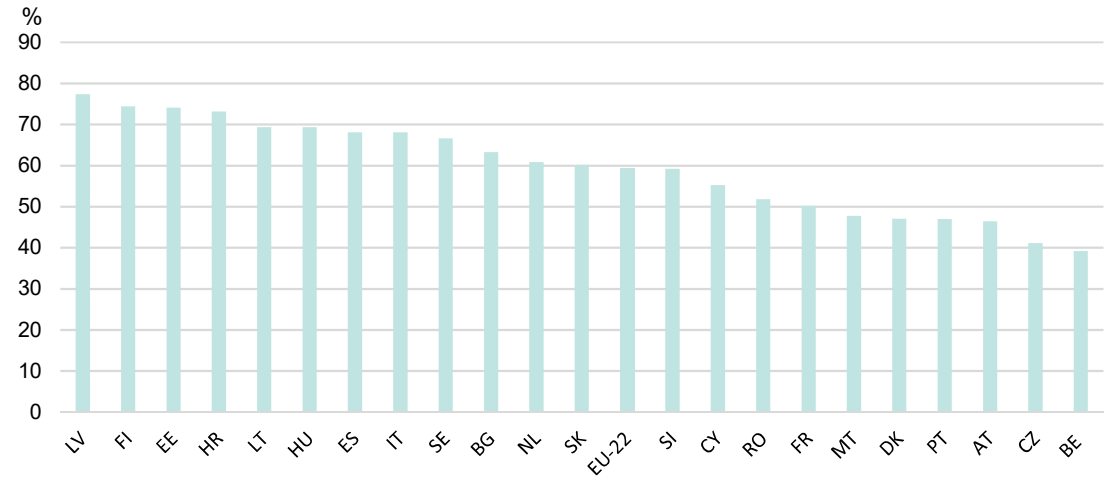
What the evidence shows

Raising teachers' pedagogical digital competences is expected to be associated with improved student outcomes. In particular, OECD data from 2018 revealed that students in schools where teachers have the necessary technical and pedagogical skills to integrate digital technology in instruction perform better in a test than students whose teachers do not possess such skills. This finding might also be driven by selection effects with better teachers in the better schools, which might explain that the difference is not statistically significant when socioeconomic status is taken into account (OECD, 2020b). Using an experiment in Flemish secondary education, Compen, De Witte and Schelfhout (2021) show that teacher engagement in a webinar series generated student learning outcomes 0.39 standard deviations higher than those of students whose teachers did not receive this intervention, thus, confirming the effectiveness of an online teacher professional development initiative that focussed also on digital competences. This effect was found immediately after programme implementation, and it persisted for at least six weeks. As an underlying mechanism, the authors suggest that engagement in the webinar series enhances teachers' self-efficacy.

In addition, raising teachers' pedagogical digital competence may help teachers feel more prepared to teach remotely in particular situations, such as the recent COVID-19 crisis. This way, attainment gaps in education systems may be reduced or even avoided as a (sudden) change to remote learning will not penalise students whose teachers would otherwise not use or feel comfortable to use digital technology in the classroom (OECD, 2020a). Meester (2021) showed that adaptive practicing software mitigated, or even reversed, the negative effects of school closures on mathematics learning. This contrasts to significant learning deficits that have been observed in education systems where teachers have less digital competences (Gambi & De Witte, 2021). If digital tools effectively succeed in mitigating the attainment deficits during school closures, raising the digital competences of teachers, and consequently fostering the use of digital tools, would result in significant welfare gains at both the individual and societal levels (Maldonado & De Witte, 2021).

Despite the benefits of raising teachers' pedagogical digital competences, there is significant variation in professional development on the topic of ICT and skills for teaching. Using Talis (2018) data, we show the variation between Member States in Figure 5.

Figure 5:'ICT skills for teaching' as a topic in professional development of lower secondary teachers who attended at least one type of CPD activity, in 2018 (%)



Source: OECD, Talis 2018.

Moreover, while many approaches have been developed that focus on improving the pedagogical digital competences of teachers, sound empirical evidence on the effectiveness of these approaches is scarce. Several literature reviews have pointed to the lack of high-quality studies and the need for more (controlled) evaluations (Kay, 2006; Lawless & Pellegrino, 2007; Yurtseven et al., 2020). In particular, the majority of the extant evaluations have been based on qualitative research, examining the effectiveness of one approach rather than comparing different approaches against each other. Evidence supporting one approach over the other is thus missing.

Besides, with a few exceptions (e.g., Compen et al., 2021), studies have mostly focussed on changes in teacher outcomes rather than student outcomes. Improving student outcomes, however, is one of the ultimate goals of pedagogical digital competences training. Nonetheless, existing (qualitative) studies provide us with insights into which approaches are available and the reasons why some approaches might succeed or fail (Tondeur et al., 2012). Nevertheless, we cannot draw strong conclusions from these existing studies due to the lack of causal evidence.

Below, we discuss the different approaches. A distinction is made between approaches identified for pre-service teachers and in-service teachers.

Approaches identified for pre-service teachers

Teacher education programmes are a natural place to start preparing teachers to integrate technology in the classroom (Kay, 2006). This has resulted in the development and evaluation of various approaches in teacher education programmes. Four main approaches were found in the literature, i.e., a one-shot workshop (e.g., Reisoğlu & Çebi, 2020), a stand-alone technology course (e.g., Angeli & Valanides, 2009; Lee & Lee, 2014), a technology-infused approach (e.g., Admiraal et al., 2017; Banas & York, 2014; Buss et al., 2015; Tondeur et al., 2017), and an integrated approach (e.g., Shinas et al. 2015; Mouza et al., 2014). One-shot workshops are primarily used to help pre-service teachers in key areas, whereas stand-alone technology courses teach pre-service teachers a wide range of computer skills. Although the former approach saves time, the set of digital competences teachers learn might be limited. A technology-infused approach implies one step further than a stand-alone technology course. In particular, rather than learning about digital technology, pre-service teachers learn about methods with digital technology during a methods course. Finally, an integrated approach implies that pre-service teachers are simultaneously enrolled in a technology course, a methods course, and a field experience, which provides them the opportunity to apply the content of the courses in a classroom setting. In the reviewed studies, (stand-alone) technology courses and methods courses were usually implemented over the course of one or two semesters, while field experiences appeared to take up to three weeks.

Regardless of the approach used, we identified several re-occurring strategies across the different studies. The strategies were consistent with the Synthesise Qualitative Data (SQD) model (Tondeur et al., 2012). Using a "meta-ethnography" approach to review 19 qualitative studies,[16] Tondeur et al. (2012) developed the SQD model including key strategies at the classroom level for the pedagogical digital competences training of pre-service teachers: (1) aligning theory with practice (to make pre-service teachers understand the reasons behind using digital technology); (2) using teacher educators or mentor teachers as a role model (to motivate pre-service teachers); (3) reflecting on the role of technology in education (by using discussion groups, observation, and writing in order to change pre-service teachers' attitudes); (4) learning technology by instructional design; (5) collaborating with peers,

[16] A "meta-ethnography" approach is an interpretative (rather than aggregative) strategy to synthesise qualitative data.

teacher educators, and mentor teachers (by discussing and sharing concerns); (6) scaffolding authentic experiences with technology (via field experiences); and (7) providing continuous feedback. The majority of the studies evaluating a specific approach included one or several of the above-mentioned strategies.

Approaches identified for in-service teachers

Following the classifications by Lawless and Pellegrino (2007) and Major and McDonald (2021), we identified three main approaches to enhance the pedagogical digital competences of in-service teachers, i.e., mentoring or coaching, online training (e.g., Rienties et al., 2013), and formal professional development including train-the-trainer activities, workshops (e.g., Reisoğlu, 2021), and teacher design teams (e.g., Koh et al., 2017). Mentoring or coaching models are focused on the differing objectives and needs of individual teachers. The support can be provided not only by professionals or technology-savvy colleagues but also by students or pre-service teachers (e.g., Liu et al., 2015). By linking in-service teachers with pre-service teachers and supporting them, both might benefit from this type of activity. Online training tends to be a less costly and more larger-scaled intervention and offers teachers flexibility and independence. However, such training may fail to provide teachers with sufficient opportunities to engage with specific pedagogical content. Related to formal professional development, train-the-trainer activities refer to the practice of initially training a group of teachers who subsequently teach a new group of colleagues. While such practice can scale up smaller interventions, Lawless and Pellegrino (2007) argue that they may fail to account for the individual needs of teachers. One-shot workshops are increasingly disfavoured in the literature since they are often too disconnected from regular classroom practices and do not provide opportunities for follow-up learning or feedback. Teacher design teams, on the other hand, allow teachers to learn how to use specific technologies within the context of their curricular needs by collaborating with peers on design tasks (e.g., (re)designing a lesson plan or course). Each approach clearly has its strengths and/or weaknesses. Yet, as argued by Lawless and Pellegrino (2007), it remains unclear whether the strength of one approach has a larger impact than the strength of another approach since no study has compared the effectiveness of different approaches.

Again, regardless of the approach, the reviewed studies included one or several strategies, which were largely consistent with key features of other teacher training programmes. What might be specific to the in-service training is the domain-specificity of an approach (Voogt et al., 2013) and the building of (online) communities within and across school settings (Lawless & Pellegrino, 2007). For the different strategies to be effective, specific conditions must be met. For instance, in-service teachers will only benefit from collaboration and feedback from peers if they are sufficiently supported and motivated to exchange information with each other (Reisoğlu, 2021; Rienties et al., 2013).

What is missing

Although raising teachers' pedagogical digital competences is expected to be associated with improved student outcomes, most studies focussed on changes in teacher outcomes rather than student outcomes. Improving student outcomes, however, is one of the ultimate goals of pedagogical digital competences training. The existing literature provides us with theoretical insights into which approaches are available, the reasons why some approaches might succeed or fail, and a mainly qualitative evidence base. However, there is in general a lack of quantitative evidence that relies on identification methods that allow for causal interpretation, and evidence that can be interpreted in standardised effects such that the (cost) effectiveness of professional development initiatives can be compared.

Cost-effectiveness aspects

Multiple approaches and strategies exist to enhance the pedagogical digital competences of both pre-service and in-service teachers. However, comparing the effectiveness of the different approaches is challenging because the evaluation studies (1) were mostly based on qualitative research, (2) usually examined the effectiveness of one approach only, and (3) used different outcome measures (such as teachers' opinions, changes in TPACK values, students' course evaluations, actual technology integration in class, self-efficacy beliefs, and more). Accordingly, it is not possible to identify a single effective approach if we look at the "effects"-side only. It is important to also consider the "estimated costs"-side. As earlier literature did not make the costs explicit, we estimated the costs based on the duration (i.e. next to direct wage costs, there are also opportunity costs), the scale of the intervention, the mode of the intervention (e.g. face-to-face, online), the number of instructors, the need for field placements, and the time to develop the initiative.

While higher effectiveness is expected for the more advanced technology-infused and integrated approaches, these approaches may also come at a higher estimated cost than one-shot workshops or stand-alone technology courses. For instance, an integrated approach requires finding (technology-rich) field placements for pre-service teachers and multiple instructors to teach the different courses.

Next, consider different approaches for in-service teachers. While approaches such as mentoring or coaching and teacher design teams are expected to be effective because of the contextualised and personalised nature, these approaches may also be more costly than other approaches. Specifically, they are usually implemented over a longer period of time and/or at a smaller scale (i.e., a one-on-one or small-group setting). As a solution and as proposed by Yurtseven et al. (2020), integrating the latter approaches in online settings (in order to reach a larger audience) might be a more cost-effective way of raising the pedagogical digital competences of in-service teachers. This remains to be tested.

Table 6: Cost-effective ways to raise the PDC of pre-service teachers

Approach	Examples of Evidence	Expected effectiveness	Estimated costs
One-shot workshop	Reisoğlu & Çebi, 2020	**Low** - Less likely to include multiple SQD strategies - Students learn limited range of computer skills	**Low** - Short duration - Across or within institutions - Face-to-face or online - One (or multiple) instructor(s)
Stand-alone technology course	Angeli & Valanides, 2009 Lee & Lee, 2014	**Low to medium** - Less likely to include multiple SQD strategies (e.g., less likely to teach students how technology intersects with pedagogical and content knowledge) - Students learn a wide range of computer skills	**Low to medium** - Long duration - Within institutions - Face-to-face - One (or multiple) instructor(s)
Technology-infused approach	Admiraal et al., 2017 Banas & York, 2014 Buss et al., 2015 Tondeur et al., 2017	**Medium** - More likely to include multiple SQD strategies - Effects depend on skills of methods instructor	**Medium** - Long duration - Within institutions - Face-to-face - One (or multiple) instructor(s) who has both knowledge about digital technology and the subject area
Integrated approach	Shinas et al. 2015 Mouza et al., 2014	**High** - More likely to include multiple or all SQD strategies - Effects depend on whether field placement is technology-rich	**High** - Long duration - Within institutions - Need for field placements - Face-to-face - Multiple instructors and teacher mentors

Note: The effectiveness of the different approaches is not derived from (causal) empirical evidence but is based upon our expectations and findings of previous (qualitative) research.

Table 7: Cost-effectiveness ways to raise the PDC of in-service teachers

Approach	Examples of Evidence	Expected effectiveness	Estimated costs
Mentoring or coaching	Liu et al., 2015	**High** - Adapted to individual curricular needs of teachers - Both mentors and mentees may benefit from training	**High** - Within institutions - Face-to-face - "One-on-one" setting (small scale)
Online training	Rienties et al., 2013	**Medium** - Timing and location flexibility - Fewer opportunities to engage with specific pedagogical content	**Low** - Across institutions - Online (large scale)
Formal professional development – **Train-the-trainer**	Lawless & Pellegrino, 2007	**Medium** - Guidance by a colleague may be more credible and relevant - Potential failure to account for local needs and provide relevant training in specific context	**Low** - Across or within institutions - Scale up smaller intervention, reaching a large audience
Formal professional development – **One-shot workshop**	Reisoğlu, 2021	**Low** - Disconnected from regular classroom practices - No opportunities for follow-up learning or feedback	**Low** - Across or within institutions - Short duration
Formal professional development – **Teacher design teams**	Koh et al., 2017	**High** - Includes multiple key strategies: learning instruction by design, collaboration, reflection - Adapted to curricular needs of teachers - Opportunity to build communities of colleagues	**Medium to high** - Across or within institutions - Long duration - Small groups of teachers (small scale)

Note: The effectiveness of the different approaches is not derived from (causal) empirical evidence but is based upon our expectations and findings of previous (qualitative) research.

3.2. Digital learning

Key policy conclusions:

- *The use of digital technologies for teaching and learning can offer many opportunities,* when properly planned and designed. However, *mitigating the risks of digital exclusion or inappropriate use of technology is vital.*
- The *impact of digital learning on student attainment depends to a considerable extent on which technologies are selected for use and on how they are implemented in the classroom*. This means that process factors are probably more prominent than structural factors. This points to the importance of raising teachers' pedagogical digital competences.
- *Low-tech behavioural interventions that contribute to parental involvement in their children's education also seem promising*. Given their very limited costs, these programmes can be considered as efficient, even with moderate effects on test scores. However, since these programmes rely on behavioural aspects of the relationship between parents, schools and students, their effects might depend on the cultural and institutional context.
- *The design of flexible digital learning approaches and methods in higher education should pay specific attention to the equity issue,* by explicitly taking care of individual learning gaps and needs.
- *More robust evidence is needed in EU countries on digital learning in compensatory education*. Studies on computer-assisted learning should collect data on all costs, including for equipment and maintenance, buying/developing specific software in the language of the country, and teacher training.
- *The European Commission could act as an active promoter of new experiments with digital learning*. Evaluations of the effectiveness of digital learning should include cost assessments, which are still very limited in number.

EU policy framework for digital learning

Digital transformation has transformed society and the economy with an ever-deepening impact on everyday life. The **Digital Education Action Plan 2021-2027**, adopted in September 2020, is the EU's policy framework to support the sustainable and effective adaptation of the education and training systems of EU Member States to the digital age. The Action Plan addresses the challenges and opportunities of the COVID-19 pandemic and offers a long-term strategic vision for high-quality, inclusive and accessible European digital education.

The Action Plan has two long-term strategic priorities: (i) fostering the development of a high-performing digital education ecosystem, and (ii) enhancing digital competences for the digital transformation. In this report, we will focus more specifically on the first aspect: the use of digital technologies in the educational system, which is an important step towards the development of a high-performing digital education ecosystem.

The Action Plan defines a set of key enabling factors that need to be fulfilled in order to achieve the successful transformation of education and training towards digital:

- tackling connectivity gaps;

- tackling equipment gaps;
- supporting education and training institutions with know-how on how to adapt and digitise in an inclusive manner;
- addressing accessibility and availability of assistive technologies;
- fostering closer dialogue on digital education between stakeholders in the economy and education institutions;
- developing guidelines for digital pedagogy, drawn from best practice and experience, and upskilling teachers.

These can be considered the basic building blocks needed to take full advantage of the opportunities offered by digital technologies to education and training.

Setting the scene

Although the digital transformation is relevant for all sectors of education, from early childhood education and care (ECEC), primary, secondary, to vocational education and training (VET), higher education and adult learning, this interim report only focuses on primary and secondary education - including compensatory education, as well as higher education.

In this paper we refer to “digitalisation” as a strategy or process that goes beyond the implementation of technology to imply a deeper, core change to the entire “business model” and the evolution of work. “Digitisation”, on the other hand, is the conversion of analogue to digital, and information and communication technology (ICT) are technologies used for accessing, gathering, manipulating and presenting or communicating information. According to this definition, digitalisation is a transformative change that affects all aspects of modern social life, including education, organisation, communication, and work.

While focussing on the digital eco-system, it is worth mentioning that digital skills and competences cover different aspects and levels, as highlighted by the DigComp-Framework. Table 8 shows the different levels of digital skills, starting with information and data literacy and communication and collaboration, which are basic skills, to content creation, safety aspects and problem solving.

Table 8: The Digital Competence Framework for citizens (DigComp 2.1)

Digital Skills				
Information/ data literacy	**Communication and collaboration**	**Digital content creation**	**Safety**	**Problem solving**
• Browsing, searching and filtering data, information and digital content • Evaluating data, information and digital content • Managing data, information and digital content	• Interacting via ICT • Sharing via ICT • Engaging in citizenship via ICT • Netiquette • Managing digital identity	• Developing digital content • Integrating and re-elaborating digital content • Copyright and licenses • Programming	• Protecting devices • Protecting personal data and privacy • Protecting health and well-being • Protecting the environment	• Solving technical problems • Identifying needs and technological responses • Creatively using digital technologies • Identifying digital competence gaps

Source: Carretero et al., 2017

The International Computer and Information Literacy Study (ICILS) indicates that grade 8 students in the participating EU Member States (Denmark, Finland, France, Germany, Italy, Luxemburg, and Portugal) scored on average 509 points, which is slightly above the overall average of 500. Given the nature of some other participating countries, this finding should probably not be overemphasised. Denmark's students scored 553 and has significantly enhanced the performance of their students, while this is not necessarily the case in all other EU Member States. Finland ranked 3rd, following Korea (531), and Germany fourth (518). The evidence shows the share of young people with only basic competences, which do not allow the proficient use of computers and the internet. For example, the share of students with level 1 or 2 proficiency is one third in Germany, more than one fourth in Finland and one-sixth in Denmark, while only a small share achieves the highest competence level. Similar patterns can be observed in other EU countries, apart from Denmark.

Finally, it is important to mention that digital skills do not replace reading and writing as well as numeracy skills, which remain key competencies. People who can hardly read and write and/or do not understand simple sentences will be excluded from the digital world, apart from simple and passive consumption of content. Research reveals that the switch from the passive to active use of digital content and tools is almost identical with the shift from low and unqualified to the medium and, particularly, highly skilled. Ideally, education curricula will capture – and combine – general and digital literacy skills. Therefore, the use of digital technologies in education serves two purposes: developing digital literacy skills, and fostering the acquisition of key competencies and knowledge.

The cost side of the digitalisation challenge is also worth investigation. With this, we mean both recurrent expenses (e.g. software licences, internet access, data bundles, ets), and investment. Whatever the concrete nature of division into investment and recurrent expenses is, the follow-up costs remain substantial, since they also comprise the development and production of content in its various forms.

Ultimately, the proper use of digital equipment, tools as well as learning management systems requires teacher pre- as well as in-service training, which demands that teacher training institutions (often higher education institutions for pre-service training and specific teacher training centres for in-service-training) are equally well-equipped and the trainers are trained accordingly.

In the light of the implications and overall benefits of digitalisation on the whole private as well as working life, it appears that the question is not, whether to invest or not, but what are the minimum – or necessary – requirements and standards to aim for.

The effectiveness of digital education is in itself a complex and multifaceted issue that can be divided into a number of distinct research topics. Our work has identified topics such as a model and cost assessment for adequately equipped and connected classrooms, the development of digital learning content, the use of learning analytics to increase learning outcomes, the impact of artificial intelligence on learning, quality assurance of online assessment and degrees, and effects of digital use in homes on learning outcomes, just to mention a few. Developments in the area of educational technology have been rapid and several of these topics are relatively new and lack a solid research base.

For this interim report, we have focused on three of the most important and central topics in this area, namely the knowledge base regarding the effectiveness and efficiency of digital learning in school education, compensatory education and higher education.

Although the use of digital tools in school education is a much-researched area, the extent of effectiveness and efficiency in digital learning has received less attention. There seems to be a consensus among practitioners and scholars that digital tools

have benefitted the efficiency and effectiveness of schools´ daily organisation, particularly in supporting administrative personnel in performing administrative tasks (e.g., financial management) and the daily organisation of the school (e.g., planning of the rooms). When it comes to digitalisation at the level of the direct learner/teacher relationship, the experiences are more ambivalent. On the one hand, many education institutions are able to digitise, and the impact of digital technology on all aspects of life can be developed to build important digitalisation competences. On the other hand, we see a range of educational benefits from physical presence and interaction that cannot easily be transferred to a digital platform, and teacher competence development is a key issues.

Research in the area of school education can be categorised into two broad categories. The first primarily addresses the effectiveness or efficiency of digital learning on student academic performance by comparing innovative digital instruction with traditional instruction (De Witte & Rogge 2014). The second examines the relationship between ICT use and student learning outcomes using cross-sectional data, especially large-scale survey data (Skryabin et al. 2015).

While there is still limited robust evidence on the impact of the use of digital tools within schools, there is much less evidence on how digital tools can be used out of the classroom, i.e. outside of the standard curriculum and activities performed in school, in particular for compensatory education. Research has shown that policies such as intense tutoring may help increase the educational attainment of low-performing students, but they require significant resources (Nickow & al. 2020). However, there is potential to leverage digital technologies to help better connect families, students and schools and to develop compensatory programmes that could be more intensive at a lower cost or reach more students. This has become all the more important during the COVID-19 pandemic, which has forced teachers and schools to increase the use of digital technologies. Nevertheless, the period has also widened the educational gap already existing between high-performing and low-performing students.

Innovations in digital learning were first implemented in higher education, under the assumption that relatively older students can manage the use of technology in a more mature way than students in primary and secondary schools. As a consequence, experimentation and innovations in digital (online) learning where implemented on a wider scale since the early 90s. Overall, this is a policy area in which some conclusions can be drawn about the effectiveness and cost of interventions and programmes.

This paper presents a preliminary assessment of what can be found in the research literature on the effectiveness of digital learning, complemented by professional and expert discussion in order to interprete the available evidence. The area is divided into the following research topics:

Topic 3.2.1	Effectiveness of digital learning in school education
Topic 3.2.2	Effectiveness of digital learning in compensatory education
Topic 3.2.3	Effectiveness of digital learning in higher education

3.2.1. School education

What the evidence shows

While effectiveness denotes the extent to which digitalisation can improve education outcomes, efficiency refers to the extent to which digitalisation can replace traditional instruction methods (e.g., reduce teaching and administrative time) (De Witte & Rogge 2014). More specifically, the impact of digitalisation in student attainment

depends to a considerable extent on which technologies are selected for use and on how they are deployed in the classroom.

The selection of papers were identified using Google Scholars and different search terms including key concepts such as “effectiveness”, “efficiency”, “digitalisation”, “one laptop per child”, etc. Only articles published 2014 or later, and for the sake of transferability of results to today´s European setting only research from European (including Russia) or Anglo-Saxon countries, has been used.

This section focuses on the effect of digital learning on students´ academic performance. Along with the direct effects on students’ academic achievements, the literature encompasses a number of other potential advantages of digital learning (Skryabin et al. 2015). They include, among others, enabling opportunities that benefit students’ reflection and analysis, making it possible for students to work more at their own pace, allowing more immediate and personalised feedback based on a given student’s learning progress and conditions, helping schools and teachers in bridging the gap between students’ in-school and out-of-school learning, and improving students’ attitudes toward digital teaching and learning (Frolova, Rogach & Ryaboca, 2020).

There are few studies of digital learning in school education using large-scale survey data. Having said that, a number of interesting studies build on data from TIMSS 2011, PIRLS 2011 and PISA 2012. For example, Ferraro (2018) shows that the use of ICT at school has a positive and strong impact on mathematics test scores. Drawing on national tests with more than 2000 students in Italy from 2011/2012, Comi et al. (2017) found that the effectiveness of digital learning at school depends on the way in which technology is used by teachers and on their ability to integrate ICT into their teaching process. According to Skryabin et al. (2015), the national ICT development level is a significant positive predictor for individual academic performance. Eickelmann, Gerick & Koop (2016) found that characteristics at the school level, such as the IT equipment used by schools, school leadership, aspects of school goals and educational strategies as well as teachers’ attitudes, play a major role in the integration of ICT into teaching and learning.

The problem with this research, though, is that while the articles were published in recent years, they draw on data that are often 10 years old. In 10 years, a lot has happened when it comes to digital education in European school settings. This is true both when it comes to hardware and software, but also to the digital competence of both teachers and students. Thus, it is difficult to know to what extent the results of this research are still valid.

More resent research seems to focus more on student academic performance by comparing innovative digital instruction with traditional instruction. For example, Arvanitaki & Zaranis (2020) conclude that using digital tools and augmented reality (AR) applications with primary school students has a positive effect on learning geometry as compared to the traditional teaching method. Hubalovsky et al. (2019) confirm that educational objectives can be achieved more effectively for some students using learning analytics. Agelii & Grönlund (2016) show that ICT use must be well integrated into pedagogy to be useful.

In a meta-study of digitalisation of education in modern scientific discourse, Frolova, Rogach & Ryabova (2020) conclude that, among other things, there is a relationship between high academic performance of students and the use of digital technologies.

There are a number of studies which look at the impact of access to technology on student performance. These include Hull and Dutch (2019) who study the results of the implementation of a “one laptop per child” (also called 1:1) programme in a North American school district. They found no impact in the short term, but mathematics scores improved in the medium term (4-5 years). Thus, the difference between the

short-term and medium-term impacts highlights the importance of long evaluation periods for technology programmes.

Studies which include cost assessments are rare. An exception is a recently published Swedish study of "a laptop to every child"-programmes (also called 1:1 programmes) in lower secondary schools in 29 Swedish municipalities (Hall, Lundin & Sibbmark 2021). They find no evidence that these programmes impact average student performance on standardised tests, the probability of being admitted to upper secondary school, or the choice of educational track. However, their analysis suggests that 1:1 initiatives may increase inequality in education by lowering academic performance among students with lower educated parents who cannot support their children in this exercice.

In conclusion, a number of studies suggest increased academic performance due to digital learning in school settings. This relates both to large-scale and small-scale studies. However, most of the large-scale studies available use data that is at least 10 years old, which is problematic in a field with rapid changes both in terms of technological developments and digital competence among teachers and students. This makes it difficult to assess to what extent the results are still valid. On the other hand, technological developments mean better performing and more user-friendly equipment and the digital competence among school staff and students can be assumed to have increased. These developments suggest that the effectiveness of digital learning is likely to have increased over the last 10 years.

Furthermore, although many (but not all) of the articles show positive results on the use of digital learning, the impact on student attainment depends to a considerable extent on which technologies are selected for use and on how they are implemented in the classroom. This means that process factors are probably more prominent than structural factors. This, in turn, points to the importance of raising teachers' pedagogical digital competences.

What is missing

Regarding research on school education, cost assessments are lacking as well as research looking at student learning outcomes using cross-sectional data, especially large-scale survey data from more recent times. Furthermore, if cost assessments are to be useful, there needs to be a common understanding of definitions of key concepts and a common framework for understanding what factors influence the effectiveness and efficiency of using digital tools in education. In short, we need a common language for describing, defining, and measuring education contexts so that we can understand what makes any two schools "similar" in the ways that matter most to the implementation of education technology (EdTech Evidence Exchange, 2021).

Cost-effectiveness aspects

Table 9: Cost-effective ways to foster digital learning in school education

Approach	Evidence base	Effectiveness	Costs
Establish a common understanding of definitions of key concepts, a common framework for understanding what factors influence the effectiveness and efficiency of using digital tools in schools.	High	High	Low
Promote new experiments in designing and delivering digital learning in European school settings, and compare effectiveness	High	High	High

and efficiency in different digital learning programmes or arrangements.			
Finance more evaluations of the effectiveness of digital learning in schools, including cost assessments using well-established methods for collecting cost data.	**High**	**High**	**Medium**

3.2.2. Digital technologies outside the classroom (compensatory education)

What the evidence shows

After reviewing interventions that focus on implementation of digital technologies within schools, here we focus on interventions using digital technologies outside of the classroom in primary and secondary education. These can be classified into three broad categories:

1. *Interventions using Computer Assisted Learning (CAL) to provide practice / tutoring activities outside the class*. The goal of these interventions is to provide an engaging way for students to learn and practice subjects outside of the classroom. The potential gains of using CAL are the direct and individualised feedback that students may receive while working at home.
2. *Interventions that replace in-person tutoring with online tutoring.* These interventions leverage the use of digital tools to provide tutoring in a cheaper way than in-person.
3. *Low-tech behavioural interventions that aim to facilitate the transmission of information to parents.*

In terms of outcomes, most of the reviewed studies focus on the short-term achievement of students. Some limited studies also consider students' satisfaction and motivation. These aspects are equally important as students need to be motivated to perform extra-curricular activities or attend non-compulsory compensatory courses.

Article selection was guided by existing literature reviews (see in particular Bulman & Fairlie 2016, Lewin & al. 2019, Escueta & al. 2020, Sahni & al. 2021), complemented with a google scholar search. The selection of studies and academic papers to be considered here follows three main criteria: (i) published in high-level academic journals or considered as meeting high standards of evaluation by platforms that review educational research (such as What Works Clearinghouse, Education Endowment Foundation or Eric.ed.gov); (ii) evaluation of effectiveness based on quantitative, econometric methods – preferably, using an approach based on Randomised Control Trial (RCT); and (iii) reporting details about the specific digital learning setting implemented. Some non-published papers are also included in the list because they are very recent and/or because they report findings that are specifically related with the most interesting content of this section. We also restricted the analysis to recent studies (2015 onwards) implemented in developed countries. This severely limits the number of available studies.

The list of papers analysed more specifically is detailed in table 1 in appendix.

Computer Assisted Learning (CAL) for homework

The use of CAL for homework allows teachers to select, adapt and review homework done by students, while allowing students to get more tailored content. Three studies using randomised control trial methods across different countries show significant effects of the use of CAL for homework in improving mathematics scores, with effects

concentrated among low-performing students (Roschelle & al 2016 in the US and Bartelet & al. 2016 in Denmark for 7th grades students, Bettinger et al. 2020 in Russia for 3rd grade students). Evidence on the impact of CAL for homework on language skills is more limited and points towards more limited effects on test scores (Bettinger & al. 2020). An interesting aspect of the study by Bettinger et al. is the analysis of the efficiency of the time spent on CAL programmes. In their experiment, using CAL for 20-25 minutes per subject/week has significant positive effects on the test scores and motivation of 3rd grade students, but doubling its time use provides no additional gain. This emphasises the need to better understand the optimal dosage of CAL for use both in and out of the classroom at each educational level. The finding by Agasisti et al. (2017) of a negative association between the intense use of computers for homework and PISA test scores indeed suggests that the use of digital tools may not always have a positive impact on students' learning. Moreover, Bartelet et al. (2016) also show that the application by teachers is key to encourage the use of these digital tools when they are not compulsory. Overall, the use of CAL outside the classroom, and in particular for homework, seems to be a promising tool to help low-performing students, as a complement to traditional learning practices. However, their success depends on the way in which the technology is used by teachers, as well as the quality of software used, the availability of IT equipment at home, and the time devoted to the use of such tools. Moreover, there is very limited information about the full costs of implementing these programmes.

Online tutoring

There is limited robust empirical evidence on the impact of online tutoring with randomised experiments. Evidence points towards a positive effect of online tutoring during the COVID-19 pandemic, when tutoring was useful in reaching students who would not otherwise have access to tutors (Carlana & La Ferrara 2021). This confirms the results of earlier non-randomised small-scale studies, whose results also suggest that providing online tutoring to students is better than no tutoring (Chappell et al. 2015). However, a randomised experiment conducted across UK classrooms that provided online mathematics tutoring, with tutors who were graduates located in India or Sri Lanka, did not yield any significant effects (Torgerson & al. 2016). Overall, while these programmes might reduce the cost of reaching students in some specific settings, there is a lack of evidence on their effectiveness as compared to in-person tutoring.

Low-tech behavioural interventions targeting parents

One promising aspect of ICT use in educational programmes relates to the development of low-tech behavioural interventions that target parents. These interventions provide information to parents with the aim of helping them to engage in activities that will support the development of their children, or to follow more closely their children's school outcomes. Web interfaces where teachers can provide information about grades and absences to parents have been implemented in different countries and at different educational levels, such as in Finland[17], and have been evaluated with randomised control trials in the US and UK. They leverage mobile phone equipment to reach parents through text messages at a very low cost. Interventions at the early stages of education target parents of pre-schoolers or kindergartners by sending them messages aimed at fostering childrens' development. They find very promising results in terms of childrens' later literacy skills, with strongest effects in the bottom ability group (York & al. 2019). Further research

[17] For a description of the system used in Helsinki: https://www.hel.fi/helsinki/en/childhood-and-education/comprehensive/cooperation/wilma/

suggests that personalised text messages that are tailored to the initial achievement level of the child might be more efficient than standard messages (Doss & al. 2019). Interventions at middle school levels focus on providing information to parents about their children's school attendance and homework completion also seem promising. Experiments in the US and UK (Miller & al. 2017; Bergman & Chan 2019, Bergman 2020) found strong effect on students' behaviour and more mixed effects on students' achievement (from limited to very positive).

What is missing

Evidence on the use of ICT outside of schools reveals some promising areas for intervention but also highlights evidence gaps.

- The use of CAL outside the classroom, as for within-school blended teaching, shows great promise. However, the efficiency and costs of such interventions vary greatly, including the costs of initial equipment for schools and families, the existence of free versus commercial software, and the training needed for teachers to be able to best optimise the use of these tools. Most studies include limited assessments of the full costs incurred in the use of CAL. Moreover, most of the evidence comes from the US and the UK, and there is a need for more European-based evidence. There is also a lack of evidence on the optimal duration of use of these programmes at different educational levels, and on their potential use for specific compensatory sessions not directly related to school homework.
- While there is some evidence that CAL can be very useful for compensatory education in developing countries (Banerjee & al. 2007, Muralidharan & al., 2019), there is limited robust empirical evidence on the use of CAL in compensatory courses outside the school curriculum in developed countries.
- Low-tech behavioural interventions that support parental involvement in their children's education, also seem to show some promise. Given their very limited costs (between a few cents when the programme is completely automatised to 5-10 dollars per students), these programmes can be considered as very cost-efficient, even with moderate effects on test scores. However, since these programmes rely on behavioural aspects of the relationship between parents, schools and students, their effect might be dependant of the cultural and institutional context. More research is therefore needed from EU countries, as well as research on how to scale up these programmes at the lowest possible costs.
- In summary, more robust evidence is needed from EU countries. Moreover, studies on CAL should collect data on all costs, including the costs of equipment and maintenance, the cost of buying/developing specific software in the language of the country and the cost of teacher training.

Cost-effectiveness aspects

Table 10: Cost-effective strategies of intervention outside the classroom using digital technologies

Approach	Evidence base	Effectiveness	Costs
Develop experiments to better understand how digital technologies can be used out of the classroom for compensatory education	High benefit of performing causal evaluation	To be assessed	Medium
Develop experiments to better understand	High benefit	To be	Medium

the optimal use of Computer Assisted Learning in education	of performing causal evaluation	assessed	
Develop the use of low-tech behavioural interventions to enhance the communication between schools, students and parents	High	High	Low

3.2.3. Higher education

What the evidence shows

The role of digitalisation in higher education has been identified as a priority topic by the European University Association (EUA), since the publication of its Trends 2018 report. It has been acknowledged that digitalisation is challenging, and it has been transforming the way students learn and institutions plan and deliver educational programmes (this even before the COVID-19 pandemic). The report shows that digital learning is increasingly embedded in higher education institutions, which are promoting a more strategic use of it.

Three main educational outputs might be considered to assess the effectiveness of digital learning in higher education in a comprehensive way:

- Achievement – the skills and knowledge acquired by students, as measured for example through standardised tests
- Satisfaction – related to the students' overall educational experiences, the degree of interaction between students, etc.
- Long-term impacts on employability, by comparing whether students attending digital learning programmes actually obtain benefits in the job market

In this brief review, we report on some key evidence, mostly related to the first output (achievement), which represents the main focus of the academic (empirical) literature. This section addresses the following question: i) is there evidence about the effectiveness of using digital learning in the context of higher education?; and ii) is there evidence on the relative costs of such interventions?

For the specific purpose of this section, we define digital learning in a broad sense, as encompassing all possible uses of technology in teaching activities. Further, a distinction is proposed between (i) online vs blended learning, and (ii) synchronous and asynchronous learning.

Table 11: Modes of digital learning

Online learning All teaching activities are conducted online, and no on-campus activities are included into the teaching experience	**Blended learning** A substantial part of the teaching activities are realised on-campus, with students and instructors conveying in the same place. Indicatively, at least 30% of activities happens on-campus.
Synchronous learning The teaching activity, when conducted online, is conducted through live sessions where the instructor and the students are connected at the same time and specific spaces for interactions are designed	**Asynchronous learning** The teaching experience, when conducted online, is conducted through activities which do not require the students and the instructor to be connected at the same time (e.g. pre-recorded videos, tests, remote cases, etc.)

The area of digital learning in higher education is of paramount importance from a policy perspective, for three main reasons:

- Digital learning has been argued tobe an important mechanism in providing wider access to higher levels of education.
- Widening access to higher education can happen without increasing costs proportionally, under certain hypotheses (so, it can be a cost-effective strategy for increasing the higher education level across the population).
- Digital learning has the potential to create opportunities for disadvantaged students, allowing them to access higher education at lower costs (for example, without living costs, etc.).

The selection of studies and academic papers for review follows three main criteria: (i) published in high-level academic journals, (ii) include an evaluation of effectiveness based on quantitative, econometric methods – preferably, using an approach based on a Randomised Control Trial (RCT), and (iii) report details about the specific digital learning setting implemented. Some non-published papers are also included in the list because they are very recent and/or because they report findings that are specifically related with the content of this section.

Most reviewed studies focus on effectiveness only, with a minority of them examining the cost side, and consider student achievement as the main output.

Several studies demonstrate that blended learning generates (or can generate, under certain conditions) positive effects for student achievement. This is the case when comparing with online-only arrangements for distance learning. Thus, the results for students attending blended courses are comparable with those attending a more traditional, on-campus educational experience (and both modes are associated with higher student results than online-only settings). This finding seems consistent across a variety of contexts (although almost all in the US context) and with different, specific design of the educational experience.

The satisfaction of students is rarely examined, so we cannot assess the impact of digital learning arrangements on this important dimension. Israel (2015), however, reports lower levels of satisfaction for online students (when compared with on-campus students), although there were no differences in achievement across different delivery modes (on-campus or blended).

Much less is known about the costs of providing digital learning. The few studies collecting specific data in this area shows that costs for producing and delivering courses through digital learning might be not so lower than those required in the context of planning and delivering the courses on-campus. Empirical evidence (although very limited) points in a different direction, though. Bowen et al. (2014) identify substantial cost savings, although in the specific context of community colleges in the US. Deming et al. (2015) also suggest that costs can be lower in courses delivered with digital learning. Protopsaltis & Baum (2019) do not find real differences in the cost structures and amount of resources needed to develop on-campus vs online courses. One study deserves attention, though. Chirikov et al. (2020) report findings from Russia, where a digital learning platform has been used for scaling educational offerings for STEM disciplines, with the costs of provision (for students) significantly lower than on-campus alternatives.

3.3. Management, infrastructure and learning environments

Key policy conclusions:

- *Learning environments and their design need to evolve* to respond to changes in teaching and learning, such as the use of ICT technologies or student-centered approaches.
- *Developing common tools or frameworks* for the assessment of current condition and design of new learning spaces to promote students' learning outcomes is highly important.
- *Defining indicators to identify the impact of the physical learning environment on education outcomes* remain a pre-condition for developign such common tools or frameworks.
- Preliminary evidence shows *non-monetary benefits associated with the multiple use of educational facilities* after school operating hours.

EU policy framework for education infrastructure

The need for smart, effective and inclusive investment in education infrastructure has been high in the EU political agenda. The **European Green Deal**[18] states that focus should be placed on renovating schools and hospitals, as the resources saved through building efficiency will be available to support education and public health, and sets the goal of leveraging EUR 3 billion for investment in education infrastructure. At the same time, the **Communication on a Renovation Wave for climate neutrality and recovery**[19] stresses the importance of scaling up investments in building renovation, including in education infrastructure. Finally, the proposal for a new **European Directive on energy performance of buildings**[20] will facilitate the renovation of homes, schools, hospitals, offices and other buildings across Europe to reduce greenhouse gas emissions and energy bills, and improve the quality of life for millions of Europeans.

The **2020 Commission Communication on Achieving the European Education Area by 2025**[21] also envisages actions for *"fostering new sustainable education and training infrastructure and renovating existing buildings ('renovation wave'), thereby creating conducive environments for this change"* under its green and digital transition dimension. In the same Communication, the Commission expresses its willingness to promote the greening of education infrastructure and acknowledges that most school and many higher education buildings are not equipped to face the demand for new competencies and pedagogies. The Communication also specifies that the Commission will provide specific support to local, regional and national authorities to facilitate mutual learning, analysis and sharing of good practices on investment in education infrastructure.

[18] EUR-Lex - 52019DC0640 - EN - EUR-Lex (europa.eu)

[19] https://eur-lex.europa.eu/resource.html?uri=cellar:0638aa1d-0f02-11eb-bc07-01aa75ed71a1.0003.02/DOC_1&format=PDF

[20] proposal-recast-energy-performance-buildings-directive.pdf (europa.eu)

[21] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0625&from=EN

Moreover, within the strategic priority areas of the **Digital Education Action Plan**[22], an effective digital capacity planning is foreseen that *"requires the development and ongoing review and updating of digital strategies addressing technology gaps in infrastructure, devices and developing relevant organisational capabilities in education, including the capacity to deliver hybrid modes of learning and teaching (remote and on-site)."*

Setting the scene

Definition of physical learning environments

The OECD Centre for Educational Research and Innovation (CERI) has been working on "Innovative Learning Environments"[23] and has focused on how people learn and under which conditions and dynamics they can learn better. A **learning environment** is defined by CERI as the interaction of four key elements – learners, teachers or in the ideal world "those engaged in promoting and facilitating learning", content, and resources (facilities and technologies) – through the intervening relational medium of the organisation. The physical learning environment, being an influential element in the complex education process, is included in the OECD CERI framework as one of the four key elements of learning environment - under the heading "resources".

According to the OECD[24], the **physical learning environment** can be defined as the physical spaces (including formal and informal spaces) in which learners, teachers, content, equipment and technologies interact. It can also be defined as the result of interactions between physical resources (learning spaces, material and technology), learners, educators, content, learning leadership, society and policy. The above OECD Framework has defined the concepts of an "adequate", "effective" and "efficient" learning environment

Buildings, classrooms and equipment are crucial elements of learning environments in schools and universities. School facilities are expected to provide a safe, secure, accessible, well-ventilated, well-illuminated, well-connected and well-maintained physical environment, to foster teaching and learning activities.

There are three common elements (explicitly or implicitly) present in all topics that underpin the importance of the area:

- *Budget spent on educational infrastructure*: education state budgets include amounts earmarked for the construction of new educational facilities, or the renovation and maintenance of existing ones. According to a recent CEB report[25], 6% of education expenditures or about EUR 48 billion, were allocated to education infrastructure in Europe in 2017 (based on Eurostat data).
- *Large stock of (aged) school buildings*: educational buildings represent 17% of non-residential buildings in Europe and they are among the oldest: around 75% of educational buildings in Europe were constructed before 1980[26].
- *Effect of physical learning environments on learning outcomes*: well-built and well-maintained infrastructure can have positive effects on student well-being

[22] https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en

[23] OECD Centre for Educational Research and Innovation (2011), *The Nature of Learning: Using Research to Inspire Practice*

[24] OECD (2017), *Framework for the LEEP Module on the Effectiveness and Efficiency of the Learning Environment*, OECD, Paris.

[25] Council of Europe Development Bank (2021), *Constructing Education: An Opportunity not to be Missed*

[26] https://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU(2016)587326_EN.pdf

and learning outcomes. Policy makers are increasingly interested in understanding the link between the physical learning environment and its impact on student performance and learning outcomes. It is assumed that concrete evidence about the impact of learning environments on education outcomes may lead to better informed policy and investment decisions.

The importance of educational facilities is also emphasised by the **UN Sustainable Development Goal 4**[27] about education *("Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all"*) and, in particular, **its target 4.a** *("Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all"*).

The full list of topics covered in this interim report is presented here below:

Topic 3.3.1	Use of school infrastructure after school operating hours
Topic 3.3.2	Allocation of construction, operation & maintenance budget
Topic 3.3.3	Learning environments: impact on pedagogies and education outcomes
Topic 3.3.4	Design of learning spaces
Topic 3.3.5	Management of the education infrastructure network

The first topic **3.3.1 Use of school infrastructure after school operating hours** refers to the use and operation of the buildings after school operating hours. It applies mainly to primary and secondary school and (potentially) VET facilities.

Topics **3.3.2 Allocation of construction, operation & maintenance budgets** and **3.3.5 Management of the education infrastructure network** are related to educational governance and management. Governance and management (planning, supervision, coordination, and implementation) of the education sector and its institutions is an important means of enhancing the quality of educational outcomes.

Policies about the allocation of construction, operation and maintenance budgets range from budgets being allocated to one central entity, to regional administration and to allocations to schools directly. This topic also includes the allocation of responsibilities in relation to the construction, operation and maintenance of education facilities. Decision-making processes underpinning the construction and renovation of schools are key to ensuring that investments in facilities are well designed, target the schools in most need, and yield high-quality and sustainable buildings. Policies about the management of the education infrastructure network relates to the allocation of operational resources and administration of the educational system within and across existing schools and universities.

However, the above mentioned fields cover a variety of issues that are often intertwined and causally linked to each other. Institution type, institutional sector affiliation, decision-making processes, individual influence of students, staff, and stakeholders, managerial initiatives, incentive structures, wages, working conditions, professional recognition and many other mutually related aspects of education governance influence the outputs of education systems.

Topic 3.3.3 Learning environments: impact on pedagogies and education outcomes is an overarching topic, relevant to all other topics, and may guide policy makers and those making investment decisions. The potential for a link between physical learning environments and education outcomes is rooted in two models: the OECD CERI Framework where the building is one of the four key elements that

[27] Link: https://sdgs.un.org/goals/goal4

define the "learning environment"[28] and the Reggio Emilia approach where the school building is regarded as the third teacher in the learning process. Specific evidence is presented in two areas:

- The impact of physical characteristics of classrooms on student outcomes[29]; and
- The impact of different spatial arrangements in classrooms on the learning outcomes of students of low socio-economic status[30].

Finally, topic **3.3.4 Design of learning spaces** addresses key questions, such as "how can we design schools that will be fit-for-purpose in 30 years?"**.** The topic explores building characteristics that support innovative pedagogies, as well as interventions in infrastructure related to:

- Creating/building innovative spaces, new spatial arrangements or teaching and learning settings corresponding to new innovative pedagogies. Such spaces range from indoor innovations (e.g. fab-labs, maker spaces, multi-purpose spaces, break out rooms, space for independent work, common spaces, etc.) to outdoor spaces (e.g. school yards, open sports courts, etc.).
- Providing appropriate lighting, air quality, temperature, acoustics, ventilation, hygiene, running water and accessibility conditions.

3.3.1. Use of school infrastructure after school operating hours

What evidence shows

The size and number of educational facilities - and especially school buildings - across EU Member States constitutes a considerable stock and sizeable public sector asset. Depending on the national context, these school buildings are most certainly not utilised to the same degree as, for example, hospitals. Schools are operational on specific weeks/months of the year, during weekdays and more or less for one third of the day. Therefore, government owned school buildings possess an underutilised potential, in terms of their available space and time:

potential = (available space) X (available time)

There is a copious literature on the *after-school care*, especially for the US, Australia and some European countries. After-school care can be described as the possibility given to students to extend their stay in school after school operating hours, with or without the provision of additional educational activities. Literature in this area has also included analysis of learning outcomes in schools where after-school care is provided and the learning effects for students of lower socio-economic background and/or of minority origin. The development of programmes for this specific after-school period has also featured in the literature.

[28] OECD Centre for Educational Research and Innovation (2011), *The Nature of Learning: Using Research to Inspire Practice*

[29] Barrett, P. S., F. Davies, Y. Zhang, and L. Barrett (2015), *The Impact of Classroom Design on Pupils' Learning: Final Results of a Holistic, Multi-Level Analysis*

[30] Barrett, Peter; Treves, Alberto; Shmis, Tigran; Ambasz, Diego; Ustinova, Maria (2019), *The Impact of School Infrastructure on Learning: A Synthesis of the Evidence,* International Development in Focus; Washington, DC: World Bank

The main difference between the concepts of *"after-school care"* and *"after-school use"* is the target audience: "after-school care" targets only the student population of a specific school unit, while "after-school use" is broader and may target the whole community population.

The use of school infrastructure after school operating hours applies mainly to primary and secondary education buildings. Policy conclusions on this topic could also include building infrastructure serving VET.

With state budgets being challenged in the last few years, it is important to look again at the stock of school buildings as a valuable public asset. It is critical to analyse the possibilities for better utilisation of school buildings in a manner that it will create value to the student population and wider communities. The extended use of school infrastructure will not create savings; however, there are non-monetary benefits associated with such policies. Savings will be created if school buildings are used for activities accommodated in buildings rented by the public sector.

There is limited literature on after-school use, as well as limited information about the benefits of such use. There are a small number of articles/reports that present cases of after-school use of infrastructure, which suggest that a few countries or cities have introduced such policies.

Examples of these policies could be found in Greece (Athens Open Schools), Portugal (Parque Escolar), Belgium, Slovak Republic and Uruguay (+School programme and Summer School programme). Here we discuss the experiences in Greece, Portugal and Belgium.

Greece: Athens Open School

Athens Open Schools was an initiative designed in order to establish and support a network of 25 municipality-run public schools in Athens as self-sustaining centres for learning, culture and social services for the benefit of local communities. The governance and administration of the programme was shared by the Municipality of Athens and Athens Partnership[31], a Special Purpose Vehicle company that was funded to support the Athens Open Schools and other similar programmes funded by donors. The Athens Open Schools operated between June 2016 and August 2019, exclusively funded by donors (the Stavros Niarchos Foundation, SNF[32] and the John S. Latsis Public Benefit Foundation[33]).

During the first year of operation, between June 2016 and August 2017, 14,000 children and adults[34] registered for activities in 25 schools. The benefits of the Athens Open Schools may be grouped into the following categories:

- *Education, training & life-long learning:* there is almost always a learning element in the activities offered – therefore it might be assumed that there is an educational benefit linked to this policy.
- *Well-being:* there may be an improvement in participants' well-being, through providing family support and supporting the work-life balance of parents (children could engage in activities after school operating hours; parents and children could join common activities; and all activities were free)

[31] Website: https://athenspartnership.org/open-schools

[32] Website: https://www.snf.org/

[33] Website: https://www.latsis-foundation.org/eng

[34] The Athens Open Schools programme was open to non-EU citizens [including refugees or migrants] that attended the public schools of Athens and/or resided in the Municipality of Athens.

- *Urban environment and society:* the school becomes the centre of their neighbourhood, the area is revitalised and the community is brought together, resulting in improved neighbourhood cohesion. An additional non-monetary benefit is the potential improvement in citizens' trust towards the Municipality and its services.

Portugal: Parque Escolar

The Parque Escolar programme targets secondary schools across Portugal and is primarily a building renovation programme. The OECD has reviewed the Parque Escolar Programme, as early as 2009 and 2012. As of August 2021, 176 schools have been renovated by the programme. Two of the programme principles are related to design and construction requirements: integration between the various functional areas (teaching and non-teaching areas); and, guaranteed conditions for their integrated operation. Moreover, the third principle of Parque Escolar is about opening up some school areas for use by the wider community and creating functional and safe conditions so that the buildings - during school or after-school hours - can be used by the local community for evening classes, cultural and social events, sports and recreation.

One of the main concepts of Parque Escolar, the *"double ring layout"* concept, allows both school users and the wider community to use school buildings. Opening up the school after school hours would generate income for the school. The spaces that would accommodate this use might be the gym, library, museum, classrooms for adult training and education. The programme also included recommendations about the administration of this operation.

Belgium

"My school, a quality space. Guide for basic education"[35] is a user-friendly guide developed by perspective.brussels, the Brussels Planning Office, to help all stakeholders assess the quality of school spaces and identify improvements to be made. The guide is developed as a manual for renovation of school infrastructure. The quality of school infrastructure is assessed through five major themes that are broken down into 31 criteria. The five themes are: adaptability and flexibility; safety; health and comfort; environment; and openness to the city. The last theme includes information about the operation of some school spaces during after-school hours.

This guide suggests that the sharing of spaces between the school and the community represents a real opportunity for school users and the general public, the inhabitants and users of the neighbourhood. The school being open to the neighbourhood may become a lever for urban development. It may also contribute to the visibility of the school in the city and respect for the neighbourhood through greater ownership of it. The guide addresses the issue of spatial adjustments (in order to allow access to the school from the public space), as well as adapted management methods based on agreements and partnerships.

What is missing

In all above mentioned cases, there is no direct evaluation of the benefits of schools being open after school hours for the student population and the community in general. It would be worth assessing the costs and benefits of such policies.

[35] Link: https://perspective.brussels/sites/default/files/documents/mon_ecole_un_espace_qualite_0.pdf

Cost-effectiveness aspects

In order to create a framework for the evaluation of after-school use of the school infrastructure policies, specific goals and indicators should be linked to the effectiveness and efficiency of the policies. Such indicators may include:

- Number of registered participants;
- Percentage of school students, parents and other community members participating;
- Number of hours of activities per week/month;
- Number of participants per week/month;
- Variety of activities and target audience (e.g. learning activities for students, vocational learning for adults, practical skills for adults, sports, recreation, etc.);
- Variations in the learning outcomes of students participating in the activities, etc.

Additional effectiveness dimensions include non-monetary aspects, such as community cohesion, work-family balance, a decrease in criminal behaviour, greater citizens trust in state/regional/municipal services. Defining measurable indicators for non-monetary aspects would be challenging.

The cost of such policies may be easier to calculate or extrapolate. Data that would be necessary in order to conduct a cost-effectiveness analysis relate to the operation of school infrastructure for additional hours, as well as to the actual activities:

- Cost of activities;
- Cost of administration (registrations, selection of activities, procurement and payments, co-ordination, etc.);
- Cost of security services (if necessary);
- Cost of cleaning services;
- Cost of energy, water and/or other utilities.
- (when applicable) Additional costs to adjust the infrastructure to host activities after school operating hours (such as dedicated access or circulation).

Table 12: Cost-effective uses of school infrastructure after school operating hours

Approach	Evidence base	Effectiveness	Costs
Open schools to the community after school operating hours	Medium	High	Low
Provide educational classes/seminars to students after school operating hours	Medium	High	Low
Provide opportunities for extracurricular activities and hobbies to students after school operating hours	Medium	High	Low
Provide VET opportunities to adults after school operating hours	Medium	High	Low
Develop frameworks for the shared use of school facilities by the community	Low	High	Low

3.3.2. Allocation of construction, operation and maintenance budget of schools and educational institutions

What the evidence shows

Buildings, classrooms and equipment are crucial elements of the learning environments of schools and higher education institutions. School facilities are expected to provide a safe, secure, accessible, well-ventilated, well-illuminated, well-connected and well-maintained physical environment, to foster teaching and learning activities. Well-built and well-maintained infrastructure can have positive effects on student well-being and learning outcomes. There is evidence that school building and renovation programmes that significantly increase the quality of facilities have a positive impact on students' attendance and test scores (Benhenda 2020; Lafortune, J., & Schönholzer, D. 2021).

The decision-making processes that lead to the construction and renovation of schools are key to ensuring that investment in facilities is well designed, targets the schools that need it most, and yields high-quality and sustainable buildings.

Educational buildings represent 17% of non-residential buildings in Europe and they are among the oldest: around 75% of educational buildings in Europe were constructed before 1980[36]. A large part of the stock needs to be renovated, both to improve the learning environments of students (including better ICT equipment) and to make them more energy efficient. There is also a need to adjust the stock (closure or opening new school buildings) in line with each country's demographics.

However, pressure on educational budgets may lead to underinvestment and low maintenance budgets, with long-term negative consequences on the quality of the building stock. An attempt to estimate the gap between the actual and optimal level of investment has been made by the European Investment Bank (EIB), but more specific country estimates are not always available as they require detailed country level data. The EIB estimates the annual infrastructure investment gap for the EU27 up to 2030 at roughly EUR 155 billion[37], i.e. 1.2% of the EU27 GDP in 2020[38]. The gap in education infrastructure comprises approximately 5.2% of the total and amounts to EUR 8 billion per year. For Germany, the KfW Bank estimated a substantial gap in school infrastructure investment of about 44 million euros in 2020 (1.2% of GDP)[39]. Some studies assess the cost of building renovation – and, in particular, energy efficient renovation.[40]

However, based on our research, there is no clear evidence on how to best organise the allocation of construction, operation and maintenance costs.

The OECD report on school funding (OECD, 2017) notes that the major basis for the allocation of funding for capital expenditures across OECD countries is the assessment of needs. This often entails the targeting of funding towards schools with the greatest need for renovation or remodeling, including emergency repairs. There is, however, no systematic review of the efficiency of different methods used for the

[36] https://www.europarl.europa.eu/RegData/etudes/STUD/2016/587326/IPOL_STU(2016)587326_EN.pdf

[37] European Investment Bank. (2018). *Investment Report 2018/2019: Retooling Europe's Economy*. https://www.eib.org/attachments/efs/economic_investment_report_2018_key_findings_en.pdf

[38] Based on calculations made by the authors of the European Commission forthcoming report "Smart, effective and inclusive investment in education infrastructure" using Eurostat data on GDP and main components (output, expenditure and income) (NAMA_10_GDP).

[39] https://schulen-planen-und-bauen.de/2020/08/06/handlungsbedarf-fuer-guten-schulbau-groesser-denn-je/

[40] https://www.sciencedirect.com/science/article/pii/S1876610217355546?via%3Dihub

allocation of construction, operation and maintenance funds. Countries have launched individual initiatives that could be used as case studies, but these have not been evaluated. Examples include:

- Bottom-up initiatives to assess the state of the building stock and facilitate funding (e.g. in France https://www.banquedesterritoires.fr/mon-diag-ecoles)
- Top-down initiatives to assess the need for renovation and establish priorities for renovation (e.g. World Bank team working with the government of Romania https://blogs.worldbank.org/education/why-education-infrastructure-matters-learning)

In terms of management of funds allocated, some lessons may be learned from the failure of the *Building Schools for the Future (BSF)* programme in England. Launched in 2003 with a total budget of £55 billion, the BSF programme aimed at renovating all secondary schools in England, through the development of public-private partnerships. However, the programme was scrapped in 2010, after the renovation of only one fifth of schools. Bruman et al (2018) carefully assessed the energy performance of five of the newly constructed schools and concluded that the CO^2 emissions in these buildings were higher than the median of the existing secondary school buildings. They identified building procurement issues and operational problems that led to limited energy performance, as well as low air quality and thermal comfort. The study highlights the need to refer to detailed frameworks and key indicators in order to be able to evaluate whether the construction meets the target with objective metrics, and to take into account feedback in relation to building utilisation after the construction period in order to optimise building performance. Given the low quality of the new buildings, it is not surprising that a subsequent study found that the new schools had no effects on students' test scores (Thomson, 2016).

Overall, this case study shows the difficulties in defining public tender rules and contracts that will ensure that newly built or renovated buildings will be energy efficient and favour the well-being of students, as these qualitative aspects are not easy to measure and not always taken into account.

What is missing

There is no direct evaluation of the efficiency of different decisions in relation to the construction and renovation of school buildings. Assessing the need for construction and renovation necessitates good information on the state of the educational building stock combined with demographic trends. However, there is no clear evidence on how to best organise this data collection.

The UK experience also emphasises the need to specify targets in terms of building quality (and in particular, environmental quality), and to ensure that incentives for meeting these targets are integrated at the procurement stage. It also highlights the need to take into account the future use of school buildings (during and after teaching hours) in the design phase.

This example also shows that the management of the allocation of construction, operation and maintenance budgets for schools and educational institutions is key to ensuring that investments deliver high quality outputs. The construction or renovation of buildings can be implemented directly by public authorities or done through a public private partnership. In both cases, the definition of contracts and tender regulations are instrumental in ensuring the high quality of buildings.

Based on our research, there is no evidence on how to best allocate resources, with a lack of research on the best management practices to achieve the construction and renovation of high-quality facilities. There is no common framework that provides

explicit and objective metrics for quality infrastructure in school buildings and how to measure them in the existing stock.

We also lack empirical evidence on how various aspects of school buildings and school renovation affect teachers' and students' outcomes. Additional information on this area is presented in topic 3.3.4 "Physical learning environments: impact on education outcomes".

Cost-effectiveness aspects

There is no study that assesses the efficiency of different practices related to the allocation of construction, operation and maintenance costs of educational infrastructures, and no cost-benefit analysis.

The following table presents some approaches that could help better understand how the allocation of construction, operation and maintenance budget of schools and educational institutions could be better monitored.

Table 13: Approaches to measure the cost-effectiveness of practices related to the allocation of construction, operation and maintenance budgets

Approach	Evidence base	Effectiveness	Costs
Develop a methodology and framework to assess the state of the building stock and establish priorities in renovation	To be evaluated	Expected benefit from increased knowledge	Medium
Develop a framework for measuring the quality of education infrastructure with explicit and objective metrics	High	High	Medium
Assess how procurement rules affect the quality of newly constructed buildings	To be evaluated	Expected benefit from increased knowledge	Low

3.3.3. Physical learning environments: impact on education outcomes

What the evidence shows

State education budgets include amounts earmarked for the construction of new educational facilities, or the renovation and maintenance of existing ones. According to a recent Council of Europe Development Bank (CEB) report[41], 6% of education expenditures or about EUR 48 billion, were allocated to education infrastructure in Europe in 2017 (based on Eurostat data). Policy makers are increasingly interested in understanding the link between the physical learning environment and its impact on student performance and learning outcomes. Concrete evidence may lead to better informed policy and investment decisions.

The potential link between the physical learning environment and education outcomes is rooted in the two models: the OECD CERI Framework where the building is one of the four key elements that define the "learning environment" and the Reggio Emilia

[41] Council of Europe Development Bank (2021), *Constructing Education: An Opportunity not to be Missed*

approach where the school building is referred to as the third teacher in the learning process.

The OECD Centre for Educational Research and Innovation (CERI) has been working on "Innovative Learning Environments"[42] and has focused on how people learn and under which conditions and dynamics they can learn better. A "learning environment" is defined by CERI as the interaction of four key elements – learners, "teachers" or in the ideal world "those engaged in promoting and facilitating learning", content, and resources (facilities and technologies) through the intervening relational medium of the organisation. The physical learning environment, being an influential element in the complex education process, is included in the OECD CERI Framework (2011b) as one of the four key elements of learning environment -under the heading "resources".

Much earlier, in the 1940s, pioneering Italian teacher and psychologist Loris Malaguzzi founded the Reggio Emilia approach to learning on the premise that children develop through interactions: first with the adults in their lives – parents and teachers – then with their peers, and ultimately with the environment around them. The physical environment, according to Malaguzzi, is the *"Third Teacher".*

More recently, the OECD Group of National Experts on Effective Learning Environments reviewed a previous version[43] and published the Framework for the LEEP Module on the Effectiveness and Efficiency of the Learning Environment[44]. This Framework guided the work and supported the design of a tool that would assist in the evaluation of the physical learning environment and would provide the evidence base for the link between the learning environment and the education outcomes. The work resulted in the OECD School User Survey: Improving Learning Spaces Together[45], a tool that collects data about the use of school buildings from the three main user groups: students, teachers and school leaders.

The impact of physical learning environments on education outcomes applies to all levels of education. Existing research focuses on its application to primary and secondary education buildings. Policy conclusions on this topic could include investments in infrastructure for VET.

Analysing the impact of physical learning environments on education outcomes and creating a sufficient evidence base is expected to inform the decisions of policy makers towards more targeted investments in the area of construction of new education infrastructure, and the renovation of existing ones. Such targeted decisions will result in both financial savings and educational benefits.

The physical learning environment is one of the factors determining the classroom climate and practice. Recent literature suggests that good architectural and educational design leads to good teaching practice and improved learning. Additionally, the quality of the building design may affect both teacher and student behaviour, morale and practices, and subsequently may influence learning outcomes.

Despite the large number of studies on the impact of the physical learning environment in learning, there is a lack of quantitative evidence to support the link between physical learning environments and learning outcomes. Specific evidence is presented in two areas:

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[42] OECD Centre for Educational Research and Innovation (2011), *The Nature of Learning: Using Research to Inspire Practice*

[43] OECD (2013), *Framework for the LEEP Module on the Effectiveness and Efficiency of the Learning Environment*

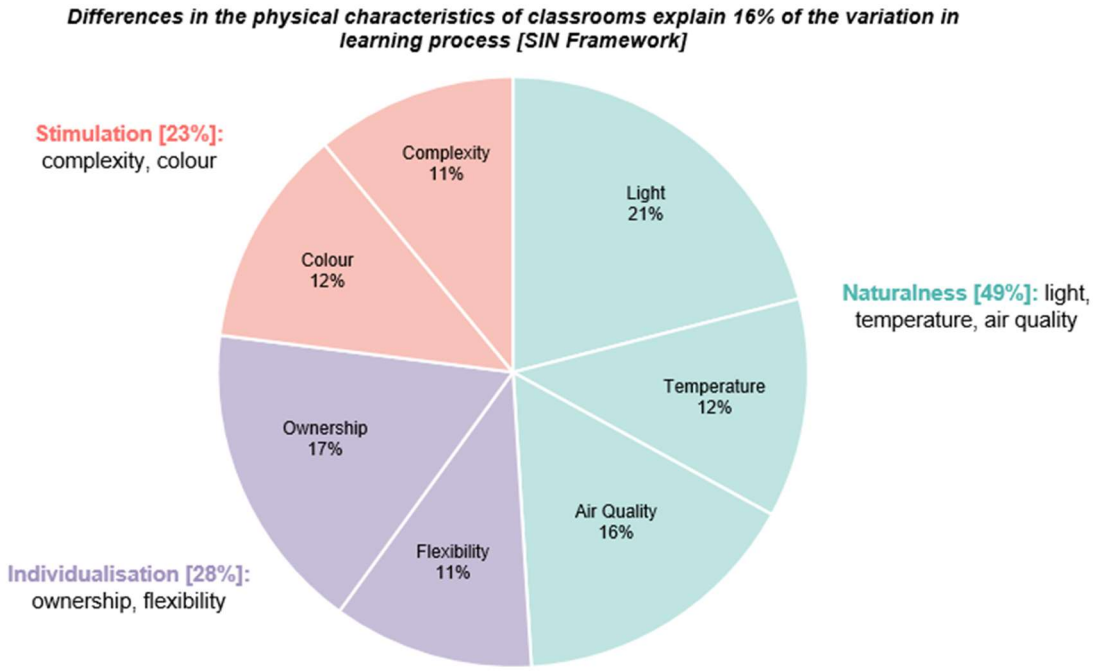
[44] OECD (2017b), *Framework for the LEEP Module on the Effectiveness and Efficiency of the Learning Environment*

[45] OECD (2018), *OECD School User Survey: Improving Learning Spaces Together*

- The impact of physical characteristics of the classrooms on student outcomes; and
- The impact of different classroom spatial arrangements on the learning outcomes of students of low socio-economic status.

A 2013 study[46] by the University of Salford (UK), examined the links between the educational environment and the academic performance of students. Data were obtained from 3,766 students, aged 5 to 11 years. The study concludes that differences in the physical characteristics of classrooms explain 16% of the variation in learning progress over a year. The overall impact of 16% is driven by a wide range of factors, expressed in the "Stimulation – Individualisation – Naturalness" (SIN) framework (Figure 6).

Figure 6: Impact of physical characteristic in learning process



Source: Barrett, P. S., F. Davies, Y. Zhang, and L. Barrett (2015), The Impact of Classroom Design on Pupils' Learning: Final Results of a Holistic, Multi-Level Analysis

In 2019, the World Bank published a report[47] about the impact of school infrastructure on learning. The report focuses on how school facilities can affect children's learning outcomes, identifying parameters that can inform the design, implementation, and supervision of future educational infrastructure projects. It reflects on aspects for which the evidence could be strengthened, and identifies areas for further exploratory work. The authors of this report reviewed and included a summary of seven large literature reviews on the subject, published between 2002 and 2016 (Table 14):

[46] Barrett, P. S., F. Davies, Y. Zhang, and L. Barrett (2015), *The Impact of Classroom Design on Pupils' Learning: Final Results of a Holistic, Multi-Level Analysis*

[47] Barrett, Peter; Treves, Alberto; Shmis, Tigran; Ambasz, Diego; Ustinova, Maria (2019), The Impact of School Infrastructure on Learning: A Synthesis of the Evidence, International Development in Focus; Washington, DC: World Bank

Table 14: Summary of literature reviews on the impact of school buildings on learning

Author/Date	Title	Method	Main findings/future work
Schneider 2002	Do School Facilities Affect Academic Outcomes?	Literature review of 137 sources	The review found that spatial configuration, noise, heat, cold, light, and air quality all affect learning. However, more definitive findings are needed.
Woolner et al. 2007	A Sound Foundation? What We Know About the Impact of Environments on Learning and the Implications for Building Schools for the Future	Team literature review of 200+ sources	The review found clear evidence that extremes of environmental elements affect learning but not as much once the elements are raised above minimum standards. It strongly recommended to involve users in the process of change. However, overall, there was not enough empirical evidence to inform the design of future infrastructure projects.
US National Research Council Committee 2006	Green Schools: Attributes for Health and Learning	Team literature review of 392 sources (general—applied to green design).	Generally, the review found that pupils' health and learning were positively affected by good indoor air quality, thermal comfort, good acoustics, well-maintained systems, and clean surfaces. The study's main focus on health highlighted problems associated with excessive moisture. More research is needed at the individual level of analysis.
Blackmore et al. 2011	Research into the Connection between Built Learning Spaces and Student Outcomes	Literature review of 700+ varied sources	The review found very little empirical evidence specifically linking design elements of learning spaces to student outcomes. The review found that studies tended to over-emphasize the design stage and not pay enough attention to how it interacts with users, to the dynamics of implementation, or to the relevance of the design to types of educational practice.
UNESCO Institute for Statistics 2012	A Place to Learn: Lessons from Research on Learning Environments	Literature review of 91+ sources	The basics of IEQ are well known, but the "learning environments research" field is developing rapidly. However, its conclusions are hard to apply in practice outside the developed world.
Davies et al. 2013	Creative Learning Environments in Education: A	Literature review of 210 sources (including how the	The review highlighted the importance of light, color, sound, and micro-climate in engendering creativity but also space, flexibility, the availability of resources, and links to outside actors. It stresses the

	Systematic Literature Review	physical environment affects creativity)	link between design elements and pedagogical issues such as how to strike the right balance between freedom and structure in learning.
Bluyssen 2016	Health, Comfort, and Performance of Children in Classrooms	Literature review of 100+ sources	The review found evidence that design elements have affected learning, absenteeism, and, mainly, health. It concluded that there is a need for more experimental and/or longitudinal research with parameters for children.

Note: IEQ = Indoor Environmental Quality
Source: Barrett, Peter; Treves, Alberto; Shmis, Tigran; Ambasz, Diego; Ustinova, Maria (2019), The Impact of School Infrastructure on Learning: A Synthesis of the Evidence, International Development in Focus; Washington, DC: World Bank

As already mentioned, the OECD developed the Framework for the LEEP Module on the Effectiveness and Efficiency of the Learning Environment (2013, reviewed in 2017) and the OECD School User Survey in 2018. The intention was to combine this tool with PISA or any other student assessment tool in order to measure the impact of learning environments on learning outcomes. Always in 2019, the World Bank used data collected through the OECD School User Survey and the pilot "Trends in Mathematics and Science Study" (TIMSS) to run a study in three regions of the Russian Federation. The 2020 report "*Learning Environments and Learning Achievement in the Russian Federation: How School Infrastructure and Climate Affect Student Success"* presents the results of this study. One of the major findings supports the argument that innovative teaching styles positively affect student learning outcomes. The use of team teaching adds four points to the TIMMS score (which accounts for 10 months of learning), and group work adds three points to the TIMMS score (which accounts for 7 months of learning). The teaching styles used in the classroom are related to the spatial characteristics of the physical learning environments, such as dimensions, furniture and equipment. Additionally, the use of space in one teaching style or another is determined both by the spatial characteristics of the physical learning environments and by the inclination of the teachers to use traditional teaching styles or introduce new innovative ones. Therefore, the use of space and its resources may enable or constrain teaching and learning.

Recent studies of innovative learning environments indicate there are positive associations between school improvement, spatial (re)design and student learning. Evidence suggests that well-designed buildings and facilities with integrated ICT can be the catalyst for innovative pedagogies that can impact on student learning.

Finally, the Council of Europe Development Bank (CEB) published in 2021 the report "*Constructing Education: An Opportunity not to be Missed*". The CEB has developed a robust framework to guide investments in the sector so that they can better contribute to promote students' learning outcomes. The first section of the report reviews the literature, exploring the links between the physical characteristics of the school setting and student learning. Some of the suggestions of the report include that *"most of the evidence tends to warn of the negative effects of a poor environment" and that "research into the effect of the physical environment demonstrates few direct impacts on student learning, but suggests many indirect effects achieved via both learning and teaching processes"*.

What is missing

There is limited quantitative data of the impact of the physical learning environments on learning outcomes. A growing base of research focuses on the design of physical learning environments, exploring all the factors indicated in this topic (light, thermal comfort, acoustics, quality of air, stimulation, individualisation, hygiene and cleanliness), as well as on other factors that may determine the space and its use (flexibility and adaptability of the space, organisation of the space and the different functions, student density in the space, introduction of specific spaces/areas in the design, furniture and equipment, safety, energy efficiency, etc.). Topic 3.3.5 addresses these issues.

As previously mentioned, only two studies with quantitative data have been conducted on the link between the physical learning environments and learning outcomes. Future research would need to identify and study the appropriate indicators related to learning outcomes. Such indicators may include academic scores, as well as indicators related to the development of 21st century skills (communication, creativity, collaboration, critical thinking, etc.). The link with other outcomes (health, well-being, etc.) may also be explored.

Cost-effectiveness aspects

Based on our research, there is no cost-benefit or cost-effectiveness analysis related to the impact of learning environments on education outcomes.

In order to measure the effectiveness and efficiency of any relevant policy, the first step would be to define some indicators to measure education outcomes (see above).

In comparison, the cost of potential policies might be easier to assume or calculate. In order to measure the cost of a design element of physical learning environments, one could measure the cost of the element if embedded in the infrastructure at the beginning and/or if inserted in the infrastructure at a later stage / after construction of the infrastructure. For example, the cost of applying team teaching to a school is a lot different if it is addressed from the (architectural) design phase, rather than when the building has been built and walls would need to be demolished.

Table 15: Cost-effective ways to configure learning environments

Approach	Evidence base	Effectiveness	Costs
Design learning spaces/classrooms so that sufficient daylight is available	Medium	High	Low
Provide openings for natural air and ventilation in each learning space	Medium	High	Low
Insert noise insulation and elements for better acoustics in the learning spaces	Medium	High	Low
Provide comfortable temperature in the spaces during summer and winter, by applying adequate energy systems and equipment	Medium	High	Medium
Use layout team teaching	Low	High	Medium
Use group work layouts in the classroom	Low	Medium	Low

3.3.4. Design of learning spaces

What the evidence shows

The design of learning spaces can foster - or hinder - the teaching and learning of 21st century skills and competences[48], such as creativity, critical thinking, collaboration, communication, problem-solving, teamwork, adaptability, leadership, curiosity, empathy, self-esteem, or resilience. Learning has moved from uniformity and conformity in the 19th and 20th centuries to being individualised and collaborative, from a delivery-driven by teachers to learning-led by learners. Activities are carried out in a variety of spaces and not necessarily - or exclusively - in a single classroom with a uniform spatial layout where students sitting in rows of desks face a teacher and a blackboard. As a result, learning spaces must evolve – as well as our design processes for building new educational infrastructures.

This topic is different to the previous one (i.e. impact of learning environments on learning outcomes) because it takes into account the effect of spaces on the educational process and addresses the issue of designing learning spaces that can adjust to new pedagogies. The first topic is usually studies by researchers, while the second one is mainly handled by architects and designers. Nevertheless, both aspects affect policy makers in their decision-making processes.

Similar to topic 3.3.4 "*Physical learning environments: impact on education outcomes"*, analysing the components of educational facilities in terms of architectural design, engineering, spatial arrangements and functionality to accommodate current and future pedagogies is fundamental to take informed investment decisions.

The characteristics of educational infrastructure that are (pre)determined by its design concern the following areas: safety and security, energy efficiency, accessibility, inclusiveness, comfort (light, temperature, acoustics, quality of air), access to technology, access to clean water and sanitation facilities, flexibility and adaptability of the space, organisation of the space and the different functions, student density in the space, introduction of specific spaces/areas in the facility, stimulation and individualisation of the space, furniture and equipment, etc. This list is indicative and additional areas may be relevant.

How to improve investment in the design of learning spaces

The physical learning environment - the physical spaces in which learners, teachers, content, equipment and technologies interact - affects the interaction of all these agents. Evidence suggests that well-designed buildings and facilities with integrated ICT can be the catalyst for teachers developing innovative pedagogies that impact on student learning (OECD, 2013 & OECD, 2017b). Improved student learning is most likely to be achieved if there are certain preconditions in the physical learning environment. Evidence also suggests that flexible spaces can encourage more effective and team teaching, better planning, the use of more diverse pedagogies, and personalised learning. They can also encourage students to be self-reliant learners capable of working in groups (OECD, 2013 & OECD, 2017b).

Adapting to modern pedagogy and improving the quality of buildings has been identified as one of the EU 27 trends in the forthcoming EU report (expected in Q1-2022) *"A study on smart, effective, and inclusive investment in education infrastructure"*. This trend is about moving from traditional learning environments and starting the process of contemplating - or even implementing - innovative learning

[48] OECD Centre for Educational Research and Innovation (2011), *The Nature of Learning: Using Research to Inspire Practice*, OECD, Paris.

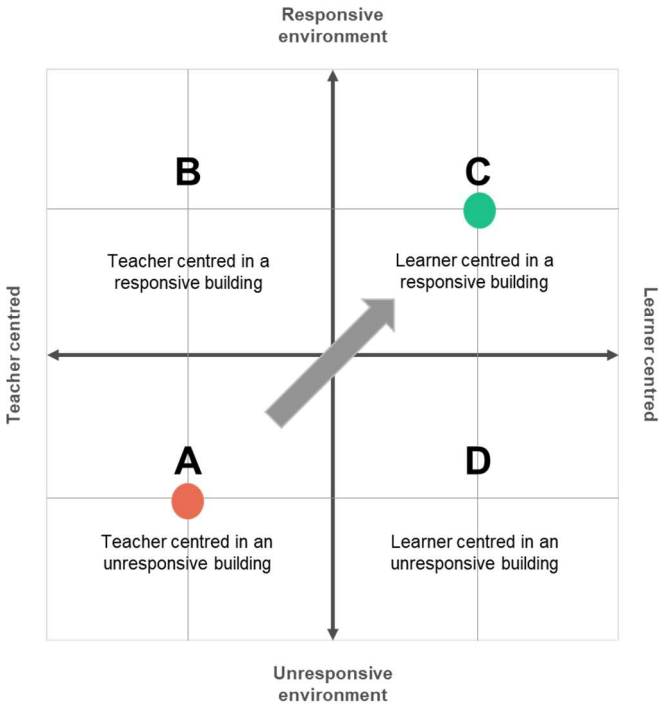
environments. It is about providing schools with spaces that provide multiple opportunities for learning. The design of learning spaces, their architecture, should be informed by innovations in teaching practices. The report also highlights that such shifts to accommodate modern pedagogy are more likely in countries which have fewer challenges in relation to the accessibility, safety and health of their education buildings.

In 2019, the OECD published the "*Analytical Framework for Case Study Collection"*, which resulted in the "*Final Report: OECD Case Study Collection on Transforming Learning Environments"* (2020). The collection of case studies on effective learning environments was designed to explore how schools around the world are transforming from traditional teaching-led learning environments supported by conventional school building design to innovative pedagogical approaches supported by responsive spatial environments. The evidence collected from the case studies is intended to help inform decision makers at the local, regional and national level, as well as school leaders as they seek to develop effective learning environments. This report includes six case studies from Australia, Chile, Greece, Italy, Japan, and the UK.

The Analytical Framework includes a model for the evaluation of schools with two broad parameters characterising: a) the pedagogical environment and b) the spatial environment (Figure 7). A given school might be learner centred or teacher centred in a building that is responsive or unresponsive to its needs. The aim was to allow case studies to be "mapped" along a spectrum: from a teacher-centric to a learner-centric pedagogical approach; and, from a responsive to a non-responsive spatial environment, and to illustrate how schools are changing their pedagogical approaches and consequently their spatial environment, and to provide insights into the process of change.

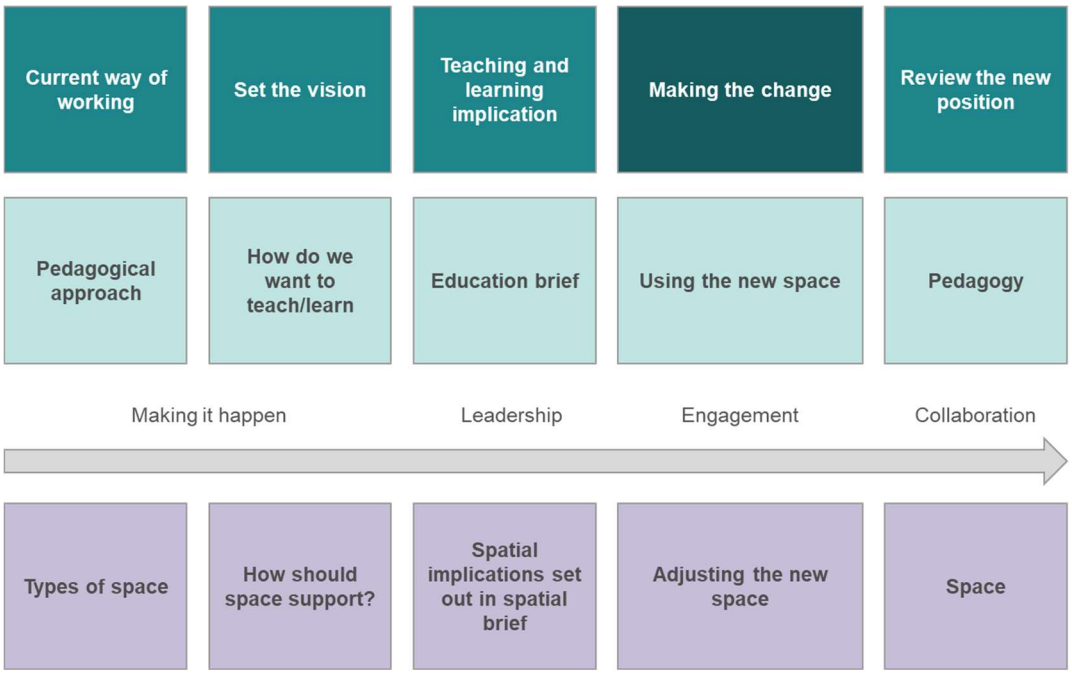
The process of change was summarised as a process flow in the Analytical Framework (Figure 8).

Figure 7: Two-parameter model about the transformation of learning environments



Source: OECD (2019), Analytical Framework for Case Study Collection

Figure 8: Process of transformation of learning environments



Source: OECD (2019), Analytical Framework for Case Study Collection

There is a vast number of additional publications, studies, case studies, reports and papers about the design of learning spaces:

- The OECD *"Designing for Education: Compendium of Exemplary Educational Facilities 2011"* (2011c), which showcases over 60 recently built or refurbished educational facilities from 28 countries. Collectively, these projects demonstrate state-of-the-art design in this field and each one is illustrated with colour photos, plans and descriptions.
- The Council of Europe Development Bank "*Constructing Education: An Opportunity not to be Missed",* which proposes a framework for multi-stakeholder collaboration combining architectural and educational perspectives. The framework aims towards a comprehensive programme of design for learning and includes the initial space design stage, through planning and trialling its use, to collectively inhabiting it, and finally reflecting on its strengths and weaknesses. The four stages of this framework include initial planning and preparation of the architectural brief; construction; hand-over of the facility and moving in; and Post-Occupancy Evaluations (POE).
- The book "*Design of Learning Spaces",* which starts from an educational perspective, and - building on work in architectural design - provides an overview of issues in the design of learning environments, covering the physical design of spaces and how that design impacts on the organisation of people in schools, their relationships and their teaching and learning. This publication targets school leaders and all those engaged in thinking about how school design might be planned and arranged to facilitate learning and teaching.

Looking at national examples, the guide developed by perspective.brussels, the Brussels Planning Office, *"My school, a quality space. Guide for basic education"*[49] is

[49] Link: https://perspective.brussels/sites/default/files/documents/mon_ecole_un_espace_qualite_0.pdf

a guide to help assess the quality of school spaces and identifies improvements to be made. The quality of school infrastructure is assessed through five major themes that are broken down into 31 criteria. The first theme, adaptability and flexibility, includes questions related to the design of learning spaces, including: the general organisation of interior/indoor spaces; the circulation areas; the classroom; the physical education space; the multipurpose space(s); the kitchen / canteen; the administration spaces; the architectural identity of the education project; use of ICT; the school entrance; and, the recreation areas (including school yards). All these elements are key in any discussion about the transformation of learning spaces.

Recent studies of innovative learning environments indicate that there are positive associations between school improvement, spatial (re)design and student learning. Evidence suggests that well-designed buildings and facilities with integrated ICT can be the catalyst for innovative pedagogies that can impact on student learning. In common with topic 3.3.4 *"Physical learning environments: impact on learning outcomes"*, there is a lack of quantitative evidence to support the link between physical learning environments - and their design - and learning outcomes. Specific evidence is presented in two areas:

- The impact of physical characteristics of the classrooms on student outcomes[50]; and
- The impact of different classroom spatial arrangements on the learning outcomes of students of low socio-economic status[51].

What is missing

The literature about physical learning environments presents limited quantitative data about the impact of the physical learning environments - and their design - on learning outcomes.

Cost-effectiveness aspects

There is no cost-benefit or cost-effectiveness analysis related to the design of learning spaces. As already mentioned under 3.3.4 *"Physical learning environments: impact on learning outcomes"*, in order to measure the cost of a learning environment design element, one could measure the cost of the element if embedded in the infrastructure from inception and/or if inserted in the facility at a later stage / after construction of the facility.

Table 16: Cost-effective designs of learning spaces

Approach	Evidence base	Effectiveness	Costs
Provide a variety of spatial layouts rather than the single classroom layout with desks facing a blackboard	Low	High	Medium
Use layout team teaching	Low	High	Medium
Use group work layouts in the classroom	Low	Medium	Low
Provide STEM spaces, makers lab, media lab	Low	High	High

[50] Barrett, P. S., F. Davies, Y. Zhang, and L. Barrett (2015), *The Impact of Classroom Design on Pupils' Learning: Final Results of a Holistic, Multi-Level Analysis*

[51] Barrett, Peter; Treves, Alberto; Shmis, Tigran; Ambasz, Diego; Ustinova, Maria (2019), *The Impact of School Infrastructure on Learning: A Synthesis of the Evidence,* International Development in Focus; Washington, DC: World Bank

Provide spaces for learning outdoors	Low	High	Medium
Design circulation areas as additional learning spaces	Low	Medium	Medium

3.3.5. Management of the education infrastructure network

What the evidence shows

The management of school and higher education infrastructure networks is key to ensuring a safe learning environment for students. School management can be analysed at different levels. In this report, we focus on school level leadership practices and the decision-making process for the management of infrastructure networks (either centralised or decentralised).[52] School management is multifaceted, as it may refer to the management of educational activities (staff, curriculum, and decisions over the budget for educational expenditures) or the management of infrastructure (in terms of operation or renovations). Studies show that, while there is wide variation in the autonomy of schools within and across countries, the different aspects of school autonomy are usually positively correlated (Hanushek et al. 2013, Bloom et al. 2015), making it difficult to separately analyse the impact of autonomy on different aspects of school management.

The management of the education infrastructure network involves three main groups of agents: families, school staff, and policy makers (national, regional or local educational authorities).

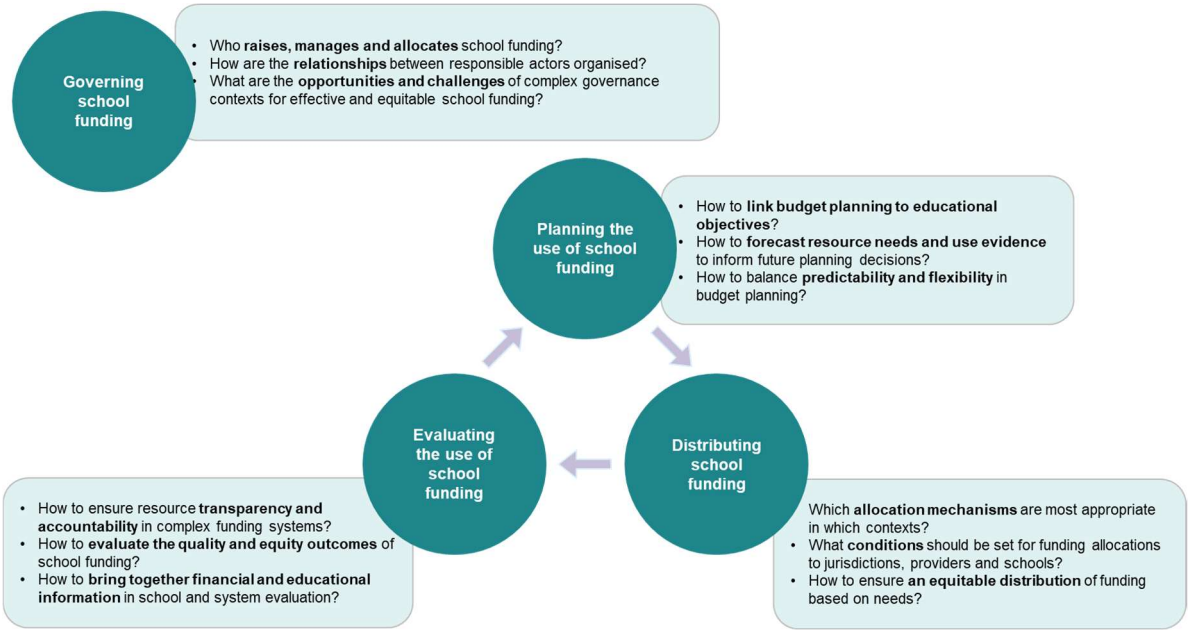
Families (and their children) are the main beneficiaries of education, but they do not manage schools. They rely on school staff to provide for children's education. This makes the management of schools more complicated for the following reasons:

- Information is imperfect and key stakeholders (parents or policy makers) may have difficulty monitoring the activity of schools. Moreover, if school management is done at a centralised level, imperfect information at the central level may lead to an inefficient allocation of school resources and management of school staff.
- The effect of school management on student learning is assumed to be primarily indirect. One of the challenges is to identify the mechanisms through which management may affect students' outcomes and identify the variables that may affect the efficiency of different management practices. Secondly, we need to measure educational outcomes at school level, but this is not an easy task. Standardised student test scores are usually used as the main measure to evaluate school performance, while measures of non-cognitive skills and student well-being are less frequently used.
- Decentralisation of management is not always accompanied with a decentralisation of funding, and financial incentives may not be in line with managerial incentives.

Figure 9 summarises the main questions related to the management of infrastructure networks and school funding. It emphasises the need to take into account both efficiency and equity aspects, and to consider school management jointly with school accountability.

[52] Teachers' management and practices (including classroom management) is discussed in another topic.

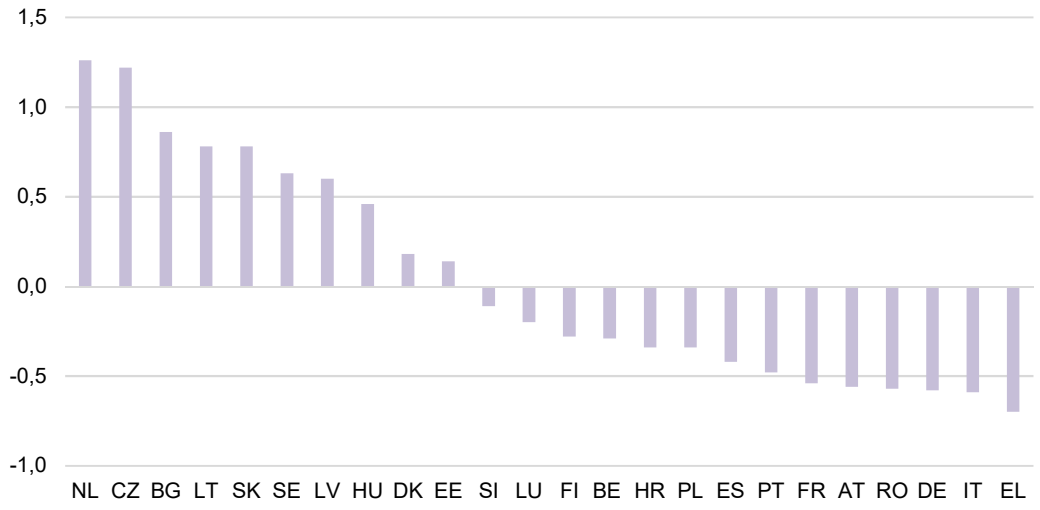
Figure 9: Main questions related to the management of infrastructures and school funding



Source: OECD (2017), The Funding of School Education: Connecting Resources and Learning, *OECD Reviews of School Resources*

EU countries have very different school management systems, from centralised management to very decentralised school management. Figure 10 shows the level of school autonomy in resource allocation calculated by the OECD with 2012 PISA data, confirming the existence of very different levels of autonomy across EU Member States. Over the past two decades, several countries have encouraged school autonomy as a means of raising student achievement. The main rationale for increasing autonomy is to transfer more power to those who are likely to have better information on how to run their school, such as school principals or local governing bodies (including parents). Increased autonomy usually necessitates increased accountability systems to monitor school results.

Figure 10: Index of school autonomy in resource allocation in OECD countries, PISA 2012



Source: OECD, PISA 2012

Evidence at the primary and secondary school levels

The analysis of the impact of management of the education infrastructure network faces two main challenges. First, it is often very difficult to disentangle the question of the management of school infrastructure from the management of staff and other pedagogical decisions. As emphasised in the OECD report on the Funding of school education (2017), countries with a strong focus on school autonomy in resource allocation over the budget allocation, also often have some autonomy over the organisation of teaching hours and staff allocation. Autonomy reforms which have been recently implemented usually affect several aspects of school management simultaneously.

Second, it is difficult to evaluate the impact of different management systems without a good counterfactual. The level of autonomy of schools is often correlated with other characteristics of the educational system and it is therefore difficult to assess the causal impact of school autonomy by comparing the management of educational infrastructure across countries with cross sectional data. Hanushek et al. (2013) have used PISA data to estimate the impact of changes in the degree of school autonomy over time on students' outcomes in a panel of countries, controlling for country effects that do not vary over time. Their results suggest that the impact of school autonomy on students' performance is very heterogeneous. While more school autonomy is associated with better academic results for highly developed/high performing countries, it seems to have a negative effect in developing countries. The analysis of PISA data shows that school autonomy itself is not necessarily enough to achieve efficiency in the allocation of educational resources, but that accountability also matters. Indeed, while there is a positive correlation between increased autonomy and PISA scores in countries where schools are more accountable; the correlation is negative in less accountable systems (OECD, 2011). These results highlight the need to take into account the local context when assessing the impact of school autonomy reforms.

Indeed, scientific studies have mainly focused on the analysis of specific school decentralisation reforms that have been implemented over the past thirty years. We can cite in particular large policy reforms implemented in three countries: Sweden, the US and the UK. Overall, even though the evaluation of country-wide reforms (such as Sweden or the UK) is complicated by the difficulty in constructing a valid counterfactual, the existing evidence points toward very heterogeneous effects.

- *Sweden* started a large school decentralisation reform in 1992, transferring decision powers over the allocation of funds to municipalities and implementing a large-scale school voucher programme that led to the development of publicly funded but privately operated schools. Several studies have tried to assess the effect of the reform on school segregation and students' outcomes, finding moderate effects on segregation and limited effects on students' outcomes (see review of the evaluations of the Swedish reform in Epple & al. 2017). The most recent study (Tyrefors & Vlachos, 2017) even points to a negative effect of students attending voucher schools compared to municipal schools at the secondary level, with effects more negative for low-ability students. These results show that in certain contexts, school autonomy combined with school choice can have adverse effects on students' performance and equality. It is important to note that the context of the reform was very specific, as it coincided with a severe economic downturn, and that it was part of a larger decentralisation reform implemented by the Swedish government.
- *The US* has experienced the development of the "charter school movement". Charter schools are usually publicly funded schools, which have more autonomy than traditional public schools over financial, staffing and

management decisions. They were originally designed as testing grounds for trying out innovative approaches to improve academic achievement in the US but have expanded substantially over time (enrolling more than 5% of primary and secondary school students in the US in 2015 and an important share of students in some urban districts such as Washington DC, Philadelphia, Detroit, New Orleans). Many small-scale studies have evaluated the marginal impact of going to charter schools by exploiting the random assignment of students at oversubscribed charter schools, where admission is determined by a lottery. Results are very heterogeneous (from negative to very positive). The general conclusion is that positive effects are usually found in deprived urban neighbourhoods with very poor-performing public schools. Successful schools are usually those who adopted intensive after class tutoring programmes (for a review, see Chabrier et al. 2016).

- ***The UK government*** started a movement of "academisation of schools" in 2002, but the movement intensified with the Academies Act in 2010. Like charter schools, academy schools are publicly funded schools with more autonomy in their management and allocation of resources than traditional public schools. Since 2010, academies can decide to become purely decentralised institutions (stand-alone trusts or SAT) or join Multi-academy Trusts (MAT). MATs constitute chains that bind schools together into institutionalised structures with varying degrees of centralisation. While there are still relatively few papers on the effect of this dramatic reform, the existing literature suggest that the effects might be heterogeneous. Eyles & Machin (2019) find positive effects of the academisation of schools before 2010 on students' test scores, comparing schools that transitioned early to academies to schools that transitioned later. However, the results of studies on the second wave of academisation suggest that there is no significant association between the degree of decentralisation and performance (Bertoni et al. 2020, Neri et al. 2021). These heterogeneous effects might be potentially correlated with the characteristics of schools that voluntarily transformed into academies in the early 2000s, which were usually lower performing schools, with large potential for improvement.

Overall, the very heterogeneous results found in the scientific literature suggest that the level of decentralisation is partly an endogenous choice that depends on the specific context. However, the greater autonomy given to specific schools to experiment with new management and teaching practices seems to have been useful to identify promising policies to reduce inequalities within schools and help improve students' performance in deprived neighbourhoods, when combined with transparent accountability measures.

Evidence at the higher education level

Studies at higher education show an inconclusive linkage so far between higher education autonomy and performance, and there is a lack of comparable evidence in the field, and a range of interacting variables that need to be controlled for, including national wealth, funding, institutional age and size (Enders et al. 2012).

Performance-based funding is a policy tool that does not seem to work quite as unanimously as a tool to increase education quality as intended, as the mechanisms required for effective monitoring and effort maximisation rarely exist in any higher education systems (Mizrahi 2021).

The introduction of managerial accountability measures have been widespread in higher education. A comparative study of the Nordic countries finds a complex interplay of these measures with academics' perceptions of the measures showcasing that higher education organisational changes are complex, dynamic

mechanisms. Performance-measurement may cause mistrust when considered out of tune with experienced meaningfulness, which in itself may negatively impact higher education performance (Hansen et al 2019).

A further complicating aspect of education governance mechanisms is that policies in the field are implemented in a context-diverse manner across institution types, as Caspersen et al. (2017) show with higher education learning outcome implementation.

What is missing

There is still very limited scientific evidence on the overall effects of different management practices on students' development. This is partly due to the difficulty in disentangling the causal effect of management from other variables that vary with each educational system. Indeed, management reforms often change practices not only for the management of infrastructure, but also for decisions regarding staff and pedagogical content. Moreover, some management reforms have been coupled with school choice, such as in Sweden. In order to better understand the role of management, we need to be able to evaluate separately the impact of different management practices regarding infrastructure from other areas of decision-making at the school level. Moreover, the efficiency of management practices seems to be related to the reliability of the accountability system, but this relationship needs further attention.

Cost-effectiveness aspects

Management practices may vary widely for a fixed amount of resources used, so management reforms have often been promoted to bring improvements without generating large cost increases. However, it is very difficult to assess the cost of different management organisations and there is very limited cost-benefit evaluation of such policies.

Table 17: Cost-effectiveness of management practices related to school infrastructures

Approach	Evidence base	Effectiveness	Costs
Separately evaluate the impact of different aspects of school autonomy	To be evaluated	High benefit from increased knowledge	Low
Develop measures of student's outcomes from yearly national exams to follow student's performance over time and implement accountability systems	High	High	High
Link autonomy and accountability in school management	High	High	Medium
Separately evaluate the impact of different aspects of school autonomy	To be evaluated	High benefit from increased knowledge	Low

3.4. Equity and inclusion

Key policy conclusions:

- *Reducing school segregation* brings benefits both in terms of equity and quality of education.
- *Desegregation policies have not been widely implemented*. Research suggests that their effectiveness depends largely on the specific characteristics and causes of school segregation in each context.
- *The effects of tracking vary depending on how it is organised*, particularly with respect to the age at which students are first assigned to a track, but also by the number of tracks, the degree of differentiation, and the relative proportion of upper secondary students in vocationally oriented programmes.
- *The evidence on the role and impact of priority education policies on student outcomes and equity is largely mixed*. Much of this variation stems from diversity in the nature and scale of the intervention/resources provided and in the measurement of impact.
- Even though *need-based grants in higher education* have a positive effect on completion rates of disadvantaged students, they *only increase enrolment rates when they provide enough money to cover unmet needs* and/or include an early commitment during high school.

EU policy framework for equity and inclusion

Inclusion and access to quality education form the cornerstone of the 1st principle of the European Pillar of Social Rights, which states that: "*Everyone has the right to quality and inclusive education, training and life-long learning in order to maintain and acquire skills that enable them to participate fully in society and manage successfully transitions in the labour market"*. They have been high in the EU policy agenda for education and training for the last twenty years and feature at the heart of the European Education Area.

In particular, the Commission Communication on achieving the European Education Area by 2025 foresees a number of flagship initiatives to boost the inclusive dimension of education. Among these, '**Pathways to school success**' aims at promoting better educational outcomes for all through fostering inclusive and supportive learning environments, as an essential condition for building more equitable and flourishing societies and economies. 'Pathways to School Success' will address simultaneously the EU-level targets for 2030 on achievement in basic skills and early leaving from education and training[53] while fully taking into account the crucial role of well-being at school. 'Pathways' has the ambition to set in motion processes of reflection and change, provide guidance on possible policy solutions, launch collaboration and dialogue with policy-makers and stakeholders and support concrete action by relevant stakeholders. To do so, the initiative combines different instruments:

[53] Targets established by Council Resolution on a strategic framework for European cooperation in education and training towards the European Education Area and beyond (2021-2030). In particular, it will address the following targets: the share of low-achieving 15-year-olds in reading, mathematics and science should be less than 15% and the share of early leavers from education and training less than 9%.

- adoption of a Council Recommendation, on a proposal which the Commission will put forward in 2022;
- peer learning and exchanges of information and experience on issues common to the education systems of the Member States (in particular through the new Working Group on Schools 2021-25);
- intensified follow-up in the European Semester;
- reinforced focus in EU funds (notably through the European Social Fund+, Recovery and Resilience Facility and Erasmus+).

Building on lessons learnt from past work at European level, as well as new insights from research and consultation activities, 'Pathways' will propose a new framework of actions and invite Member States to actively promote educational success through integrated and comprehensive strategies including monitoring, prevention, intervention and compensation and combining universal measures with more targeted ones for specific groups at risk.

'Pathways' will be complemented by the creation of an *expert group* to develop proposals on strategies for creating supportive learning environments for groups at risk of underachievement and for supporting well-being at school. Set-up in 2022, the group will develop 1) policy recommendations for developing supportive learning environments for groups at risks, promoting mental health and well-being, and for preventing bullying and violence at school; 2) proposals for effective up-take of successful practices in schools; and 3) recommendations for awareness raising activities at EU and national level.

Other actions put forward under the inclusion dimension of the European Education Area include:

- Action to make the 2021-2027 **Erasmus+ and European Solidarity Corps programmes more inclusive**, including a new Erasmus+ and European Solidarity Corps Inclusion and Diversity Strategy (published on 29 April 2021) and a Framework of inclusion measures of the Erasmus+ and the European Solidarity Corps Programmes 2021-2027 (adopted on 22 October 2021, as a Commission Implementing Decision), as well as the 2022 call and programme guide for Erasmus+ and European Solidarity Corps (published in November 2021).
- **Platform for mutual learning to support reforms towards inclusive and gender equal education** and the further implementation of the 2018 Council Recommendation on promoting common values, inclusive education, and the European dimension of teaching – through the new Working Group on Equality and Values in education and training 2021-2025. Planned deliverables include: thematic fiches on innovation for gender equal education (e.g. on addressing the underperformance of boys), on the inclusion of children with disabilities and special education needs, ethnic & racial minorities, on fighting school segregation etc., guidance on the use of disaggregated data for the assessment of policy reforms, as well as a collection of good practices for a Compendium of inspiring practices on inclusive and citizenship education.
- A Proposal for a Council Recommendation on the **mobility of young volunteers across the EU** (to be adopted in January 2022) providing updated policy guidance to address new volunteering trends, legal, financial and administrative barriers and enhance the inclusiveness, quality and recognition of cross-border volunteering under the European Solidarity Corps.

- Support for the establishment of up to 100 **Centres of Vocational Excellence** to be world-class reference points for both initial training of young people as well as continuing up- and reskilling of adults and to promote entrepreneurial initiatives and act as knowledge and innovation hubs for companies (SMEs in particular) and to support high quality skills and competences that lead to quality inclusive employment and career-long opportunities.

Setting the scene

More equity in education also means more quality. Research shows that education systems that improve equality of opportunities and reduce inequality in students' learning conditions are also the ones that get better academic results and more positive student wellbeing scores. Equity involves a dimension of fairness, a complex concept with no single definition as there are different theories of social justice in political philosophy. Beyond the many debates, all authors agree that fairness is at least making sure that personal and social circumstances – for example gender, socio-economic status or ethnic origin – are not obstacles to achieving life opportunities. In education, this means ensuring that all children can have the same learning opportunities to realise their potential.

Equity and compensatory policies embrace a wide range of interventions. Most of them have valuable objectives in themselves. Exploring all these possible policies is beyond the scope of this chapter. Here we will focus particularly on those education policies that are crucial to increase the effects of equity gains in educational quality. The highly cited book *The Spirit Level,* by Wilkinson and Picket, showed in 2009 that more equal societies always do better. Higher equality generates positive outcomes in many areas, education being no exception. More equal societies usually present better academic results - which are also more independent of students' social background - and present higher levels of student wellbeing.

Thus, the objective of this area is to select a number of policies for which we have some evidence (and for which we certainly need more evidence) of their positive outcomes in terms of quality gains.

Four topics for which research has shown positive quality outcomes coming from increasing education equity are identified as follows:

Topic 3.4.1	Desegregation policies
Topic 3.4.2	Effects of tracking and ability grouping
Topic 3.4.3	Priority education policies
Topic 3.4.4	Access and persistence in higher education

3.4.1. Desegregation policies

What the evidence shows

School segregation understood as the separation of students among different schools base on their ethnic or social origin, academic performance or any other attribute of social or educational vulnerability is a critical dimension of education inequality. Causes of school segregation are diverse and depend on many different aspects, such as residential segregation, school choice policies, admissions systems, parental preferences or the geography of educational opportunities (Bonal and Bellei, 2018). Research has identified that education systems with higher levels of school segregation reduce the opportunities of students with lower socio-economic backgrounds.

There is a large literature focusing on how school composition is an important determinant of individuals' behaviour. Peer effect has been identified as the process through which peers' backgrounds might influence their classmates' individual choices and outcomes. The interaction between high and low achievers favours the process of learning of most vulnerable students, which benefits from an adequate learning climate and higher expectations. On the contrary, high levels of concentration of low achievers undermine students' learning opportunities and disappoint teachers and students' expectations. Peer effects can be understood as an externality that spills over from peers' family background (Cebolla-Boado & Medina, 2011; Patacchini et al, 2017). Good students can help their weaker peers (both through the provision of help and their acting as examples), students with greater difficulties enjoy a better curriculum (since teachers prepare it for the highest performing students) and, finally, better students deepen their learning thanks to their support of low-performing students (Dronkers et al., 2011). Other research (Mickleson, 2018; González Motos, 2016) has also pointed out how contact with classmates of other origins make students more familiar with new behaviours, expectations and motivations, which are clearly related to family background. In this sense, students from low-income families can benefit from the attributes of their peers from higher income families, attributes that are more valued within school systems. These benefits cannot occur in a context of school segregation. School segregation implies the homogenisation of school composition, limiting diversity among classmates and increasing the interaction of students with peers of similar background.

School composition also impacts school quality. Research has highlighted the existence of a better learning climate, greater support from families and fewer disciplinary problems in more integrated schools (Thrupp et al. 2002). Students from families with a lower socio-economic background increase their expectations of academic success when they move from schools with a socially disadvantaged composition to schools with a higher social composition. Likewise, students with a migrant background increase their school expectations and performance when attending more diverse schools (Baysu et al. 2016). In general, the performance of underprivileged students is more sensitive to changes in the characteristics of the school composition (Duru Bellat et al., 2004; Dupriez et al., 2008).

Academic results differ between segregated and non-segregated scenarios, with lower inequalities in more inclusive education systems (Benito et al. 2014). PISA data have also demonstrated that those countries that have been able to be more inclusive and to reduce school segregation are also the ones that have shown higher progress in the level of students' competencies. Research has also identified that inter-ethnic networks in the educational context tend to have positive effects on processes of inclusion of socially disadvantaged students, increasing the social cohesion of communities (Stark et al. 2015; González Motos, 2016).

There is also evidence that reducing school segregation is cost-effective (Basile 2012). The lost income associated with all sorts of inequalities, including educational inequalities, is considered to be significant. School segregation may produce income losses through several mechanisms. First, since school segregation lowers the academic performance of the whole education system and there is a relationship between performance and economic returns, a segregated school system can produce highly significant earning losses. Second, reducing school segregation can lead to a positive economic balance in public spending per student accounting for public savings in areas such as health, security or welfare, as well as the gain derived from labour inclusion (Billings et al. 2014; Johnson, 2011)

Desegregation policies have not been implemented as systematic policies in the EU. Evidence from the US is greater. Several court sentences abandoning the historical doctrine of 'separate but equal' in US schools opened the door to desegregation

policies and especially to busing plans in many school districts. While these policies were active in the 1970s, they started to decline from the 1980s. However, desegregation policies have remained controversial in US education (Noblit, 2015) and their efficacy has been questioned after decades of resegregation in US schools (Frankenberg and Orfield, 2012).

Tackling school segregation is identified as a main policy in the EU[54]. However, to date, EU Member States have been reluctant to design and implement school desegregation policies. However, there are a range of strategies in the hands of policymakers to make schools more inclusive and less segregated. Their effectiveness depends largely on the specific characteristics and causes of school segregation in a given context. The level and characteristics of residential segregation, the diversity of educational supply, the school admissions system and socio-spatial inequalities from school location are factors influencing the opportunity and effectiveness of different instruments.

The main policies to tackle school segregation may include:

- *Busing*: The main policy implemented in the US, due to historical apartheid and high levels of racial segregation of neighbourhoods and districts. School buses took children from racially isolated neighbourhoods to attend more diverse schools in more affluent districts.
- *Re-definition of catchment areas (school zoning)*: Catchment areas to determine local and proximity schools exist in those countries without school choice or with some form of controlled choice. Re-definition of catchment areas can potentially change school composition by making them more socially diverse.
- *Changing school choice regulations*: School choice possibilities differ among different education systems. Some of them include different choice capacities for primary or secondary education. Regulations about the freedom of choice for certain or all schools may impact school segregation.
- *School admission systems:* There are different school admissions systems among European education systems. Many of them have different systems for primary and secondary education, usually allowing for higher levels of selection in accessing particular secondary schools. In addition, school admissions may include regulations on the systems for sorting parental preferences for specific schools. The use of these regulations may affect overall school segregation levels.
- *Distribution of students in vulnerable situation*: This policy requires good systems of detection and classification of students in vulnerable situations and a mechanism of seat reservation for them. The policy aims to balance the distribution of students with higher learning difficulties among schools within a territory.
- *Closing schools (or classrooms):* This policy aims at achieving higher diversity in school composition by closing schools or classrooms in those territories with high levels of concentration of vulnerable students. By closing an isolated school students from that school may be distributed among other local schools.

[54] Infringements cases launched by the European Commission under the Racial Equality Directive concerning segregation of Roma children (2014 CZ, 2015 SK, 2016 HU) are currently ongoing.

- *Making less demanded schools more attractive:* schools with low levels of demand that concentrate a high number of students in vulnerable situation can be transformed by using different strategies, such as changing leadership or changing the school project. The most well-known example of these policies are *magnet* schools, which started in the US but are now present in several European education systems. Magnet schools are schools that focus on a specific area (arts, science) in partnership with some external public or private body. Schools are transformed and become schools with a singular offer aiming to attract more affluent families.

Despite the diversity of instruments available, desegregation policies have not been widely implemented, with the notable exception of the US due to law enforcement. In addition, evaluations assessing the impact of desegregation policies are still scarce. The lack of longitudinal data in some countries has been a barrier to evaluating the effects of specific reforms. Other difficulties include selection bias in experimental designs and causal attribution biases. Methods used may include time series analysis, difference-in-difference or counterfactual analyses. The following table includes some examples:

Table 18: Studies on school (de)segregation policies

Study	Policy	Effects on	Method	Territory	Results
Allen (2007)	Nearest school allocation (simulation)	Reduction of segregation	Counterfactual analysis	UK (LEAs)	School segregation is almost always lower in the proximity counterfactual than in the actual data
Bonal et al. (2020)	Nearest school allocation (simulation)	Reduction of segregation	Counterfactual analysis	Barcelona (Spain)	Evidence of a significant reduction of school segregation for all socially disadvantaged students.
Saatcioglu (2010)	Desegregation (by busing and other policies)	Dropout rates	Multilevel growth models for longitudinal data (4 cohorts)	Cleveland (US)	Minority (Black and Hispanic) dropout rates changed slightly, and only for the second cohort.
Allen et al (2013)	Lottery systems to allocate students to oversubscribed	Student sorting	Diff-in-diff.	Brighton and Hove (UK)	Increase in student sorting but a significant weakening of

	schools				the dependence of school attended on student's prior attainment
Makles & Schneider (2011)	Abolition of school districts	Ethnic segregation on primary schools	Random effects model	North-Westfalia (Germany)	Abolishing school districts does not increase systematic segregation in primary schools.
Angrist and Lang (2004)	Busing	Student performance	Longitudinal Regression analysis	Boston (US)	No adverse effects of increasing the fraction of minority students on non-minority students. Small positive effects of diversity on minority girls' performance.
Betts et al (2015)	Magnet schools	Diversity and attainment	Longitudinal study of selected schools	US (21 schools from the MSAP)	Positive outcome on diversity and achievement

What is missing

It appears evident that there is a clear need to promote policies to tackle school segregation as well as to increase the number of evaluations of existing experiences. In the EU, there are currently desegregation programmes in countries such as Belgium, The Netherlands, Finland and Spain. Despite the relevance of these programmes, many of them do not undertake quality evaluations to assess their effectiveness.

The more critical gaps in the literature are:

- Impact evaluation of policies designed to tackle school segregation and improve school integration. More and better knowledge is needed about the *net* impact of policies such as changing school admissions, expanding school choice or opening the educational market to new forms of educational provision (such as schools that offer special classes or curricula, or new private providers) on school segregation.
- Impact evaluation of general education policies leading to school segregation. Educational reforms with a diversity of goals (school curriculum, school fees, teachers' work conditions, school innovation, etc.) may have potential effects on school segregation and generate differences in educational quality. Regular assessments of the effects of these policies on school segregation are needed.

- More studies are needed on the effects of school integration on different outcomes (performance, students' wellbeing, students' attitudes, and a number of social benefits in monetary and non-monetary terms).
- *Peer-effect* mechanisms. Studies on the effects of school composition on educational performance are based on the hypothesis that there are positive (or negative) peer-effects derived from school integration and heterogeneity. However, we need more and better knowledge on the specific mechanisms by which peer-effects operate. This requires the use of mixed methods approaches to explore how interpersonal contact impacts students' learning.
- *Tipping points* research. Behavioural economics explores the collective outcomes of micro-decisions. In the field of segregation studies, it is crucial to understand the tipping points that alter individual decisions regarding school choice. Small differences in tipping points can make a difference in the overall level of school segregation.
- *Rationalities of educational demand*. Most education policies are based on assumptions that cannot be taken-for-granted and must be investigated. In the field of school segregation studies, it is crucial to increase our knowledge on the boundaries and preferences of school choice that condition demand behaviour and impact on school segregation.

Cost-effectiveness aspects

Cost-effectiveness analyses of school desegregation are very exceptional. Problems of attribution and measurement of certain outcomes make this type of analysis complex in this area. Cost evaluation is also a matter of discussion, as some dimensions associated with costs are estimates of both monetary and non-monetary dimensions. In the US, the study of Basile (2012) is an interesting example of what type of cost-effectiveness analysis can be done. He estimates the cost-effectiveness of socio-economic school integration based on the economic payoff of increased graduation, and the costs of programmes that encourage families to choose to cross neighbourhood borders for their children's schooling. The increase in graduation rates generates gains from increased tax revenue and savings from reduced spending associated with health care, crime, and welfare. On the costs side, he estimates an increase of 10% of public expenditure in basic education as a result of cross-neighbourhood choice. The total gain - which includes both the public gain as well as increased private earnings - is estimated at more than three times the cost, and the total return on this investment is estimated to exceed the costs by a factor of greater than five. This analysis does not include less tangible benefits, such as an increase in civic participation or better social cohesion.

Cost-effectiveness analyses of specific interventions associated with school integration and the reduction of school segregation need to be designed, particularly in the context of current programmes in place in some European countries.

Table 19: Cost-effectiveness of school (de)segregation policies

Approach	Evidence base	Effectiveness	Costs
Nearest school allocation	Medium	High	Low
Busing	Medium	Medium	High
Distribution of marginalized students	Medium	High	Medium
Magnet school	Low	Medium	Medium

3.4.2. Effects of tracking and ability grouping

What the evidence shows

Tracking is discussed in numerous papers of education economists and sociologists (e.g., Strietholt et al., 2019, Betts 2011, European insights from Wößmann 2007, Brunello & Checchi 2007, Hanushek & Wößmann 2006, Ammermüller, 2005). By definition:

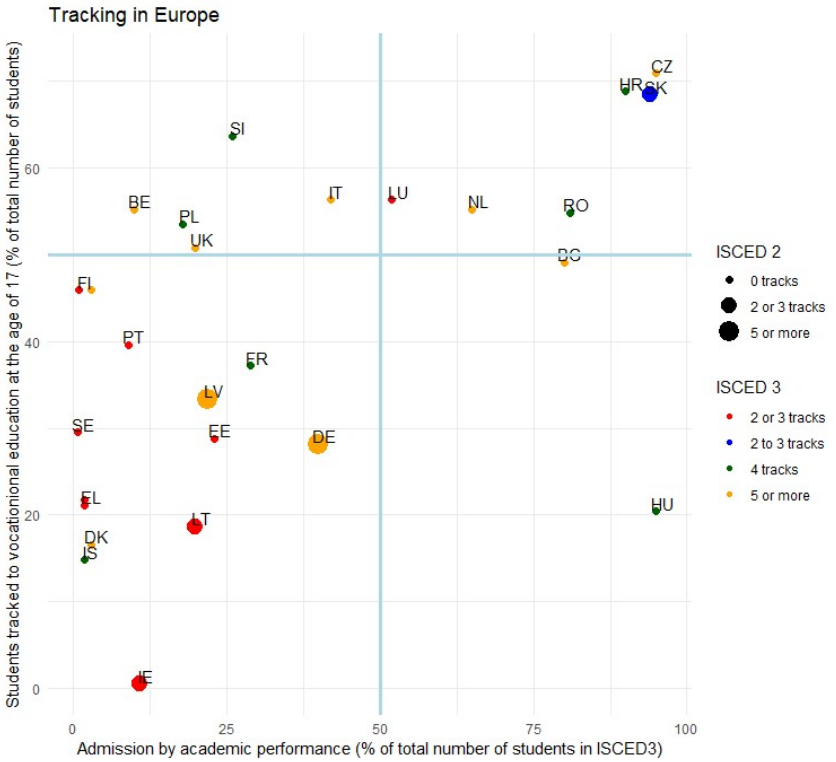
- it involves placing students into different classrooms – often different schools (mostly in middle and high school) – based on their choice of academic and vocational tracks, often based on their ability or career aspirations (Chmielewski 2014);
- the main arguments for such practices are often historical and are dependent on the skill regime of the country;
- such placements are fixed and shape students' destinations and career paths (Loveless 2009).

Tracking is different from ability grouping, which by definition (Steenbergen-Hu et a. 2016, Deunk et al. 2018):

- involves placing students into different classrooms or small groups based on their initial achievement skill levels, readiness, or abilities;
- the main purpose is to create a more homogeneous learning environment so that teachers can provide instruction better matched to students' needs and students can benefit from interactions with their comparable academic peers;
- such placements are not permanent school administrative arrangements that lead to restrictions on students' graduation, destinations, or career paths.

Tracking generates academic segregation where students of different levels of academic ability are concentrated in particular schools. Most EU education systems offer different types of schools, thus a certain degree of differentiation. While a greater variety of school types can cater to the diverse needs of students, it can also increase educational inequalities (Ammermüller, 2005; Strietholt et al., 2019). Therefore, it can be argued that there is no unique "level of tracking", rather a need to find the right balance between differentiation and tracking. According to Horvac et al. (2020), there are systems where tracking starts early (between ages 10 and 13), such as Germany or the German-speaking and Flemish Communities of Belgium; or around the age of 14 to 15, such as Italy and Portugal; or relatively late trackers such as Denmark, Norway, and Finland. There are also countries where grouping by ability is used course-by-course, e.g. Ireland and the UK (ibid.). Based on PISA school level data (on 15 to16-year old students), Poder et al. (2013) show that the countries that track most intensively are Romania, Germany, and Switzerland. However, most countries have tracks present at upper-secondary level (at the age of 17), where most countries track students to vocational or academic tracks (Denmark, Flemish Belgium, Greece, and Flemish Belgium).

Figure 11: Tracking in Europe



Source: Eurydice, 2020; PISA 2018 school level indicators

Current topic is suggested by experts and there has been studies about equity related issues in Europe addressing in large extent also tracking (Eurydice 2020, OECD 2012). However, there is no information about the level of investment, in terms of the costs, or about the benefits arising from tracking programmes.

Evidence about the impact of tracking

- There are different types of tracking: those between programmes (academic, vocational); and those between schools (different schools, e.g. elite vs regular, private vs public). There is evidence that both types of tracking reduce education equity (harmful practice) and have mixed effects on efficiency (e.g. PISA points), latter indicates that there are winners and losers as a result of it (Hanushek and Wößmann, 2006; Schuetz et al., 2008; Wößmann 2009, OECD, 2012, Poder et al. 2013).
- Studies providing evidence are using quasi-experimental or regression techniques and are mostly cross-country student-level studies. Some selected studies are listed in the table below:

Table 20: Studies on the impact of tracking

Study	Method	Country (sample)	Results	Tracking features
Hanushek and Woessmann (2006)	Dif-in-dif	45 countries	Significant effect of early tracking on inequality; no clear effect on mean performance	ISCED 2
Schuetz,	Regressions	54	Late tracking and pre-	Age of

Ursprung, and Woessmann (2008)	with school cluster robust standard errors	countries (student level)	school duration reduce the impact of family background; inverted U-shaped effect of pre-school enrolment; no tradeoff with efficiency	tracking
Ammermüller and Pischke (2009)	Instruments (IV estimates)	6 countries (FR, DE, IS, NL, NO, SE)	Modestly large peer effects; Measurement error important; Selection introduces little bias	Peer effects grade 4
Zimmer and Toma (2000)	School fixed effects estimates	5 countries (BE, FR, NZ, CA, US)	Positive peer effects; gains from high-quality peers stronger for low-ability students; mixed results on school types	Mathematics results age 13-14

- Tracking is the result of stratification in education, meaning that students of similar ability levels are allocated to the same schools or within the same classes, thereby increasing academic segregation (Parker et al., 2016). In early tracking the socio-economic background correlates with achievement, meaning that early tracking generates larger gaps between students from higher and lower socio-economic backgrounds (review by Strietholt et al., 2019).

Evidence about the impact of ability grouping

- There are different types of ability grouping: (a) between-class (comprehensive ability classes, XYZ groupings, multilevel classes); (b) within-class (small homogenous instruction groups); (c) cross-grade grouping; (d) special grouping (for gifted). The table below reports the results of meta-studies from Steenbergen-Hu et al. (2016), Deunk et al. (2018).

Table 21: Impact of ability grouping

Type of ability grouping	Impact on efficiency	Impact on equity
Between-class	**Negative**	**Negative**
Within class	**Positive**	**Positive**
Cross-grade	**Positive**	NA
Special grouping	**Positive**	NA

- Studies have various qualities, and many studies are non-experimental. In the current case we report the results from Steenbergen-Hu et al. (2016) and Deunk et al. (2018) which apply meta-analysis including only methodologically rigorous papers.

What is missing

Discussions about the mechanisms explaining why tracking is harmful are mainly related to peer effects (e.g., peer-to-peer teaching by Kimbrough et al (2017)), and some experimental evidence that the early age of assignment by ability is highly correlated with SES characteristics, so tracking reproduces social classes (Batruch et al. (2019)). Peer effects indicate that peers can serve as socialisers, and according to social learning theory (Bandura 1969) or group socialisation theory (Harris 1995) peers influence not only learning but what is significant in life (see also previous section for discussion of peer-effects). Using behavioural genetics research, Harris (1995) suggest that socialisation forces from the peer group have a bigger influence on us than the hereditary environment. A discussion on the timing of tracking is also emerging, with Jakubowski et al. 2016 showing that postponing vocational tracking from 16 to 17 years improves students' general skills (PISA).

Cost-effectiveness aspects

- Cost-benefit analysis or evidence on the cost-effectiveness of tracking is not available. Tracking is an essential part of some educational systems (e.g. Germany) and is related to the skill-regimes of the country. Thus, a change in this institutional feature of the education system might not be politically and economically feasible.
- Cost-benefit or cost-effectiveness analysis of ability grouping is not available. It can be argued that the costs of within-class ability grouping are low.
- Inter-track transition can partially offset the unequal nature of this initial assignment, implementing a policy that allows transition can be cost-effective. However, empirical evidence shows that a small proportion of students changes track (OECD, 2017, p. 163).

Table 22: Cost-effectiveness of tracking and ability grouping

Approach	Evidence base	Effectiveness	Costs
Postponing tracking to the age of 16-17	Medium	High	Uncertain
Within class ability grouping	Medium	Medium	Low
Inter-track transition policies	Medium	Medium	Uncertain

3.4.3. Priority education policies

What the evidence shows

Priority education policies aim to provide some disadvantaged subpopulation with additional resources in order to achieve equal opportunity through unequal treatment. These policies first emerged in the 1970s (UK and France), traditionally targeting schools serving socially and academically disadvantaged populations. A recent Eurydice (2020) report notes that while more than half of all EU countries allocate additional financial or non-financial support to 'disadvantaged schools', measures to improve the socio-economic composition of schools and incentives to attract teachers to disadvantaged schools are less common. In general, priority education policies have evolved from a systemic and uniform set of policy measures addressed towards

schools or territories to a higher process of individualisation and diversification (Francia, 2013). The degree to which these shifts have promoted education equity is a matter of debate in the policy and academic community. Overall, the importance of these programmes and their contribution in the reduction of school failure has been underlined by the OECD and the European Union in various evaluations discussed below (OECD, 2012; OECD, 2016; Eurydice, 2020a).

The evidence on priority education policies is mixed and the programmes are not without controversy, with commentators emphasising the lack of a simple mapping between individual disadvantage and school/area-based disadvantage (Connelly et al., 2014; Tunstall and Lupton, 2003), and the way in which the context of disadvantaged schools varies significantly, with implications for the kinds of interventions which are appropriate (Thrupp, 2006). Overall, there is ongoing debate, and largely mixed evidence on impact. Much of this stems from variation in the nature and scale of the intervention and diversity in the measurement of impact. In particular, there is wide variation across programmes in the magnitude of the additional expenditure and the way in which such funding is allocated. In some cases, the additional money given to identified schools has been insufficient to overcome overall inequalities in spending.

Some studies, taking more robust statistical approaches, point to sorting effects and growing segregation. For this reason, the scale of additional funding needs to take account of potential school profile changes and needs to provide comprehensive supports to overcome strong multiplier effects. Davezies & Garrouste (2020) highlight the ecological fallacy - selection into the programme is often made at the school level, on the basis of social and academic criteria (location in deprived areas, poor academic achievement, large proportion of students from ethnic minorities or from disadvantaged social backgrounds). A second source of bias concerns the fact that individuals may select themselves into (or out of) the programme by choosing (or avoiding) a school that benefits from it. This sorting effect has become a key issue across many countries.

One solution could be to increase additional resources for treated schools, in order to compensate for sorting by high SES families. However, the appropriate size of additional resources and their expected effect on families' school choices are difficult to anticipate.

Another solution could be replacing school-based policies with individual-based ones, in order to prevent the negative signal on school quality (Maurin 2004). However, this changes the policy paradigm, as it dissociates individuals from the school and local context, therein moving away from addressing context effects. Overall, the results highlight that adverse effects on school (and potentially residential) segregation have to be taken into account ex-ante in the design of school-based compensatory education policies, so families' strategic school choices also have important implications in the ex-post evaluation of such policies.

Some studies measure these impacts. The French *"Réseaux ambition réussite"* (RAR) programme, for example, targeted low-achieving and socially disadvantaged lower secondary schools between 2006 and 2011. Using geocoded data and a regression discontinuity framework, the results show that selection and sorting bias explain the programme's negative effects on students' educational outcomes. Once these biases are taken into account, there is no significant effect on students' academic achievement as measured by the Brevet national exam scores.

It is evident that the scale of funding in many priority education programmes is likely to be insufficient to overcome economic, social and educational inequalities between schools. For some programmes, most of the spending is in the form of reduced class size, which is likely to be of limited value in isolation. There is strong evidence that teaching in these schools is more challenging, and it is difficult to attract and retain

teachers (McCoy et al. 2014), even with a small bonus in some countries. Using French administrative data on secondary school teachers, one study analysed a non-pecuniary, "career-path oriented" centralised incentive scheme designed to attract and retain teachers in French disadvantaged schools. They find that while the incentive had a positive impact on the number of consecutive years teachers stay in disadvantaged schools, they find no impact on the teacher experience gap nor the student achievement gap between schools serving disadvantaged and non-disadvantaged populations (Benhenda and Grenet, 2020).

Some examples of different policies and their impact are provided in Table 23. Very few studies provide cost-benefit analyses, although several provide valuable analyses of the impact of targeted or priority funding on student performance, variously measured. These include studies in the UK (Hutchings et al., 2012), Ireland (Smyth, McCoy and Kingston, 2014), France (Bénabou et al., 2009) and Spain (Bonal and Pages, 2019).

Table 23: Priority education policies and their impact

Illustrative Programmes	Evidence on impact
UK: **London Challenge** resources to promote out-of-school learning, leadership & teacher retention in disadvantaged schools.	Positive: Hutchings et al (2012): performance among low-income students increased at a faster rate than the national average.
UK: **Excellence in Cities** 1/3rd of secondary school students in England. 3 strands: Learning Mentors, Learning Support Units, Gifted and Talented program, also Specialist schools.	Positive: Machin et al (2005): positive effects which have increased over time. Potentially cost-effective - relatively low cost (£120 per pupil/year), benefits do not have to be very large to generate a positive outcome.
France: **ZEP:** lower ratios and salary incentives to attract and retain the best teachers. Compensatory education represents about 10% of the annual spending per pupil.	Mixed. Bénabou et al. (2009) no discernible effect on students' academic achievement; included obtaining at least one qualification, reaching 8th or 10th grade, and success at the Baccalauréat.
Ireland: **DEIS**: 19% primary and 26% secondary schools; reduced class size, additional funding, access to planning supports, literacy/numeracy programmes, professional development supports etc.	Positive, given sorting: Smyth et al., 2014: Performance gap has remained constant over time, but growing complexity of need in DEIS schools (sorting effects), so gap would have widened in the absence of the programme.
Netherlands: A school with all of its students from the disadvantaged minority group 2X funding where all students non-disadvantaged. One subsidy= 70% disadvantaged minority students extra funding for personnel; second extra funding for computers and software.	Negative: Leuven et al. (2007): For both subsidies negative point estimates, which are for some outcomes significantly different from 0. Extra funding for computers and software seems especially detrimental for girls' achievement.
Spain: **Education priority areas**: 'maximum complexity schools' (n=340) social context of the school (parental education, occupational status, presence of migrant students, presence of students with special needs). These schools have more autonomy to select teachers and receive complementary human and material resources.	Limited impact: Bonal & Pagès (2019): poor results and limited impact. Recommend Education Priority Territories as spaces of coordination between local and regional governments; Education Territory Councils, formed by all educational stakeholders with capacity to set priorities; regulation of access and human resources allocation in schools; Initial and in-service training; Resource allocation based on social & educational

	needs.
US: **Title 1** financed supplementary educational services in reading and mathematics in disadvantaged schools. Increases Federal revenues of schools ~ $460/student. Partially offset by decreases in revenues from state categorical aid grants, so that the net increase to schools is about $360 per student.	Limited impact: Matsudaira et al. (2012): no clear impact. Schools appear to respond to the incentives embedded in the Title I allocation process by manipulating the fraction of their students signed up for free lunch to secure more Federal funds.
Chile: **Subvencion Escolar Preferencial** increase in school vouchers used to fund private and public schools by 50% for lowest SES students. Funding to reduce class size, improve technology or purchase other resources. Provides schools with an incentive to become more attractive to low-income families.	Limited impact: Feigenberg (2018): No impact on achievement gap or achievement gains. Decline in achievement gap is 'illusory' after decomposition of gains into between- and within-school components, the impact of family background controls, and other analyses.

What is missing

The evidence on the role and impact of priority education policies is largely mixed, stemming at least partly from the lack of rigour in the evaluation of many policies and initiatives in this area. While these policies are prevalent across member states, not all policies have effective evaluation built into programme design.

Among the key gaps in the literature, we can list the following:

- Many studies do not include comprehensive school profile measures, thereby allowing identification of any sorting effects that might arise as well as differential impact across school settings.
- Few studies include counterfactual analysis, which would allow a more rigorous insight into impact.
- It is unclear if targeting approaches have differential impacts. However, there would appear to be a case for a degree of tapering of funding for schools rather than a sharp withdrawal below the specified cut-off.
- Cost-benefit analysis is not included in many studies – both in terms of short term/early outcomes and longer-term benefits over the educational career, for example.

Cost-effectiveness aspects

Very few studies provide cost-benefit analyses, although several provide valuable analyses of the impact of targeted or priority funding on student performance, variously measured. Overall, the evidence points to key components in the effective design and evaluation of these policies:

- The importance of clear outcome-linked objectives in the design of policies, with counterfactual or comparison group analyses particularly beneficial.
- The importance of including rich school profile indicators from the outset and over time. Many studies have relied on relatively limited measures of student social background, such as eligibility for free school meals, available through administrative records (Gorard, 2006)

- The value of multiple indicators capturing both academic and socio-emotional dimensions, including students' engagement, attendance, aspirations, as well as achievement.
- The need to guard against narrow achievement measures given that domains of knowledge subject to regular assessment can 'squeeze out' time spent on other curricular areas.
- The importance of guarding against unintended consequences or resources being used for purposes other than for which they are intended.

Table 24: Cost-effectiveness of priority education policies

Approach	Evidence base	Effectiveness	Costs
Capturing outcome-linked measures of PEP impact	High	High	Medium
Measuring both academic and socio-emotional outcomes in PEP	Medium	High	Medium
Capturing rich/multidimensional school/neighbourhood profile measures	Medium	Medium	Medium
Measuring how resources are actually utilised	Low	Medium	Medium

3.4.4. Access and persistence of higher education

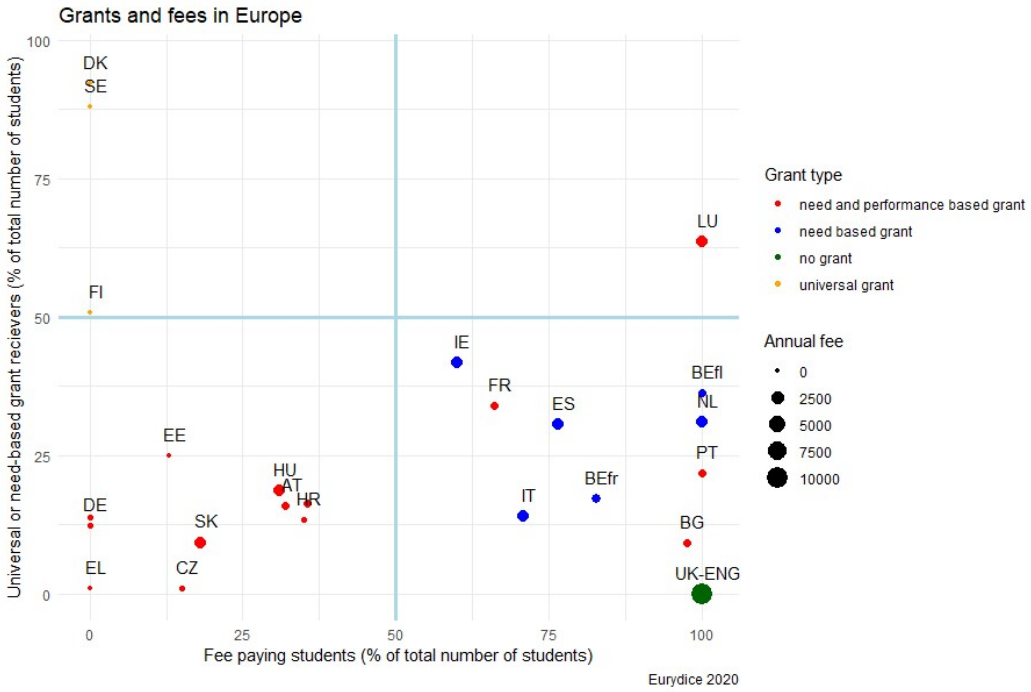
What the evidence shows

Recent trends in higher education generated a 'trilemma' – low public costs, low private costs (tuition fees), and mass access to higher education (Ansell 2008)), which bring along changes in higher education governance models (Dobbin & Knill 2014) and more cost-sharing (Marcucci and Johnstone, 2007) between the private and public sectors. Garritzmann (2016) distinguishes between *"Four Worlds of Student Finance"*. According to that model, countries fall into four groups regarding their tuition–subsidy systems: a low-tuition–low-subsidy cluster (mainly continental EU countries), a low-tuition–high-subsidy regime (mainly Nordic EU countries), a high-tuition–high-subsidy system (mainly Anglo-Saxon countries), and a high-tuition–low-subsidy cluster (some Asian and Latin American countries). While the coverage of Eastern European countries remains patchy due to data deficiencies (e.g. Estonia followed the dual-system and from 2013 onwards the continental system). Garritzmann (2016) indicated that from the perspective of educational access, high-tuition regimes (often categorised as privately funded systems) are not the only ones with barriers to educational access, but low-support countries might also have a detrimental influence on admission regardless of the level of tuition fees. This is mainly due to (in)direct costs related to studies, such as accommodation and other living costs, especially relevant for students from remote areas. Thus, whereas in the case of high-tuition countries the problem of educational equity is explicit, in the case of countries with inadequate support access to higher education is unequal, even without tuition fees, due to other study-related costs.

A recent Eurydice report regarding higher education financing (2020b) provides a detailed comparative overview of fees and grants in Europe. Also, EU countries invest to varying degrees in tertiary education (as a % of GDP, Norway is highest at 1.6% and the UK is lowest UK at 0.5%), and these investments contain varying amounts ot public funding (in Finland 90% of funds come from the public sector and in the UK only 25% comes from the public sector). Higher education financing varies

widely by country and contains a mix of formula-based funding, performance-based funding, tuition fees, voucher type student financing schemas, and public tenders (see also Estermann & Claeys-Kulik 2016, Claeys-Kulik & Estermann 2015). In addition, Eurydice (2008) provides a detailed comparative overview of financing and resource usage across universities.

Figure 12: Grants and fees in Europe



Source: Eurydice, 2020

How to improve access and graduation of disadvantaged students

Evidence related to tuition fees

- Recent European evidence in relation to tuition fees is scarce. There is evidence from the most well-known reform in England in 1998 (e.g. Murphy et al. 2019), and some evidence from Germany (e.g. Bruckmeier et al. 2015; Baier and Helbig, 2014; Dwenger et al. 2012) and France (Moulin et al. 2016). Most of these studies show mixed results. In some cases, there are no significant effects and in others some negative effects for disadvantaged students, both in terms of access and the probability of graduation (e.g. Bruckmeier et al. 2015; Moulin et al. 2016). Havranek et. al. (2018) summarise the results of 43 studies from the 1970s to 2016, finding that there is substantial heterogeneity between individual studies and on average the mean tuition–enrolment elasticity is close to zero.
- Studies providing evidence largely use quasi-experimental techniques or reflect on natural experiments and are country-specific or cross-state (in the German case) studies. Havranek et al. (2018) apply Bayesian averaging for their meta-analysis of 43 individual studies.

Evidence related to grants

- Evidence from the EU confirms that the effect of needs-based grants is only identifiable when the amount of aid is large enough (e.g. a fee-waiver - which amounted to 174 euros - had small positive statistically non-significant effects,

an additional 1,500 EUR per year increased enrolments by almost three percentage points, and by almost five percentage points for enrolment in the first year of undergraduate programmes (Fack & Grenet, 2015)). Herbaut & Geven (2019) conclude that needs-based grants do not systematically increase enrolment rates but only lead to improvements when they provide enough money to cover unmet needs and/or include an early commitment during secondary school. Also, needs-based grants improve the completion rates of disadvantaged students.

- Evidence in relation to other demand side (student financing) supports, such as vouchers, has been scarce and case specific. Agastisti et al. (2008) show that vouchers are similar to universal grants and can lower fees by increasing competition between universities.
- Many studies (52 in total) have used experimental (RCT) or quasi-experimental research designs. However, in terms of different approaches, the number of studies is limited (e.g. in the case of universal grants or the case of performance-based grants) so no generalisations can be made. Nevertheless, it can be concluded that merit-based grants rarely improve the outcomes of disadvantaged students.

Table 25: Evidence related to grants (summary from Herbaut & Geven, 2019)

Number of studies by type of intervention	Access (number of studies 29)	Graduation (number of studies 23)
Universal grants	**Positive** (1)	**Positive** (1 and small effect)
Needs-based grants	**Mixed** (14)	**Positive** (12)
Merit-based grants	**Negative** (6)	**Not significant** (4)
Performance-based grants	**Positive** (4)	**Positive** (2)
Loans	**Positive** (2)	**Mixed** (3)
Tax-credit	**Not significant** (2)	**Positive** (1)

Study characteristics:

RCT design (% of total)	18%	23%
Cross-country (number of countries)	8	3
National interventions in time (% of total)	43%	45%
Single-institution interventions (% of total)	7%	9%

Evidence related to other support measures

Herbaut & Geven (2019) find that outreach policies are broadly effective in increasing access for disadvantaged students when these policies include active counselling, but

not when they only provide general information on higher education. Also, Sneyers & De Witte (2017) show that student-faculty mentoring has a significant positive effect on both retention and graduation, indicating that the effect size is bigger than in the case of needs-based grants.

Evidence related to school social mix

There is some evidence (Smyth and McCoy, 2021) that schools can have a bigger effect than student background in channeling young people towards or away from higher education, meaning that school social mix has a stronger effect than socioeconomic status (SES). This suggests that socially mixed schools increase the chances of lower SES young people accessing higher education.

Evidence related to cost efficiency of various support measures

Evidence from the US (Hendren & Sprung-Keyser, 2020) shows that child-related investments including college subsidies are cost-effective, indicating that the marginal value of public funds (MVPF), calculated as the ratio of willingness to pay and net government costs, in relation to these policies is very high. Despite the general patterns presented, it can be argued (ibid.) that some policies targeting children yield low MVPFs, for example youth job training programmes and college subsidies when they do not significantly increase attainment.

What is missing

The theoretical literature contains mainly negative evidence on fees, while empirical evidence shows mixed results. Some conclusive evidence related to cost-effectiveness is available in the US, but not in the EU. There are very few RCT-type studies. There are few experimental studies on vouchers in the EU or debates over the applications of vouchers as an alternative for universal grants or demand side alternative to supply side financing. A few sources can be found (see Harman 1998, Ahonen 1996, Van Ravens 1998, Hodkinson ja Sparks 1995), and some debates related to life-long learning and its financing.

Cost-effectiveness aspects

Cost-benefit analysis or cost-effectiveness evidence is not available for the EU. US-based analysis shows that subsidies to universities and colleges can be highly cost-effective; however, there is no clear analysis on the design of these subsides.

Table 26: Cost-effectiveness of access and persistence policies

Approach	Evidence base	Effectiveness	Costs
Vouchers	Low	Medium	Uncertain
Needs-based grants	High	High	Medium
Performance-based grants	Medium	Low	Medium
Outreach policies	Medium	High	High
School social mix	Medium	High	Low

4. Cost-benefit analysis for the evaluation of education programmes and interventions

In this last part of the report, we discuss two important aspects of policy evaluation that may help design innovative and effective education policies: impact evaluation analysis and cost-benefit analysis. Rigorous impact evaluations are necessary to assess the efficiency of educational policies, and the review of existing studies conducted in this report allows us to identify policies with promising effects. Impact evaluations are developing rapidly in many countries, although designing a common framework for policy evaluation could be very useful to increase knowledge about evaluation methods and detect effective policies among European countries. Moreover, impact evaluations currently rarely include cost benefit analysis, while such evaluation is necessary to better assess the efficiency of the use of public funds and compare the effectiveness of different policy interventions.

Education is indeed an investment with long term benefits, and it is important to be able to measure the costs of such policy interventions and relate them to its benefits, to guide public action. It is important to take into account the specificity of education policies when performing cost benefit analysis in this area. Indeed, assessing the costs and benefits of educational interventions is much more complex than an example of a standard project as they involve multiple costs and benefits.

The objective of this part of the report is to briefly present cost-benefit analysis and evaluation methods. The methodological aspects and data requirements of cost-benefit analysis are presented in the following subsection. It is followed by a short presentation of the main challenges of a rigorous evaluation and an introduction to the current methods that can be used for evaluation analysis. These methodological aspects include some technical parts, which are illustrated with examples.

4.1. Introduction to cost-benefit analysis for education policies

The literature review underlying the report revealed that the academic and institutional literature is still relatively scarce when considering a comparison of costs of the different interventions and programmes. The attention of analysts, academics and policy-makers is often concentrated on the effectiveness side (what is the result obtained by the programme or intervention?) but there is much less evidence on the cost side (how much does it cost achieving that specific result?). Given the scarce public resources, focusing on the costs is as important as focusing on effectiveness. This section aims to promote the use of Cost-Benefit Analysis (CBA), which is an instrument for comparing the benefits obtained through a programme or intervention vis-à-vis with its costs. Cost Benefit Analysis (CBA) compares the advantage(s) deriving from a decision (a programme, policy, or intervention) with the costs that are necessary for implementing the decision itself. This modelling requires the calculation, in monetary terms, of both the advantages (“benefits”) and the “costs”. The comparison between benefits and costs can be made in monetary terms (net benefits) or as a ratio between benefits and costs (benefit/cost ratio).

$$Net\ Benefit = Benefit(s) - Cost(s) \quad \text{or} \quad BC\ ratio = \frac{Benefit(s)}{Cost(s)}$$

To illustrate the technicalities related to the use of CBA in the context of specific educational policies, programmes or interventions we refer to a hypothetical application to the case of assessing school closures during the COVID-19 pandemic. The reasons for using this simulated example are three. First, the Report is not

considering this policy, so we can deal with a situation that is not specifically related to the discussion covered by our work, and which can be applied to it eventually. Second, this policy has been substantially implemented and very central to the strategies of many countries around the world, including Europe. Third, there are several recent articles or papers that deal (directly or indirectly) with the calculation of benefits and costs for these policies, such as for example Psacharopoulos et al. (2021), Engzell et al. (2021) and Azevedo et al. (2021).

At the end of this section, we provide an additional example of cost-benefit application: we compute the costs and benefits of internationalisation in higher education.

Determining benefits in monetary terms

The first methodological challenge for applying CBA to the evaluation of an educational policy or intervention is calculating the benefits' monetary value. Determining the monetary value in this context is difficult because the policy/intervention under scrutiny could not have a direct effect on monetary choices made by individuals and societies, while being more related with the provision of public goods and/or public regulations. In the example chosen in this report, the benefit consists of the reduction in mortality or infection rates due to keeping schools closed.

A first approach for monetising benefits consists of assessing the Willingness to Pay (WTP), where the economic evaluation of a benefit is the area below the demand curve of a given good or service for the quantity being evaluated (think for example of the willingness to pay for schooling in a policy aiming at expanding education opportunities). The citizens rarely reveal their preferences explicitly, especially in areas (like education) where the service is not traded on market. As a consequence, analysts can create surveys to ask them directly about their WTP (for example how much they would like to pay for expanding educational options). The total benefit of the policy or intervention is then calculated as the sum of the WTP (Willingness to Accept - WTA) of all the citizens impacted by the policy. Not all educational policies have features that are adequate for estimating demand curves for a public good/service. Indeed, evaluating the WTP in the case of goods or services that are not traded on a market, such as education, which is largely provided publicly and freely, is particularly difficult. Alternative methods exist for different cases, such as hedonic prices, similar markets, and benefit transfer methods (see Brent, 2017 for details and explanations).

Moreover, in the case of services such as education, the benefits are not only private, but also have potential additional positive effects on society as a whole. In particular, policies that increase the level of education might have overall positive effects on innovation and productivity. These "externalities" are not always taken into account by private citizens when taking education decisions. As a result, the social benefit of educational policies may exceed the sum of private benefits. It is necessary to measure the existence of such benefits and estimate their value for society as a whole.

In the hypothetical Case selected for the Report, the monetary values of the benefit(s) could be calculated as the economic value of reducing contagion and of saved lives (some theoretical and methodological discussions about this point are in Pindyck, 2020). Similarly, depending on their personality traits, some students flourished during the pandemic. This resulted in them learning and exploring new subjects (Iterbeke and De Witte, 2021).

Determining and calculating costs

When considering costs in CBA applications, an economic definition is used that refers to the concept of "cost" as the "opportunity cost" of resources utilised for a given intervention, programme or policy. Market prices for the various resources used in the policy or intervention (such as personnel, materials, depreciation etc.) are the key measures to be used. When prices are not available, the approach can be based on shadow prices (SPs), intended as a proxy for reflecting the opportunity costs. Shadow pricing is the practice of assigning a monetary value to an item, commodity, or service that is not normally exchanged in any marketplace (see also De Rus, 2021 for additional details and suggestions).

On a practical level, costs are evaluated collecting systematic information about different categories. The total cost of a policy/intervention is then considered to be the sum of the various categories of costs, which in the first approximation can be classified in the following: (i) *direct costs*, defined as goods or services associated with the implementation of the policy, (ii) *indirect costs*, i.e. the costs that economic agents (individuals and organisations) incur as an effect of the policy, and (iii) *intangible costs*, which can be defined as individual and/or organisational consequences of the policy for which there is not a directly performed economic evaluation, as for example pain, sufferance and missed opportunities.

The three categories of costs can be described for the hypothetical Case used here. Direct costs are those related to the cost of digital equipment, or some teachers or supporting personnel who might lose their job, or the costs of parents who had to stop working to take care of children. In a similar vein, governments devoted significant resources to mitigate the attainment deficits that were caused by the pandemic (De Witte and Smet, 2021). Indirect and intangible costs are the long-term effects of school closures on students, such as the lower academic achievements (the so-called learning losses) and the reduction of future income due to these negative impacts of lower learning opportunities (please note that the latter is the economic measurement of the former). For example, evidence from Belgium shows significant attainment deficits immediately after the first wave of the COVID-19 pandemic (Maldonado & De Witte, 2021), with poor resiliency one year later (Gambi and De Witte, 2021). Moreover, the school closures might bring deficits in the socio-emotional and motivational development of the affected students due to the lack of contact with classmates and the psychological strain on families during an extended stay at home (Hanushek and Woessmann, 2020).

After defining the type of costs incurred by a policy, the next step is to collect information about the costs. Practical and operative instructions exist about how to collect cost information, among which we recall here the "ingredient method" suggested by Levin & McEwan (2000). The breakdown of costs into "ingredients" allows the identification of their nature, an information that then can be matched with their "categories". A typical classification of costs/ingredients by nature is the following one:

- *Personnel*, the economic value of human resources required for the intervention or policy under scrutiny.
- *Facilities*, in other words the costs of physical spaces required for the policy or intervention (evaluated at the market price).
- *Equipment and materials,* which refer to furnishings, operational voices and all the materials that are required for implementing the policy or intervention.

A remainder category called *other inputs* is often considered, where costs for all the other ingredients which cannot be easily classified into the three categories above are included.

Taking time dimension into consideration

When policies, interventions or programmes last for many years, special attention must be paid to determining costs and benefits in a multiyear perspective, by considering the role played by inflation, as well as the necessity to discount future costs (for determining their present value). Operationally, a calculation of the Net Present Value of the programme/intervention must be realised before it is actually implemented. In so doing, costs' projections and estimations from each year must be adjusted for price inflation. In every year, the inflation-adjusted cost expressed in period t as considered the one for which the evaluation takes place, can be computed through the following formula, where $Cost_{t+n}$ is the nominal cost in the generic year t+n, k is the discount rate for adjusting the value from t+n to t, and $Cost_t$ is the inflation-adjusted cost as evaluated in the year t.

$$Cost_t = \frac{Cost_{t+n}}{(1+k)^{t+n}}$$

The same reasoning can be applied straightforwardly to benefits, where the present value (PV) of future benefits is lower than the one apparent from merely considering the nominal value. In direct analogy with the discounting process for costs, the present value of a benefit referred to the year *t+n* ($Benefit_{t+n}$), in the year *t* ($Benefit_t$) is calculated as:

$$Benefit_t = \frac{Benefit_{t+n}}{(1+k)^{t+n}}$$

In the example chosen for the Report, the discount rate k should be calculated formulating hypotheses about the factors affecting the future value of resources in the years after the policy considered, such as inflation, interest rates and students' opportunity costs. In the case of COVID-19 pandemic, as with many other educational interventions, the benefits should be discounted across the lifetime of the students. The attainment deficits are expected to negatively affect long-run GDP. For example, a learning loss equivalent to one-third of a year of schooling for the current student cohort is estimated to mean 1.5% lower GDP on average for the remainder of the century (Hanushek and Woessmann, 2020).

Another example of cost-benefit analysis: higher education

A second example consists of a cost-benefit analysis in higher education, in particular of the costs and benefits of internationalisation in higher education. De Witte and Soncin (2021) assessed in a detailed way the various costs and benefits of international students on national economies, in the Flemish region of Belgium. The costs and benefits of internationalisation may be traced back to four categories: (i) resource costs borne by institutions (e.g. public spending for education, scholarships, student support), (ii) administrative costs borne by governments (e.g., social costs for health care), (iii) direct economic benefits (e.g., tuition fee, consumptions, income from visitors) and (iv) external effects (e.g. classroom peer effects, soft diplomatic power, displacement of domestic students). Exploiting various sources of micro-data, De Witte and Soncin (2021) apply the outlined framework to monetise the direct effects. They distinguish between costs and benefits during education, and the costs and benefits after graduation. The latter is highly dependent on the stay-rate of international students.

De Witte and Soncin (2021) estimate the net present value to actualise the yearly difference between benefits (good expenditures, private social contributions,

taxation on gross salaries and employer contributions) and costs (income support to the working-age population, family services and pensions). The results show that the long-term benefits outweigh the costs, and corresponds to a present value of 4.2 billion EUR. In other words, the results show net positive benefits that exceed costs by a factor ranging between 2.4 (lower bound) and 3.1 (upper bound) times. The results vary highly with the level of education, as the ratio is the lowest for doctoral students (1.2–1.6) and highest for master students (5.1–6.3)

4.2. Evaluation methods in education

CBA and evaluation analysis may be seen as complementary. In a sense, evaluation analysis is a preliminary step for a high-quality CBA. While the CBA is used to assess the overall effectiveness of an intervention, evaluation analysis (EA) is used to study the impact of a given type of education or policy intervention on some outcome variables.

There may be many outcome variables of interest, depending on the type of intervention. An example discussed in the Report is that of remote teaching. EA can be used to rigorously assess the impact of remote teaching on the performance of students exposed to this teaching methodology. Ancillary variables may be: the equality of performance of students; the sociability of students exposed to remote teaching; the reduction in the number of infections during a pandemic; and so on. EA can be used to assess the impact of the same treatment – remote teaching – on a number of outcome variables.

In a sense, EA can be seen as a preliminary tool or step for an effective and successful CBA. Indeed, EA can provide measures of the impact on a given outcome variable, before measuring the actual benefits that the outcome produces as a consequence of a given intervention. Translating these impacts into costs and benefits is one of the tasks of CBA. Often this requires, as noted in the previous section, finding the monetary terms of the costs and benefits ascertained by evaluation analysis.

The principle of evaluation analysis and the "gold standard" of randomised experiments

Randomised experiments are often presented as the gold standard in evaluation as they allow for the clear identification of a target and a control group (Duflo et al. 2007). The former is a group exposed to the treatment – remote teaching in the above example - while the latter is the group not exposed to the treatment to whom the target group is compared. In principle, the target and control group should be the same individual undergoing the treatment on one occasion and not undergoing the treatment another time. This would be the case for the physical and natural sciences. However, for the social sciences this is impossible, because the same individual cannot be part of the target and control group at the same time, for obvious reasons. This problem is known as the "missing data problem". To overcome this information problem, social scientists resort to quasi-experiments. This implies finding a control group as similar as possible to the target group except for the fact that they did not undergo the treatment. In the above example, to assess the impact of remote teaching on students' performance and other ancillary variables, we should find a group of students who did not undergo remote teaching, but who have exactly the same characteristics as the target group.

An example of randomised experiment in education

Randomised control trials (RCT) have been developed as a way to test innovative policies, by randomly selecting a control and treated group among a target population. The method has been used extensively to assess the impact of technology in education, and in particular its usefulness to deal with the omnipresent academic diversity in classrooms. Using a computer-based learning environment, Iterbeke, De Witte and Schelfhout (2021) studied the effects of adaptive instruction and elaborated feedback on the learning outcomes of secondary school students in a financial education programme. They randomly assigned schools to four conditions based on a crossing of two factors: the type of instruction (uniform or adaptive) and feedback (verification or elaborated). A total of 1177 students in 32 schools completed the programme in ability groups in the classroom. The results showed that the programme, on average, enhanced the financial knowledge of students by almost half of a standard deviation. No significant changes in students' financial behaviour were found. Despite the promise of adaptive practices to address the individual needs of students, they observed no additional learning gains associated with adaptive instruction and elaborated feedback.

RCT are particularly useful to assess the impact of new policies at the classroom level, as different treatment arms can be designed to test different aspects of the policy. However, it is not always possible to perform randomised experiments, especially for large scale policies. In other contexts, researchers have relied on "quasi natural experiments", when the implementation of a policy allows the differentiation of a control and a treatment group due to some specific exogenous criteria (such as age, location, some specific allocation rule...).

Main evaluation methods

Different methodologies have been devised to compare a target and a control group. The most representative methodologies are presented below. More precisely, the quasi-experimental methods reviewed here are matching, regression discontinuity designs and difference-in-difference approaches.

a. Matching approach

The main challenge and advantage of this approach is to prevent sample selection bias, at least under the observable characteristics, in the identification of the target and control group. Such bias would result in under/overestimation of the impact of the treatment, according to whether the control group presents omitted heterogeneity that is not fully accounted for by our econometric approach. It is important to clarify that while the matching approach is able to control for bias which is due to observable differences among the target and control group, it provides no guarantee against omitted heterogeneity which cannot be observed or that is not proxied by observed characteristics. Omitted heterogeneity may include motivation in studying, talent or skills that are not measured in the available data bank.

In order to create a "quasi-experimental" observation environment, that is, to minimise observed differences in characteristics between treated and untreated samples, the most common approach is propensity score matching (PSM) (see Caliendo and Kopeinig, 2008, for a practical guidance). This is a statistical matching technique that identifies the control group in untreated subjects having observable characteristics most similar to the treated subjects. Following Angrist and Pischke (2009), the PSM approach allows for the computing of the so-called ATT, i.e. the Average Treatment Effect on the Treated. The ATT represents the impact of the programme on the

treated in the event of undergoing remote teaching as compared to the counterfactual case where the treated themselves did not participate in the programme. Since case two is impossible to observe, we select a control group with the characteristics most similar to those of the target group. The analysis is done in two steps. At step one, we study the characteristics associated with the target group and then we use these characteristics to calculate a propensity score in the control group that allows us to select a sample in all aspects similar to the target group except they did not receive remote teaching, but "live" teaching.

This allows an assessment of the impact of remote teaching on the performance of students and other ancillary variables of interest, including equality of performance within the class. The matching approach has many different declinations, so to say. In the last two decades, matching has become an increasingly popular method in economics in general and in education economics in particular, due to its statistical accuracy and effectiveness, especially in the context of cross-sectional data.

Example of matching method

Recalling our previous example of remote teaching, if for some reason the group undergoing remote teaching has a higher human capital level than the group undergoing in-person teaching, the impact of remote teaching on the outcome variables would be overestimated. In this case, the higher scores of the outcome variables found for the target group may be attributed to the treatment while, instead, they could be associated with heterogeneity between the two compared groups. Matching is done to ensure that the target and control groups only differ in terms of treatment, with other observed characteristics that affect the outcome variable of an individual (e.g. age, educational background of the individuals and their parents, etc.) being equal (see, among others, Angrist, 1998; Angrist and Pischke, 2009; Cerulli, 2015; Sianesi, 2004).

b. Regression discontinuity design (RDD)

This method to identify the ATT is used in particular conditions, namely when there is a cut-off or threshold for instance for participation in a programme. De Paola and Scoppa (2014) provide an example of application of this methodology by studying the impact of compensatory courses for undergraduate students at the University of Calabria. Participants in the programme were selected from among the students who sat a placement test to access the university whose score was below a given threshold. Then the performance of these students is followed over time and compared to that of the students who were not admitted to the compensatory course because they had a slightly better score in the placement test. Comparison of the performance of the target group with that of the control group allows an assessment of the so-called Local treatment effect of the programme on the treated. The authors find that the compensatory course improved the performance of participants above the level of the students who did not attend, because they had a slightly better score in the placement test. One shortcoming of this methodology is that comparison is essentially between individuals who are below and above the cut-off point identified to enter the programme, so cannot be taken to measure the overall effect on all participants.

Example of a regression discontinuity design

RDD is widely used in studies examining the impact of class size policy on education outcomes. The positive relationship between smaller classes and students' test scores, for example, does not necessarily imply that the smaller classrooms lead to better performance. The reason might be that high-achievers

had been allocated to classes of a smaller size whereas low-achievers had studied in larger classes. To test such relationships by true experiments requires random assignment of students to classes of different sizes, which might not be feasible and rarely happens. Therefore, the studies apply a quasi-experimental approach. The cutoff point is defined by the maximum class size imposed in some countries. Konstantopoulos and Shen (2016) apply the method to estimate the impact of class size on mathematics achievement measured by TIMSS for 4th and 8th graders in Cyprus. They use a cap of 30 students per class. Once the threshold is reached, students are allocated to a new class. Therefore, schools with enrolments just above a multiple of the maximum class size (for ex. 31; 61 students) have smaller average classes (15.5; 20.3 students) than the size of the average class (29; 24.5 students) in schools with enrolments just below it (29; 29.5 students). The assigned class size is calculated on the basis of the class size cap and school enrolment. This allows for an empirical estimation of its causal effect on student performance around the cutoff points (± 5 students) since the class size is released from the influence of other factors which might affect it. The results from the RDD approach indicate that class size does not affect mathematics performance. However, the alternative estimation provided by the authors shows a beneficial effect of smaller classes in the 4th grade. Among the studies applying this method are also those of Nandrup (2016) for Denmark, Li and Konstantopoulos (2016) for a panel of 14 EU Member States, and Argaw and Puhani (2018) for Germany. A main drawback of RDD is the assumption that individuals do not have precise control over the assignment variable so each one would have almost the same probability of receiving the treatment or being denied the treatment (Lee and Lemieux, 2010). In the case of class size, it is assumed that schools do not manipulate enrolment or, for example, more educated parents do not intentionally select schools with smaller classes.

c. Difference-in-difference (DID)

This method is different from the previous ones in that it identifies the general effect of a treatment comparing individuals in an area where the treatment has happened with another where the treatment did not happen. While the matching approach provides a direct and individual-level performance of a programme, instead the difference-in-difference approach identifies the overall impact of the programme on a given outcome variable at the aggregate level. The DID methodology requires identifying a time before and after the policy and two groups/areas - the treated and control - to be compared over the same period of time, that is before and after the policy implementation. This is why it is called DID method, because it compares the post/pre-treatment levels of the outcome variables in the two groups/ areas which are compared. Imagine that a training programme is implemented in one region, but not in the nearby region at a given point in time. With DID we can compare the change in employment or unemployment in the two regions after and before the treatment to see whether the regions which experienced the treatment had a larger increase in the outcome variable.

An important assumption of the model is the so-called “common trend hypothesis”, which means that the two regions compared should have the same macroeconomic trends over the period when the policy was implanted. Imagine that the region where the programme was not implemented experienced a larger increase in GDP, then in this case, the DID approach would fail to catch the positive impact of the training programme on the outcome variables not because the programme was ineffective, but because the nearby region experienced a much larger increase in GDP. The condition for the DID method to work properly is that the two regions experience the same macroeconomic trends, over the period considered.

Example of difference-in-difference

The DID methodology has been widely used not only for the evaluation of training programmes, but also for education policy, as the following example shows for modular education. Modular education refers to the division of conventional courses into smaller components or modules. Each module enables students to obtain a partial certificate that can be combined into a qualification. Mazrekaj and De Witte (2019) evaluate whether modular education, which is widely used in secondary and tertiary education, has been effective in reducing early school leaving (ESL). ESL is high on the European policy agenda given the relationship with undesirable social and health outcomes, resulting in significant costs at individual and societal level.

The study exploits a policy change in the Flemish Community of Belgium, which recently introduced modular education for some programmes. Using a difference-in-difference framework with diverse adoption dates per school, the results indicate that modular education may significantly reduce school dropout in vocational education by 2.5 percentage points (from a baseline dropout rate of 28%), with the largest effects on foreign born students. Therefore, modular education is likely to be an effective policy to tackle school dropout and reduce the ethnic attainment gap. Additionally, students enrolled in modular education are more likely to be employed and to incur higher earnings on the labour market. The mechanisms that may explain the positive impact of modular education on diploma attainment are increased flexibility in choice of modules, partial certification and goal setting.

Choice of method

The availability of several methods offers the possibility of adapting the evaluation in order to choose the most appropriate technique in a given context, and given the available data. To understand better how different methods can be applied in different contexts, take again the example of the assessment of a training programme on the employment opportunities of individuals. With the matching approach it is possible to compare a group of participants (target group) with non-participants who applied for and were randomly not selected to attend the training programme. The RDD can be used if, for instance in the case of the European Youth Guarantee, participation in the programme can be decided based on the age of the unemployed. While in Southern European countries, the age at participation in the EYG is 29, in other Northern European countries it is 24. This cut-off point can be used to assess the local treatment effect of the programme on the treated by comparing the labour market performance of individuals below 24 and above 24, who did not attend the programme. Bratti et al. (2021) found that the EYG did not affect the employment chances of participants as compared with the performance of young people above the age of 24. The DID would imply comparing the employment or unemployment rate of two nearby regions where the former has an active labour market policy programme and the other has not. the DID methodology requires identifying a time before and after the policy and comparing the two regions over the same period of time. The different methodologies rely on different assumptions and require different types of data (longitudinal data for DID, detailed micro data for RDD and matching). Assessing which methodology is best suited to the evaluation of a given policy is a key part of the evaluation process.

Overall, although each approach has some shortcomings and limitations, causal inference methods have greatly improved our understanding of the impact of a given treatment on educational outcomes.

Quantitative evaluations should also be complemented by qualitative evaluations in a multidisciplinary approach. For example, qualitative studies are necessary to better understand the context in which policies are implemented, and help define the aspects to be measured and evaluated. Qualitative approaches also allow us to go beyond impact evaluations and analyse the process of implementation of a policy by studying how the different actors participate in the implementation of a policy. These analyses are crucial to better understand the reasons why a policy might be supported and successfully implemented and the mechanisms that may explain why the efficiency of a given policy might vary across contexts. Overall, a multiplicity of concurrent approaches is key to ensure the quality of evaluation analysis as well as to increase the transparency of the overall evaluation processes.

By developing, promoting and implementing rigorous and comprehensive evaluations, educational system will be better equipped to choose from among the most efficient policies, and to design innovative policies. This will help develop effective, resilient and equitable policies that promote quality education and training in each European country.

5. Way forward

The review presented in this interim report already provides an extensive overview of existing evaluations of educational policies. Many policies to improve the quality of education at the primary and secondary school levels have been reviewed. However, some areas and education levels have been less covered than others. We are aware, in particular, that the coverage of early childhood education on one hand, and higher education and training on the other hand, are much more limited in the interim report. In the final report, we aim to increase the coverage of these topics, and provide an additional review of the efficiency of policies in the following areas: early childhood education and care, compensatory policies for socioeconomic disadvantage, special education provision, higher education and transition to the labour market, vocational education and training and adult education.

The review of the topics conducted for the interim report allowed us to identify many promising education policies that deserve further experimentation and implementation. From a methodological standpoint, the review revealed that a large body of robust evidence comes from the US and UK, and much less so from EU countries. Moreover, the number of evaluations that provide detailed cost-benefit analysis is even more limited.

Experimentation and evaluation are key steps in the design and successful development of policy interventions to ensure that they can be adapted to each specific context. The development of the expertise for evaluation and dissemination of findings at the EU level could support the design of effective education policies in each EU country. The work done by the experts shows the importance of having expertise on the evaluation of education policies within each country. In particular, a culture of evaluation can build on four pillars:

1. **Experimentation.** In order to evaluate the efficiency of education policies, it is important to develop more pilot experiences with rigorous evaluations.
2. **The use of appropriate evaluation methods**. Causal evaluation involves the use of appropriate quantitative methods, (randomised control trials, quasi experiments). Quantitative evaluation can be combined with qualitative analysis to provide a comprehensive analysis of the process of policy implementation.
3. **The development of data collection.** Evaluation requires thinking about the outcomes to be measured (cognitive / non cognitive achievements, equity measures, labour market outcomes, etc.). The organisation of a data infrastructure allowing the collection of data on such outcome measures and to follow the achievements of cohorts of students over time allows the study of the medium and long term beneficial effects of educational policies.
4. **The assessment of cost and benefits.** Education policies are investments with current costs and long-term benefits. It is therefore very useful to perform cost-benefit analysis of education policies to assess the efficiency of such interventions and choose among different policies. This also requires the collection of detailed data on costs.

There are gains to be expected from gathering expertise and evidence on policy evaluation at the EU level. The development of a culture of evaluation in the EU could be fostered and supported by specific actions at the European level, such as:

- Development of expertise on evaluation methods (both causal quantitative analyses and qualitative studies of the process of policies implementation).
- Dissemination of knowledge about rigorously evaluated policies to develop best practice.

- Funding of policy experiments for the evaluation of the development of innovative education policies.

6. Appendix (references)

Teachers and trainers

Admiraal, W., van Vugt, F., Kranenburg, F., Koster, B., Smit, B., Weijers, S., & Lockhorst, D. (2017). Preparing pre-service teachers to integrate technology into K-12 instruction: evaluation of a technology-infused approach. *Technology, Pedagogy and Education, 26*(1), 105–120. https://doi.org/10.1080/1475939X.2016.1163283

Andreu, S., Ben Ali, L., Blouet, L., Bressoux, P., Charpentier, A., Cioldi, I., Lacroix, A., Lima, L., Murat, F., Odin-Steiner, D., Raffaelli, C., Rocher, T., Vourc'h. R. (2021). Évaluation de l'impact de la réduction de la taille des classes de CP et de CE1 en REP+ sur les résultats des élèves et les pratiques des enseignants. *Série Études: Document de travail n° 2021.E04.* Paris: Ministère de l'Education nationale, de la jeunesse et des sports. https://archives-statistiques-depp.education.gouv.fr/Default/doc/SYRACUSE/50756/evaluation-de-l-impact-de-la-reduction-de-la-taille-des-classes-de-cp-et-de-ce1-en-rep-sur-les-resul?_lg=fr-FR

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education, 52*(1), 154–168. https://doi.org/10.1016/j.compedu.2008.07.006

Alfonso, M, Santiago, A. & Bassi, M. (2020). Estimating the impact of placing top university graduates in vulnerable schools in Chile. Inter-American Development Bank Education Division (SCL/EDU). Technical Notes. No. IDB-TN-230. http://www.teachforallnetwork.com/articles/bid_study.pdf

de Arriba, R. (2017). Participation and collaborative learning in large class sizes: wiki, can you help me? *Innovations in Education and Teaching International*, vol. 54, p. 364–373. https://doi.org/10.1080/14703297.2016.1180257.

Ballou, D., Sanders, W., & Wright, P. (2004). Controlling for student background in value-added assessment of teachers. Journal of educational and behavioral statistics, 29(1), 37-65.

Banas, J. R., & York, C. S. (2014). Authentic learning exercises as a means to influence preservice teachers' technology integration self-efficacy and intentions to integrate technology. *Australasian Journal of Educational Technology, 30*(6), 728–746.

Barata, C., M., Manuela Calheiros, M., Patricio, J.N., Graca, J., Luisa Lima, M. (2015). Evaluating the impact of national education policy to reduce retention and increase achievement in compulsory education. *Elementary School Journal*, vol. 116, p. 149-171, https://doi.org/10.1086/682748.

Barnett Berry, K. C. B., Darling-Hammond, L., & Kini, T. (2021). 'The Importance of Teaching and Learning Conditions. Influences on Teacher Retention and School Performance in North Carolina', Learning Policy Institute.

Barnett Berry, K. C. B., Darling-Hammond, L., & Kini, T. (2019). *How teaching and learning conditions affect teacher retention and school performance in North Carolina*. Palo Alto, CA: Learning Policy Institute.

Blatchford, P. & A. Russell (2019). New ways of thinking about research on class size: an international perspective. Introduction to the special section. *International Journal of Educational Research*, vol. 96, p. 120–124. https://doi.org/10.1016/j.ijer.2018.09.011.

Borman, G. D. & Dowling, N. M. (2008). Teacher attrition and retention: A meta-analytic and narrative review of the research. *Review of Educational Research*, 78(3), 367–409.

Boyd, D., Lankford, H., Loeb, S. & Wyckoff, J. (2003). Analyzing the Determinants of the Matching of Public School Teachers to Jobs: Estimating Compensating Differentials in Imperfect Labor Markets; Working Paper 9878; National Bureau of Economic Research: Cambridge, MA, USA, 2003.

Boyd, D., Dunlop, E., Lankford, H., Loeb, S., Mahler, P., O'Brien, R. & Wyckoff, J. (2012). Alternative certification in the long run: A decade of evidence on the effects of alternative certification in New York City. In annual meeting of the American Education Finance and Policy Conference, Boston, MA.

Bozzi, M., Raffaghelli, J. & Zani, M. (2021). Peer Learning as a key component of an integrated teaching method: Overcoming the complexities of Physics teaching in large size classes. *Education Sciences*, vol. 11, https://doi.org/10.3390/educsci11020067.

Brage, M., Checchi, D., Garrouste, C. & Scervini, F. (2019). Selecting or rewarding teachers? International evidence from primary schools. IZA Discussion Paper 12200.

Bressoux, P. (2017). Research on class size in France. In Blatchford, P., K. Chan, M. Galton, K. Lai, J. Lee (Eds.) Class Size. Eastern and Western perspective. Routledge, 2017, London and New York.

Bressoux, P., Lima, L. & Monseur C. (2019). Reducing the number of pupils in French first-grade classes: Is there evidence of contemporaneous and carryover effects? *International Journal of Educational Research*, vol. 96, p. 136–145. https://doi.org/10.1016/j.ijer.2018.10.006.

Bueno, C., & Sass, T. R. (2016). The effects of differential pay on teacher recruitment, retention and quality. Department of Economics Andrew Young School of Policy Studies. Georgia State University.

Buss, R. R., Wetzel, K., Foulger, T. S., & Lindsey, L. (2015). Preparing Teachers to Integrate Technology Into K–12 Instruction: Comparing a Stand-Alone Technology Course With a Technology-Infused Approach. *Journal of Digital Learning in Teacher Education, 31*(4), 160–172. https://doi.org/10.1080/21532974.2015.1055012

Capucha, L., Cabrito, B., Carvalho, H., Sebastiao, J., Martins, S. D. C., Capucha, A. R.,. & Mucharreira, P. R. (2017). A dimensão das turmas no sistema educativo português. Lisboa: Ministério da Educação. [The class size in the Portuguese educational system]. Executive Summary, Available in: https://www. portugal.gov.pt/pt/gc21/comunicacao/documento?i=a-dimensao-das-turmas-no-sistema-educativo-portugues. Accessed 23 August 2021.

Checchi, D., & De Paola, M. (2018). The effect of multigrade classes on cognitive and non-cognitive skills. Causal evidence exploiting minimum class size rules in Italy. *Economics of Education Review*, vol. 67, p. 235–253. https://doi.org/10.1016/j.econedurev.2018.10.003

Chetty, R., Friedman J., & Rockoff J. (2014). 'Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood.' American Economic Review. September. 2633-2679.

Chevalier, A., Dolton, P. & McIntosh, S. (2007). Recruiting and Retaining Teachers in the UK: An Analysis of Graduate Occupation Choice from the 1960s to the 1990s. Economica, 2007. Volume74. Issue 293: 69-96. https://doi.org/10.1111/j.1468-0335.2006.00528.x

Compen, B., De Witte, K., & Schelfhout, W. (2019). The Role of Teacher Professional Development in Financial Literacy Education: A Systematic Literature Review. *Educational Research Review 26*, 16-31. https://doi.org/10.1016/j.edurev.2018.12.001

Compen, B., De Witte, K., & Schelfhout, W. (2021). The impact of teacher engagement in an interactive webinar series on the effectiveness of financial literacy education. *British Journal of Educational Technology, 52*(1), 411–425. https://doi.org/10.1111/bjet.13013

Conrads, J., Rasmussen, M., Winters, N., Geniet, A. & Langer, L. (2017). Digital Education Policies in Europe and Beyond: Key Design Principles for More Effective Policies. Redecker, C., P. Kampylis, M. Bacigalupo, Y. Punie (ed.), EUR 29000 EN, Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-77246-7, doi:10.2760/462941, JRC109311

Darling-Hammond, L., Saunders, R., Podolsky, A., Kini, T., Espinoza, D., Hyler, M., & Carver-Thomas, D. (2019). *Best practices to recruit and retain well-prepared teachers in all classrooms*. Palo Alto, CA.

Darling-Hammond, L., Holtzman D., Gatlin S.J., & Vazquez Hellig, J. (2005). Does Teacher Preparation Matter? Evidence about Teacher Certification, Teach for America, and Teacher Effectiveness. Education Policy Analysis Archives, 13, 42. https://doi.org/10.14507/epaa.v13n42.2005

Dieterle, S. (2015). Class-size reduction policies and the quality of entering teachers. *Labour Economics*, vol. 36(C), p. 35-47. https://doi.org/10.1016/j.labeco.2015.07.005.

Donovan, P., A. Hood (2021). Experiential learning in the large classroom using performative pedagogy. *Journal of Management Education*, vol. 45, p. 344–359, https://doi.org/10.1177/1052562920965625.

Dolton, P. (2006). "Teacher supply", in Hanushek, E. & F. Welch (eds.), Handbook of the Economics of Education, Elsevier, http://dx.doi.org/10.1016/S1574-0692(06)02019-8.

Dolton, P., Tremayne, A. & Chung, T. P. (2003). The Economic Cycle and Teacher Supply. A paper commissioned by the Education and Training Policy Division, OECD, for the Activity Attracting, Developing and Retaining Effective Teachers (March 2003).

Dolton, P. & Marcenaro-Gutierrez, O. D. (2011). If You Pay Peanuts do You Get Monkeys? A Cross Country Comparison of Teacher Pay and Pupil Performance. Economic Policy, 1: 5–55

Ecalle, J., Gomes, C., Auphan, P., Cros, L. & Magnan, A (2019). Effects of policy and educational interventions intended to reduce difficulties in literacy skills in grade 1.

Studies in Educational Evaluation, vol. 61, p. 12-20, https://doi.org/10.1016/j.stueduc.2019.02.001.

Education International Research (2021). *The Global Report on the Status of Teachers 2021. Report of a survey conducted by EI in 2020 Greg Thompson*.

European Commission (2013). Study on Policy Measures to Improve the Attractiveness of the Teaching Profession in Europe: Vol. 2. Final Report. Publications Office of the European Union. Luxembourg. http://dx.doi.org/10.2766/41166

European Commission/EACEA/Eurydice (2018). *Teaching Careers in Europe: Access, Progression and Support. Eurydice report*. Luxembourg: Publications Office of the European Union

European Commission/EACEA/Eurydice (2021a). *Teachers in Europe: Careers, Development and Well-being. Eurydice report*. Luxembourg: Publications Office of the European Union.

European Commission/EACEA/Eurydice (2021b). Teachers' and School Heads' Salaries and Allowances in Europe – 2019/20. Eurydice Facts and Figures. Luxembourg: Publications Office of the European Union.

European Commission/EACEA/Eurydice (2021c). Comparative reports. National Education Systems. Retrieved [November 12, 2021] from https://eacea.ec.europa.eu/national-policies/eurydice/national-description_en

Eurostat (2021). Education Statistics, Retrieved [November 13, 2021] from Statistics | Eurostat (europa.eu).

Falch, T., Johansen, K. & Strøm, B. (2009). Teacher shortages and the business cycle. Labour Economics, 16(6): 648-658. https://folk.ntnu.no/torbergf/Articles/LABECO939.pdf

Falch, T. (2013). Wages and recruitment: Evidence from external wage changes, CESifo Working Paper No. 4078. Category 4: Labour markets. Center for Economic Studies and ifo Institute (CESifo), Munich. http://hdl.handle.net/10419/69561 https://www.econstor.eu/bitstream/10419/69561/1/735087725.pdf

Feng Li & Sass, T.R. (2017). "The Impact of Incentives to Recruit and Retain Teachers in 'Hard-to-Staff' Subjects," (2017) Journal of Policy Analysis and Management 37 (1): 112-135. https://caldercenter.org/sites/default/files/WP%20141.pdf

Filges, T., C. Sonne-Schmidt & B. Nielsen (2018). Small class sizes for improving student achievement in primary and secondary schools. Campbell Systematic Reviews, https://doi.org/10.4073/csr.2018.10.

Finn, J. (2019). Academic and non-cognitive effects of small classes. *International Journal of Educational Research*, vol. 96, p. 125–135. https://doi.org/10.1016/j.ijer.2019.05.006

Fredriksson, P., Ockert, B. & Oosterbeek, H. (2014). Inside the black box of class size: mechanisms, behavioural responses, and social background. IZA DP 8019, Institute for the Study of Labor, Bonn, Germany,

https://www.iza.org/publications/dp/8019/inside-the-black-box-of-class-size-mechanisms-behavioral-responses-and-social-background.

From, J. (2017). Pedagogical Digital Competence — Between Values, Knowledge and Skills. *Higher Education Studies*, *7*(2), 43–50. https://doi.org/10.5539/hes.v7n2p43

Gambi, L. & De Witte, K. (2021). The resiliency of school outcomes after the COVID-19 pandemic. Standardised test scores and inequality one year after long term school closures. Department of Economics Discussion Paper Series DPS21.12, pp. 50.

Glazerman, S., Protik, A., Teh, B., Bruch, J., Max, J., & Warner, E. (2013). Transfer incentives for high-performing teachers: Final results from a multisite randomized experiment. Executive Summary, NCEE 2014-4004, Washington DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, US Department of Education. https://files.eric.ed.gov/fulltext/ED544269.pdf

Hafen, C. A., Hamre, B. K., Allen, J. P., Bell, C. A., Gitomer, D. H., & Pianta, R. C. (2015). Teaching through interactions in secondary school classrooms: Revisiting the factor structure and practical application of the classroom assessment scoring system–secondary. The Journal of early adolescence, 35(5-6), 651-680.

Han, S.W., Borgonovi, F., & Guerriero, S. (2018). What motivates high school students to want to be teachers? The role of salary, working conditions, and societal evaluations about occupations in a comparative perspective. American Educational Research Journal. 55: 3-39. https://doi.org/10.3102/0002831217729875

Han, S.W., Borgonovi, F., & Guerriero, S. (2020). Why don't more boys want to become teachers? The effect of a gendered profession on students' career expectations. International Journal of Educational Research. Volume 103. 2020. 101645. https://doi.org/10.1016/j.ijer.2020.101645

Hanushek, E. A., Piopiunik, M. & Wiederhold, S. (2019). The Value of Smarter Teachers. International Evidence on Teacher Cognitive Skills and Student Performance. Journal of Human Resources Details: 54(4). pp. 857-899. http://hanushek.stanford.edu/publications/value-smarter-teachers-international-evidence-teacher-cognitive-skills-and-student-0

Hanushek, E. A., & Rivkin, S.G. (2004). "How to Improve the Supply of High Quality Teachers." In Brookings Papers on Education Policy 2004, ed. Diane Ravitch, 7–25. Washington, DC: Brookings Institution Press. DOI: 10.1353/pep.2004.0001

Hanushek, E. A, & Rivkin, S.G. (2010). "Generalizations about Using Value-Added Measures of Teacher Quality." American Economic Review. 100 (2): 267–71.

Hanushek, E. A., Schwerdt, G., Wiederhold, S., & Woessmann, L. (2015). Returns to skills around the world: Evidence from PIAAC. European Economic Review, 73, 103-130.

Hanushek, E. A. & Woessmann, L. (2011). How much do educational outcomes matter in OECD countries? Economic Policy, Volume 26. Issue 67: 427–491. https://doi.org/10.1111/j.1468-0327.2011.00265.x

Hattie, J. (2017). The right question in the debates about class size. In Blatchford, P., K. Chan, M. Galton, K. Lai, J. Lee (Eds.) Class Size. Eastern and Western perspective. Routledge, 2017, London and New York.

Hojo, M. & Senoh, W. (2019). Do the disadvantaged benefit more from small classes? Evidence from a large-scale survey in Japan. *Japan and the World economy*, vol. 52, https://doi.org/10.1016/j.japwor.2019.100965.

Hough, H. & Loeb. S. (2013). Can a district-level teacher salary incentive policy improve teacher recruitment and retention?, Policy Brief 13-4, Policy Analysis for California Education, PACE, https://www.aeaweb.org/articles?id=10.1257/aer.101.3.460

Hoxby, C. M. & Leigh, A. (2004). "Pulled Away or Pushed Out? Explaining the Decline of Teacher Aptitude in the United States." *American Economic Review.* 94(2): 236-240. DOI: 10.1257/0002828041302073

International Labour Organisation (2021). *The future of work in the education sector in the context of lifelong learning for all, skills and the Decent Work Agenda, Report for the Technical Meeting on the Future of Work in the Education Sector in the Context of Lifelong Learning for All, Skills and the Decent Work Agenda* (Geneva, 17–21 May 2021), International Labour Office, SECTOR, Geneva: ILO.

Ingersoll, R. M. & Smith, T. M. (2004). The wrong solution to the teacher shortage. Educational Leadership, 60(8), 30–33.

Jepsen, C. (2015). Class size: does it matter for student achievement? IZA World of Labor 190, doi: 10.15185/izawol.190.

Kane, T. J. , Rockoff, J. E. & Staiger,.D. (2006). What Does Certification Tell Us About Teacher Effectiveness? Evidence from New York City. NBER Working Paper No. w12155. https://ssrn.com/abstract=896463

Kara, E., Tonin, M. & Vlassopoulos, M. (2021). Class size effects in higher education: Differences across STEM and non-STEM fields. *Economics of Education Review*, vol. 82, https://doi.org/10.1016/j.econedurev.2021.102104

Karas, A. (2021). The effect of class size on grades and course evaluations: Evidence from multisection courses. *Bulletin of Economic Research*, p. 1-19. https://doi.org/10.1111/boer.12274.

Kay, R. H. (2006). Evaluating Strategies Used To Incorporate Technology Into Preservice Education: A Review Of the Literature. *Journal of Research on Technology in Education,* *38*(4), 383–408. https://doi.org/10.1080/15391523.2006.10782466

Kedagni, D., Krishna, K., Megalokonomou, R. & Zhao Y. (2021). Does class size matter? How, and at what cost? *European Economic Review*, vol. 133. https://doi.org/10.1016/j.euroecorev.2021.103664.

Koh, J. H. L., Chai, C. S., & Lim, W. Y. (2017). Teacher Professional Development for TPACK-21CL: Effects on Teacher ICT Integration and Student Outcomes. *Journal of Educational Computing Research*, *55*(2), 172–196. https://doi.org/10.1177/0735633116656848

Konstantopoulos, S. &. Shen, T. (2016). Class size effects on mathematics achievement in Cyprus: evidence from TIMSS. *Educational Research and Evaluation*, vol. 22, p. 86-109, doi: 10.1080/13803611.2016.1193030.

Kraft, M. & Papay, J. (2017). Developing workplaces where teachers stay, improve, and succeed. in *Quintero, Esther* (Ed.) *Teaching in Context*. Massachusetts: Harvard *Education* Press.

Krueger, A. (1999). Experimental estimates of education production functions. *Quarterly Journal of Economics*, vol. 114(2), p. 497–532. https://doi.org/10.1162/003355399556052.

Krumsvik, R. A. (2011). Digital competence in Norwegian teacher education and schools. Högre Utbildning, 1(1), 39-51.

Ladd, H. F. (2011). Teachers' perceptions of their working conditions: How predictive of planned and actual teacher movement? Educational Evaluation and Policy Analysis, 33(2), 235–61.

Lawless, K. A., & Pellegrino, J. W. (2007). Professional Development in Integrating Technology into Teaching and Learning: Knowns, Unknowns, and Ways to Pursue Better Questions and Answers. *Review of Educational Research, 77*(4), 575–614. https://doi.org/10.3102/0034654307309921

Leuven, E. & Oosterbeek, H. (2018). Class size and student outcomes in Europe. EENEE Analytical Report 33, Executive summary, https://doi.org/10.2766/59709.

Leuven, E. & Rønning, M. (2014). Classroom grade composition and pupil achievement. *The Economic Journal*, vol. 126, p. 1164-1192, https://doi.org/10.1111/ecoj.12177.

Li, W. & Konstantopoulos, S. (2016). Class Size Effects on Fourth-Grade Mathematics Achievement: Evidence from TIMSS 2011. *Journal of Research on Educational Effectiveness*, vol. 9, p. 503–530. https://doi.org/10.1080/19345747.2015.1105893.

Liebowitz, D,. González, P., Hooge, E. & Gonçalo, L. (2018). OECD Reviews of School Resources: Portugal 2018, OECD Reviews of School Resources, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264308411-en.

Liu, S.-H., Tsai, H.-C., & Huang, Y.-T. (2015). Collaborative Professional Development of Mentor Teachers and Pre-Service Teachers in Relation to Technology Integration. *Educational Technology & Society, 18*(3), 161–172. http://www.jstor.org/stable/jeductechsoci.18.3.161.

Major, C. & Mcdonald, E. (2021). Developing Instructor TPACK: A Research Review and Narrative Synthesis. *Journal of Higher Education Policy and Leadership Studies, 2*(2), 51–67. https://doi.org/10.52547/johepal.2.2.51

Maldonado, J. & De Witte, K. (2021). The effect of school closures on standardised student test outcomes. *British Educational Research Journal*, Forthcoming. https://doi.org/10.1002/berj.3754

Maulana, R., Helms-Lorenz, M. & Van de Grift, W. (2017). Validating a model of effective teaching behaviour of pre-service teachers. *Teachers and Teaching*, vol. 23, p. 471–493. https://doi.org/10.1080/13540602.2016.1211102.

Mazrekaj, D., Triebs, T. and De Witte, K. (2021). Mind the gap: measuring academic underachievement using Stochastic Frontier Analysis. *Exceptional Children*. In Press.

Meeter, M. (2021). Primary school mathematics during Covid-19: No evidence of learning gaps in adaptive practicing results. *Trends in Neuroscience and Education*.

Merrill, B. C. (2021). 'Configuring a Construct Definition of Teacher Working Conditions in the United States: A Systematic Narrative Review of Researcher Concepts' *Review of Educational Research.* 91(2): 163 –203.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: a new framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

Mouza, C., Karchmer-Klein, R., Nandakumar, R., Ozden, S. Y., & Hu, L. (2014). Investigating the impact of an integrated approach to the development of preservice teachers' technological pedagogical content knowledge (TPACK). *Computers & Education, 71*, 206–221. https://doi.org/10.1016/j.compedu.2013.09.020

Mucharreira, P., Cabrito, B. & Capucha L. (2019). Net costs of class-size reduction: The portuguese case [Costes Netos Derivados De La Reduccion Del Numero De Alumnos Por Clase: El Caso Portugus]. Cadernos de Pesquisa, vol. 49, p. 164–181. https://doi.org/10.1590/198053145794.

Nagler, M., Piopiunik, M., & West, M. (2015). Weak markets, strong teachers: Recession at career start and teacher effectiveness. NBER Working Paper No. 21393.

Nandrup A. (2016). Do class size effects differ across grades? *Education Economics*, vol. 24, p. 83-95, doi: 10.1080/09645292.2015.1099616.

Nelson, M. J., & Hawk, N. A. (2020). The impact of field experiences on prospective preservice teachers' technology integration beliefs and intentions. *Teaching and Teacher Education, 89,* 103006. https://doi.org/10.1016/j.tate.2019.103006

Normore, A., L. Ilon (2006) Cost-Effective School Inputs: Is Class Size Reduction the Best Educational Expenditure for Florida? Educational Policy, vol. 20 (2), p. 429-454. doi: 10.1177/0895904805284053.

OECD (2019). Working and Learning Together: Rethinking Human Resource Policies for Schools, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/b7aaf050-en.

OECD (2020a). Teachers' training and use of information and communications technology in the face of the COVID-19 crisis, *Teaching in Focus, 35*, OECD Publishing, Paris. https://doi.org/10.1787/696e0661-en

OECD (2020b). *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*. PISA, OECD Publishing, Paris. https://doi.org/10.1787/ca768d40-en

OECD (2020c). *Teachers' well-being: a framework for data collection and analysis*. OECD Publishing, Paris.

OECD (2021a). Education at Glance. OECD Publishing, Paris.

OECD (2021b). OECD Statistics. Retrieved [October 15, 2021] from https://data.oecd.org/.

van der Pers, M. & Helms-Lorenz, M. (2019). Regional school context and teacher characteristics explaining differences in effective teaching behaviour of beginning

teachers in the Netherlands. *School Effectiveness and School Improvement*, vol. 30, p. 231–254. https://doi.org/10.1080/09243453.2019.1592203.

Petko, D. (2012). Teachers' pedagogical beliefs and their use of digital media in classrooms: Sharpening the focus of the 'will, skill, tool' model and integrating teachers' constructivist orientations. *Computers & Education, 58*(4), 1351–1359. https://doi.org/10.1016/j.compedu.2011.12.013

Reisoğlu, İ. (2021). How Does Digital Competence Training Affect Teachers' Professional Development and Activities? *Technology, Knowledge and Learning.* https://doi.org/10.1007/s10758-021-09501-w

Reisoğlu, İ., & Çebi, A. (2020). How can the digital competences of pre-service teachers be developed? Examining a case study through the lens of DigComp and DigCompEdu. *Computers & Education, 156*(103940). https://doi.org/10.1016/j.compedu.2020.103940

Rienties, B., Brouwer, N., Carbonell, K. B., Rozendal, A., van der Loo, J., Dekker, P. & Lygo-baker, S. (2013). Online training of TPACK skills of higher education scholars: a cross-institutional impact study. *European Journal of Teacher Education, 36*(4), 480–495. https://doi.org/10.1080/02619768.2013.801073

Saloviita, T. &Pakarinen, E. (2021). Teacher burnout explained: Teacher-, student-, and organisation-level variables. *Teaching and Teacher Education*, vol. 97, https://doi.org/10.1016/j.tate.2020.103221.

Savage C., Ayaita A., Hübner, N. & Biewen. M. (2021). Who Chooses Teacher Education and Why? Evidence from Germany. Educational Researcher. Volume: 50 issue: 7. 483-487. https://doi.org/10.3102/0013189X211000758

Schanzenbach, D. (2014). Does CS matter? Retrieved [August 21, 2021] from Boulder, CO: National Education Ploicy Center. https://nepc.colorado.edu/publication/does-class-size-matter.

Schmid, R. F., Bernard, R. M., Borokhovski, E., Tamim, R. M., Abrami, P. C., Surkes, M. A., Wade, C. A., & Woods, J. (2014). The effects of technology use in postsecondary education: A meta-analysis of classroom applications. *Computers & Education*, *72*, 271–291. https://doi.org/10.1016/j.compedu.2013.11.002

See, B, H., Morris, R., Gorard, S., Kokotsaki, D. & Abdi, S. (2020). Teacher Recruitment and Retention: A Critical Review of International Evidence of Most Promising Interventions. Educ. Sci. 2020. 10(10). 262. https://doi.org/10.3390/educsci10100262

Seufert, S., Guggemos, J., & Sailer, M. (2021). Technology-related knowledge, skills, and attitudes of pre- and in-service teachers: The current situation and emerging trends. *Computers in Human Behavior, 115,* 106552. https://doi.org/10.1016/j.chb.2020.106552

Shen, T., S. Konstantopoulos, (2017). Class size effects on reading achievement in Europe: Evidence from PIRLS. *Studies in Educational Evaluation*, vol. 53, p. 98-114, https://doi.org/10.1016/j.stueduc.2017.04.001.

Shinas, V. H., Karchmer-klein, R., Mouza, C., Yilmaz-Ozden, S., & Glutting, J. J. (2015). Analyzing Preservice Teachers' Technological Pedagogical Content Knowledge Development in the Context of a Multidimensional Teacher Preparation

Program. *Journal of Digital Learning in Teacher Education, 31*(2), 45–55. https://doi.org/10.1080/21532974.2015.1011291

Sibieta, L. (2018). The teacher labour market in England: shortages, subject expertise and incentives. Education Policy Institute Briefing Paper. London: EPI.

Sutcher, L., Darling-Hammond, L. & Carver-Thomas, D. (2016). A Coming Crisis in Teaching? Teacher Supply, Demand, and Shortages in the U.S. Palo Alto, CA: Learning Policy Institute.

Tamim, R. M., Bernard, R. M., Borokhovski, E., Abrami, P. C., & Schmid, R. F. (2011). What Forty Years of Research Says About the Impact of Technology on Learning: A Second-Order Meta-Analysis and Validation Study. *Review of Educational Research, 81*(1), 4–28. https://doi.org/10.3102/0034654310393361

Thibodeaux, A. K., Labat, M. B., Lee, D. E. & Labat, C. A. (2015). The effects of leadership and high-stakes testing on teacher retention. Academy of Educational Leadership Journal, 19(1), 227–49.

Tondeur, J., Roblin, N. P., van Braak, J., Voogt, J. & Prestidge, S. (2017). Preparing beginning teachers for technology integration in education: ready for take-off? *Technology, Pedagogy and Education, 26*(2), 157–177. https://doi.org/10.1080/1475939X.2016.1193556

Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P. & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education, 59*, 134–144. https://doi.org/10.1016/j.compedu.2011.10.009

Voogt, J., Fisser, P., Roblin, N. P., Tondeur, J. & van Braak, J. (2013). Technological pedagogical content knowledge – a review of the literature. *Journal of Computer Assisted Learning, 29*, 109–121. https://doi.org/10.1111/j.1365-2729.2012.00487.x

De Witte, K. & Smet, M. (2021). Financing Education in the Context of COVID-19. *European Expert Network on Economics of Education - EENEE Ad Hoc Repor*t 3. Pp. 27.

World Bank (2013). What *Matters* Most for Teacher Policies: A Framework Paper. Systems Approach for Better Education Results *(SABER).* Working paper series; no. 4. Washington, DC. World Bank.

Worth, J. & De Lazzari G (2017) *Teacher Retention and Turnover Research. Research Update 1: Teacher Retention by Subject*. Slough: NFER.

Wekerle, C. & Kollar, I. (2021). Fostering pre-service teachers' situation-specific technological pedagogical knowledge – Does learning by mapping and learning from worked examples help? *Computers in Human Behavior, 115,* 106617. https://doi.org/10.1016/j.chb.2020.106617

Yurtseven Avci, Z., O'Dwyer, L. M., & Lawson, J. (2020). Designing effective professional development for technology integration in schools. *Journal of Computer Assisted Learning, 36*, 160–177. https://doi.org/10.1111/jcal.12394

Zyngler, D. (2014). Class size and academic results, with a focus on children from culturally, linguistically and economically disadvantaged communities. *Evidence*

Based, issue 1, https://www.classsizematters.org/wp-content/uploads/2014/05/EvidenceBase2014Issue1.pdf

Digital learning

Agasisti, Gil-Izquierdo, and Han (2017). ICT use at home for school-related tasks: what is the effect on a student's achievement? Empirical evidence from OECD PISA data. *MPRA Paper No. 81343*,

Agélii Genlott & Grönlund (2016). Closing the gaps – Improving literacy and mathematics by ict-enhanced collaboration. *Computers & Education* 99 (2016) 68-80.

Alpert, W. T., Couch, K. A., & Harmon, O. R. (2016). A randomized assessment of online learning. *American Economic Review, 106(5)*, 378-82.

Arvanitaki & Zaranis (2020). The use of ICT in teaching geometry in primary school. *Education and Information Technologies* (2020) 25:5003–5016.

Banerjee, A. V., Cole, S., Duflo, E., & Linden, L. (2007). Remedying education: Evidence from two randomized experiments in India. *The Quarterly Journal of Economics*, 122(3), 1235-1264

Bartelet, D., Ghysels, J., Groot, W., Haelermans, C., Maassen van den Brink, H. (2016) "The Differential Effect of Basic Mathematics Skills Homework via a Web-Based Intelligent Tutoring System across Achievement Subgroups and Mathematics Domains: A Randomized Field Experiment." *Journal of Educational Psychology*, Vol 108(1), Jan, 2016 pp. 1-20.

Bergman, P., and Chan, E. W. (2019). "Leveraging parents through low-cost technology: The impact of high-frequency information on student achievement." *Journal of Human Resources*.

Bergman, P. (2021). "Parent-child information frictions and human capital investment: Evidence from a field experiment." *Journal of Political Economy.*

Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014). A meta-analysis of blended learning and technology use in higher education: From the general to the applied. *Journal of Computing in Higher Education, 26(1)*, 87-122.

Bettinger, E., Fairlie, R., Kapuza, A., Kardanova, E. Loyalka, P., & Zakharov, A. (2020). "Does edtech substitute for traditional learning? Experimental estimates of the educational production function" NBER Working Paper No. w26967

Bettinger, E., Fox, L., Loeb, S., & Taylor, E. (2017). Virtual classrooms: How online college courses affect student success. *American Economic Review, 107(9)*:2855–2875.

Bowen, W. G., Chingos, M. M., Lack, K. A., & Nygren, T. I. (2014). Interactive learning online at public universities: Evidence from a six- campus randomized trial. *Journal of Policy Analysis and Management, 33(1)*, 94-111.

Bulman, G. & Fairlie R. W. (2016) "Technology and education: Computers, software, and the internet." In *Handbook of the Economics of Education*. Vol. 5, 239–280.Elsevier.

Carlana M. & La Ferrara, E. (2021) "Apart but Connected: Online Tutoring and Student Outcomes during the COVID-19 Pandemic", Working Paper

Cacault, M. P., Hildebrand, C., Laurent-Lucchetti, J., & Pellizzari, M. (2021). Distance Learning in Higher Education: Evidence from a Randomized Experiment. *Journal of the European Economic Association, 19(4)*, 2322-2372.

Carretero, S.; Vuorikari, R. and Punie, Y. (2017). *DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use, EUR 28558 EN*, doi:10.2760/38842

Chappell, S.; Arnold, P., Nunnery, J., Grant, M. (2015) “An Examination of an Online Tutoring Program's Impact on Low-Achieving Middle School Students' Mathematics Achievement”, *Online Learning*, v19 n5 p37-53

Chirikov, I., Semenova, T., Maloshonok, N., Bettinger, E., & Kizilcec, R. F. (2020). Online education platforms scale college STEM instruction with equivalent learning outcomes at lower cost. *Science Advances, 6(15)*.

Comi, Argentin, Gui Origo, and Pagani (2017). Is it the way they use it? Teachers, ICT and student achievement. *Economics of Education Review 56* (2017) 24–39.

De Witte & Rogge (2014). Does ICT matter for effectiveness and efficiency in mathematics education? *Computers & Education 75* (2014) 173–184

Doss, C., Fahle, E. M., Loeb S. & York. B. N. (2019). “More Than Just a Nudge Supporting Kindergarten Parents with Differentiated and Personalized Text Messages.” *Journal of Human Resources* 54, no. 3: 567-603

EdTech Evidence Exchange (2021). The EdTech Genome Project. Report, July 2021.

Eickelmann, Gerick & Koop (2016). ICT use in mathematics lessons and the mathematics achievement of secondary school students by international comparison: Which role do school level factors play? *Educ Inf Technol* (2017) 22:1527–1551

Escueta, M., Quan, V., Nickow, A. J., & Oreopoulos, P. (2017). Education technology: An evidence-based review. *NBER Working Paper 23744.*

Escueta, M., Quan, V., Nickow, A. J., & Oreopoulos, P. (2020). "Upgrading Education with Technology: Insights from Experimental Research." *Journal of Economic Literature*, 58 (4): 897-996.

European Commission (2020). Digital Education Action Plan (2021-2027). Resetting education and training for the digital age.

Ferraro, S (2018). Is information and communication technology satisfying educational needs at school? *MPRA Paper No. 87040*

Figlio, D., Rush, M., & Yin, L. (2013). Is it live or is it internet? Experimental estimates of the effects of online instruction on student learning. *Journal of Labor Economics, 31(4)*, 763-784.

Frolova, Rogach & Ryabova (2020). Digitalization of Education in Modern Scientific Discourse: New Trends and Risks Analysis. *European Journal of Contemporary Education, 2020, 9(2).*

Hall, Lundin & Sibbmark (2021). A laptop for every child? The impact of technology on human capital formation. *Labour Economics, Volume 69, April 2021*, 101957.

Hart, C. M., Friedmann, E., & Hill, M. (2018). Online course-taking and student outcomes in California community colleges. *Education Finance and Policy, 13(1)*, 42–71

Hubalovsky, Hubalovska, and Musilek (2019). Assessment of the influence of adaptive E-learning on learning effectiveness of primary school pupils. *Computers in Human Behavior, Volume 92*, March 2019, Pages 691-705.

Hull, M. och K. Duch (2019). One-to-One technology and student outcomes: evidence from Mooresville's digital conversion initiative. *Educational Evaluation and Policy Analysis 41(1): 79–97*.

Israel, M. J. (2015). Effectiveness of integrating MOOCs in traditional classrooms for undergraduate students. *The International Review of Research in Open and Distributed Learning, 16(5)*

Levin, H. M., & McEwan, P. J. (2000). Cost-effectiveness analysis: Methods and applications (Vol. 4). Sage

Miller, S., Davison, J., Yohanis, J., Sloan, S., Gildea, A., & Thurston, A. (2017). Texting parents: Evaluation report and executive summary. Education Endowment Foundation

Muralidharan, K., Singh A., and Ganimian A. J.. 2019. "Disrupting education? Experimental evidence on technology-aided instruction in India." *American Economic Review* 109, no. 4: 1426-60

Nickow, A., Oreopoulos, P., and Quan, V. (2020). The impressive effects of tutoring on prek-12 learning: A systematic review and meta-analysis of the experimental evidence. NBER Working Paper, (w27476)

Roschelle, J., Feng, M.,Murphy, R.F. & Mason, C. A. (2016). "Online Mathematics Homework Increases Student Achievement." AERA Open 2 (4).

Sahni, S.D. & Polanin, J.R. & Zhang, Qi & Michaelson, L. & S.Caverly, & M.Polese, & Yang, E.. (2021). A What Works Clearinghouse Rapid Evidence Review of Distance Learning Programs.

Skryabin, Zhang, Liu, and Zhang (2015). How the ICT development level and usage influence student achievement in reading, mathematics, and science. *Computers & Education 85* (2015) 49-58.

Xu, D., & Jaggars, S. S. (2013). The impact of online learning on students' course outcomes: Evidence from a large community and technical college system. *Economics of Education Review, 37*, 46-57.

York, B. N., Loeb S., Doss C., 2019. "One Step at a Time," *Journal of Human Resources*, vol 54(3), pages 537-566.

Appendix 1. Lists of papers selected

Table 1. List of papers selected for consolidating evidence about effects of digital learning in school education

Study	Setting (level, country, period)	Intervention	Evaluation method	Results
Research built on large-scale survey data				
Comi et al. (2017)	More than 2000 10th grade students in Italy in 2011/12	Computer-based teaching in Mathematics and mother tongue	Within-student between-subject estimator	Computer-based teaching methods increased student performance when they increase students' awareness in digital use and when they enhanced communication. A negative impact of practices requiring an active role of the students in classes using digital devices.
Ferraro (2018)	Dataset from Italy, PISA 2012	Impact on mathematic test scores of the use of a computer, laptop or tablet at school	The BART model was applied as flexible Bayesian methodology	The paper shows that using ICT at school leads to better learning and knowledge acquisition among students and leads to better results among the students' mathematics scores.
Skryabin et al. (2015)	Datasets from TIMSS 2011, PIRLS 2011, PISA 2012, International Telecommunication Union, and World Bank. 4th and 8th grade students	Investigation of how national ICT development level and individual ICT usage influence achievements in reading, mathematics, and science	Comparison of country- and individual-level variables	National ICT development level is a significant positive predictor for individual academic performance in all three subjects for both 4th grade and 8th grade students
Eickelman et al (2016)	Dataset from PISA 2012 with more than 24 000 9th grade students from Australia, Germany, the Netherlands, Norway and Singapore	The effect of school level factors on the mathematics achievement of secondary school students	Multi-level regression model and a multi-level path model	Characteristics at school level, such as the IT equipment of schools, school leadership, aspects of school goals and educational strategies as well as teachers' attitudes, play a major role in the integration of ICT

				into teaching and learning and turn out to be relevant across the educational systems
Agasisti et al. (2017)	Dataset from PISA 2012 from EU-15	Investigation of the relationship between the way in which students use ICT at home for school-related purposes and their test scores in reading, mathematics and science.	Propensity score matching and instrumental variables	In most countries there is an association between using computers intensely for homework and achieving lower test scores across all subjects
Research built on comparing innovative digital instruction with traditional instruction				
Arvanati & Zaranis (2020)	46 students in 4th grade from Crete in 2018/2019	Incorporation of Augmented Reality (AR) technology in geometry teaching	Experimental and control group with pre- and post-testing	The use of AR has a positive effect on learning geometry as compared to the traditional teaching method
Hubalovsky et al. (2019)	30 students in 3rd grade from Czech Republic in 2014/2015	Use of adaptive algorithms in mathematics	Experimental and control group	The results confirm shortening of the total average time, conservation of the average value of success rate and increase of the average value of effectiveness. This means that educational objectives can be achieved with some students more effectively using learning analytics.
Agelii & Grönlund (2016)	502 students in 3rd grade from Sweden in 2011-2013	Introduction of the Write to Learn (WTL) methodology using several ICT tools to write texts, discuss and refine them together with classmates and teachers using digital real-time	A difference-in-difference methodology with three groups, one control group with traditional methods, another control group	WTL yields by far best results; higher average score both in literacy and mathematics, smaller gender gap, and significantly better results for the under-achievers. The method using

		formative feedback and assessment	with ICT individually and one experiment group using ICT and WTL	technology individually performs worst, which shows that ICT use must be well integrated into the pedagogy to be useful
Hull & Dutch (2019)	5 800 students from K-12 in North Carolina in 2012/2103	One laptop per child	A difference-in-difference methodology comparing student outcomes with students from neighbouring school districts	While short-term impacts of the program were statistically insignificant, math scores improved by 0.13 standard deviations in the medium term (4-5 years). Time spent on homework stayed constant, but students spent more of their homework time using a computer. There was mixed evidence on whether reading scores improved in the medium term.
Frovola et al. (2020)	Meta-study of 24 articles from 2013-2019	Digitalization of education	Systematic review	There is a relationship between high academic performance of students and the use of digital technologies. Other advantages of digitalization are: expanding the boundaries of self-directed learning, developing leadership in the pedagogical environment, creating conditions for the formation of individual educational trajectories of students, modernizing tools for assessing student knowledge, and also differentiating forms and methods for

				teaching. Some possible destructive consequences of digitalization of education are also detected. They include ousting experienced teachers with insufficient digital competence from the educational space; information overload; an increase in cognitive distortions; a decrease in the effectiveness of training regarding the formation of interpersonal communication skills of students; the deepening of digital divide; the formalization and dehumanization of education.
Hall et al. (2021)	Students in grade 7-9 in 26 Swedish municipalities in 2008-2016	One laptop per child	Mixed method comparing survey data from schools with administrative data on student performance	No evidence suggesting that 1:1 programs impact average student performance on the standardized tests, the probability of being admitted to upper secondary school, or the choice of educational track.

Table 2. List of the papers selected for consolidating evidence about the effects of digital learning out of the classroom

Study	**Setting (Level, Country & Period)**	**Intervention**	**Evaluation Method**	**Results**
Compensatory education with online tutoring				
Carlana & La Ferrara, 2021	Middle school students in Italy in 2020 (schools closed due to COVID_19)	Online tutoring of students by voluntary students (av. 3H/week during 5 weeks)	Randomized experiment compares treatment with no treatment	short term increase in test scores of 0.26 SD on average + positive effects on socio-emotional skills

Torgerson et al. 2016	5th year UK students in 2014/2015	Weekky Math online tutoring of students by graduates from India and Sri Lanka (45 minutes for 20 weeks)	Randomized experiment compares treatment with no treatment in 64 schools	No significant effects compared to business as usual (might include one-to-one in person tutoring)
After school programs / Homework using Computer assisted learning in developed countries				
Roschelle et al. AERA Open, 2016	7th grade students (middle school) in one US State (Maine) in 2010s	Use of computer assisted learning software for Math homework + teacher training.ASSISTments is a web-based system that delivers mathematics homework from textbooks to students online, gives students instant feedback on their responses, and provides teachers with reports about homework	Randomized experiment compares classes in treated vs control schools (in total 46 schools)	Short term increase of math scores concentrated among low achieving students (increase in 0.29 SD)
Bettinger et al. 2020	3rd grade students in Russia in 2018	Use of two dosages of CAL for homework in Math and Language (Base dosage : 20-25 min per week per subject or intensive dosage: 2X times higher)	Randomized experiment in treated vs control classes in 343 schools (6000 students), with 2 different intensity of treatment	Results point strongly to an effect of the base dosage, but not of intensive use. Short term increase in maths (0.12 SD) and language scores (0.07SD) of the base dosage. Intensive dosage has no additional effect for Maths scores and effect is zero compared to treatment group for language. Also find an effect on motivation for base dosage)
Bartelet et al. 2016	7th grades students in one school in Netherlands in 2012/13	Free access to a CAL program for math at home	Randomized experiments of 350 students in one schools, classes randomly assigned to treatment or control	Results point to significant effects on math test scores, larger for low-ability students, but show that withouth direct guidance, students may stick to easiest

				exercises. Teachers incitations seem to matter
Low-tech interventions to encourage parental invovment in children's education (not necessarily for low-income families)				
York et al. (2019)	Parents of pre-schoolers in the US (San Francisco) in 2013 to 2016	Text messaging program READY4K! To help with children development (8 month long program with 3 texts per week)	Randomized experiment compares treatment with no treatment among 1031 families	Increased parental involvment wich translated into learning gains for children (0.11 SD for litterary assesment), concentrated among lower performing children (0.31 SD)
Doss et al. (2019)	Parents of kindergartners in the US (San Francisco) in 2013 to 2016	Text messaging program READY4K! With standard versus personalized text messages	Randomized experiment compares treatment with no treatment among 794 families	Strong positive effect of personalized text message on subsequent litteracy tests of children
Bergman & Chan 2019	Parents of students in 22 middle and high schools in the US (West Virginia) in 2015	Text message to parents regarding their child's academic performance, including grades, upcoming tests and missing assignments	RCT at the school-grade level among 1137 volunteering parents	Positive effects on attendance, reduction in number of courses faileds and increase in GPA, but no effect on (low stakes) standardized scores
Bergman 2021	Parents of students in one high school in the US (Los Angeles) in 2010-2011	Text messages regarding missing assignment and upcoming tests	RCT among 306 students	Positive effects on attendance, completed homework and test scores
Miller et al. (2017)	Parent of students in secondary schools in the UK in 2014-15	Text messages regarding missing assignment and upcoming tests, etc.	RCT among 15697 students	Positive effects on attendance, positive but limited effects on test scores

Table 3. List of the papers selected for deriving/consolidating evidence about the effects of Digital Learning in Higher Education

Study	Digital Learning Type	Setting	Evaluation Design	Methodology	Output indicator	Effect
Figlio, D., Rush, M., & Yin, L. (2013)	Online vs. live	Course of Introductory microeconomics course, US University	Randomized experiment	Descriptive statistics + regression	Exam score	Small but statistically significant negative impact of online education
Xu, D., & Jaggars, S. S. (2013)	Online vs. live	Courses of Washington State's 34 two-year public community or technical colleges (US)	Quasi-experimental design	IV - Instrumental Variables	Course persistence and course grade	Statistically significant negative impact for online education, for both outputs
Bowen, W. G., Chingos, M. M., Lack, K. A., & Nygren, T. I. (2014)	Blended vs. live	Statistics course in six public universities (US)	Randomized experiment	Descriptive statistics + regression	Pass rates, final exam scores, and performance on a standardized assessment of statistical literacy. simulation on costs	Non significant difference in terms of student outputs. Costs simulation shows saving ranging from 36 to 57% in the long run
Bernard, R. M., Borokhovski, E., Schmid, R. F., Tamim, R. M., & Abrami, P. C. (2014)	Blended vs. live	Review of blended learning in higher education	-	Meta-analysis on 96 studies	Student achievement	Statistically significant positive effetc of blended learning over on-campus results
Israel, M. J. (2015).	Blended with MOOC	Review of previous studies	-	-	Student achievement and satisfaction	Statistically significant positive impact of blended learning, although lower student satisfaction

Bettinger, E., Fox, L., Loeb, S., & Taylor, E. (2017)	Online vs. live	At DeVry university (US) for each class students can decide whether to enroll online or in presence		IV - Instrumental Variables	Course grades, course grades in the subsequent term, probability of remaining enrolled	Statistically significant negative effect for online education students
Alpert, W. T., Couch, K. A., & Harmon, O. R. (2016).	Online vs. blended vs. live	Principles of microeconomics (US)	Randomized experiment	Descriptive statistics + regression	Exam score	Statistically significant negative effect for online education vs on-campus. Non statistically significant effect for blended education
Escueta, M., Quan, V., Nickow, A. J., & Oreopoulos, P. (2017)	Online and MOOCs vs live	Review of the literature	-	-	Review of studies considering student achievement, accessibility, persistence	Mixed evidence in online learning. Behavioural studies on MOOC persistence usually show positive effects
Hart, C. M., Friedmann, E., & Hill, M. (2018)	Online vs. live	California Community College	Quasi-experimental design	FE - Fixed effects	Likelihood of course completion, course completion with a passing grade.	Statistically significant negative effects from students in online courses
Cacault, M. P., Hildebrand, C., Laurent-Lucchetti, J., & Pellizzari, M. (2021)	Online vs. live	European university in Switzerland	Randomized experiment	Descriptive statistics + regression	Student achievement and class attendance	Small negative effect of online education on class attendance. The effect of online learning is statistically significant positive for high-ability students, and negative for low-ability students
Deming, D. J., Goldin, C., Katz, L. F., & Yuchtman, N. (2015).	Costs for distance education	Data from Integrated Postsecondary Education Data System (US)	-	Regression	Natural log of tuition and fees	Prices for full-time undergraduate online education declined from 2006 to 2013 (thus online learning can bend the curve)

Hoxby, Caroline (2018)	Revenues of online students	Internal Revenue Service and the Department of Education data on students who completed most or all post-secondary education online	Quasi-esperimental study	Regression and cost analysis	Return on investment (ROI) based on earnings	Fully online learning does appear to increase the rate of income growth of income, but not enough to make up for the cost to the individual student
Protopsaltis, S., & Baum, S. (2019).	Effectiveness and costs	Review of the literature	-	-	Student learning, costs, return on investment	Positive, statistically significant effects of blended learning. Return on investment seems to favour traditional education. Online education costs similar to on-campus education.

Management, infrastructure and learning environments

21st Century School Fund (2009), *Research on the Impact of School Facilities on Students and Teachers: A Summary of Studies Published Since 2000*, 21st Century school fund.

Barrett, P. S., F. Davies, Y. Zhang, and L. Barrett (2015), *The Impact of Classroom Design on Pupils' Learning: Final Results of a Holistic, Multi-Level Analysis*, Building and Environment 89: 118–33.

Barrett, P., F. Davies, Y. Zhang, and L. Barrett (2016), *The Holistic Impact of Classroom Spaces on Learning in Specific Subjects*, Environment and Behavior 2016.

Barrett, Peter; Treves, Alberto; Shmis, Tigran; Ambasz, Diego; Ustinova, Maria (2019), *The Impact of School Infrastructure on Learning: A Synthesis of the Evidence,* International Development in Focus; Washington, DC: World Bank. © World Bank. Retrieved from:https://openknowledge.worldbank.org/handle/10986/30920

Benhenda, A. (2020), *The impact of school facility expenditures on pupil attainment*, No 10, CEPEO Briefing Note Series, Centre for Education Policy and Equalising Opportunities, UCL Institute of Education.

Bertoni, M., Gibbons, S. & Silva, O. (2020), *School choice during a period of radical school reform. Evidence from academy conversion in England*, Economic Policy, Volume 35, Issue 104, Pages 739–795, https://doi.org/10.1093/epolic/eiaa023

Björklund, A, Edin, P-A, Fredriksson, P & A Krueger (2004), *Education, Equality and Efficiency – An analysis of Swedish School Reforms During the 1990s*, Report 2004:1, Institute for Labour Market Policy Evaluation (IFAU), Uppsala.

Blackmore, J. et al. (2010), *The Connections Between New Learning Spaces and Student Learning Outcomes: A Literature Review*, Department of Education and Early Childhood Development, Melbourne.

Blackmore, J., D. Bateman, J. Loughlin, J. O'Mara, and G. Aranda (2011), *Research into the connection between built learning spaces and student outcomes*, Education, Policy and Research Division, Department of Education and Early Childhood Development, State of Victoria: Melbourne.

Bloom, N., Lemos, R., Sadun, R. and Van Reenen, J. (2015), *Does Management Matter in schools?*, Economic Journal, 125: 647-674. https://doi.org/10.1111/ecoj.12267

Bluyssen, P. M. (2016), *Health, comfort, and performance of children in classrooms: New directions for research*, Indoor and Built Environment. Vol 26, Issue 8, 2017.

Burman E., Kimpian J., Mumovic D. (2018), *Building Schools for the Future: Lessons Learned From Performance Evaluations of Five Secondary Schools and Academies in England*, Frontiers in Built Environment, 4.

Caspersen, J, Frølich, N, Muller, J (2017), *Higher education learning outcomes – Ambiguity and change in higher education*, European Journal of Education; 52: 8– 19. https://doi.org/10.1111/ejed.12208

Chabrier, Julia, Sarah Cohodes, and Philip Oreopoulos (2016), *What Can We Learn from Charter School Lotteries*, Journal of Economic Perspectives, 30 (3): 57-84. See also the website "Charter schools in perspective"

Council of Europe Development Bank (2021), *Constructing Education: An Opportunity not to be Missed*, CEB. Retrieved from: https://coebank.org/media/documents/Constructing_Education.pdf

Cleveland, B., and K. Fisher (2014), *The Evaluation of Physical Learning Environments: A Critical Review of the Literature*, Learning Environments Research 17 (1): 1–28.

Davies, D., D. Jindal-Snape, C. Collier, and R. Digby, (2013), *Creative Learning Environments in Education: A Systematic Literature Review*, Thinking Skills and Creativity, 8: 80–91.

Eyles, A. & Machin, S. (2019), *The Introduction of Academy Schools to England's Education*, Journal of the European Economic Association, Volume 17, Issue 4, Pages 1107–1146.

Enders, J., de Boer, H. & Weyer, E. (213), *Regulatory autonomy and performance: the reform of higher education re-visited*, High Educ 65, 5–23. https://doi.org/10.1007/s10734-012-9578-4

Epple, Dennis, Richard E. Romano, and Miguel Urquiola (2017), *School Vouchers: A Survey of the Economics Literature*, Journal of Economic Literature, 55 (2): 441-92.

European Agency for Special Needs and inclusive Education, (2017), *Decentralisation of Educational Systems: Seminar report*, https://www.european-agency.org/sites/default/files/Decentralisation%20in%20Education%20Systems_0.pdf

Hansen, H. F., Geschwind, L., Kivisto, J., Pekkola, E., Pinheiro, R., & Pulkkinen, K. (2019), *Balancing accountability and trust*, Higher Education, 78(3), 557–573. [10]. https://doi.org/10.1007/s10734-019-0358-2

Hanushek, E. A., Link, S. & Woessmann, L. (2013), *Does school autonomy make sense everywhere? Panel estimates from PISA*, Journal of Development Economics, Volume 104, Pages 212-232.

Higgins, S., E. Hall, K. Wall, P. Woolner, and C. McCaughey (2005), *The Impact of School Environments: A Literature Review*, The Centre for Learning and Teaching School of Education, Communication and Language Science, University of Newcastle, Australia.

Kok H, Mobach M, Omta O. (2015), *Predictors of study success from a teacher's perspective of the quality of the built environment*, Management in Education 29(2):53-62. doi:10.1177/0892020614553719

Lafortune, J., & Schönholzer, D. (2021), *The Impact of school facility investments on students and homeowners: evidence from Los Angeles*, Working Paper.

Neri, L., Pasini, E. & Silva, O. (2021), *The Organizational Economics of School Chains*, working paper https://www.aiel.it/cms/cms-files/submission/all20210727141727.pdf

OECD/CELE (2009), *Review of the Secondary School Modernisation Programme in Portugal*, OECD, https://www.oecd.org/portugal/44247100.pdf

OECD (2011), *School Autonomy and Accountability: Are They Related to Student Performance?*, PISA in Focus, n 9, OECD, Paris, https://doi.org/10.1787/5k9h362kcx9w-en

OECD Centre for Educational Research and Innovation (2011b), *The Nature of Learning: Using Research to Inspire Practice,* OECD Publishing, Paris.

OECD (2011c), *Designing for Education: Compendium of Exemplary Educational Facilities 2011*, OECD, Paris. http://dx.doi.org/10.1787/9789264112308-en

OECD (2012), *Modernising secondary school buildings in Portugal*, OECD Publishing, Paris, https://doi.org/10.1787/9789264128774-en

OECD (2013), *Framework for the LEEP Module on the Effectiveness and Efficiency of the Physical Learning Environment,* OECD, Paris.

OECD (2017), *The Funding of School Education: Connecting Resources and Learning*, OECD Reviews of School Resources, OECD, Paris, https://doi.org/10.1787/9789264276147-en

OECD (2017b*), Framework for the LEEP Module on the Effectiveness and Efficiency of the Learning Environment,* OECD, Paris.

OECD (2018), *OECD School User Survey: Improving Learning Spaces Together*, OECD, Paris. Retrieved from: http://www.oecd.org/education/OECD-School-User-Survey-2018.pdf

OECD (2019), *Analytical Framework for Case Study Collection*, OECD, Paris. Retrieved from: https://www.oecd.org/education/effective-learning-environments/Analytical-Framework-for-Case-Study-Collection.pdf

OECD (2020), *Final Report: OECD Case Study Collection on Transforming Learning Environments* in, OECD, Paris.

Perspective.brussels (2018), *Mon école, un espace de qualité. Guide pour l'enseignement fondamental*, https://perspective.brussels/sites/default/files/documents/mon_ecole_un_espace_qualite_0.pdf

Picus, L.O. et al. (2005), *Understanding the relationship between student achievement and the quality of educational facilities: evidence from Wyoming*, *Peabody Journal of Education*, Vol. 80, No. 3, pp. 71-95.

PricewaterhouseCoopers (2003), *Building Better Performance: An Empirical Assessment of The Learning and Other Impacts of Schools Capital Investment*, Department for Education and Skills UK, London.

Santiago, P. et al. (2016), *OECD Reviews of School Resources: Slovak Republic 2015*, OECD Reviews of School Resources, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264247567-en

Santiago, P. et al. (2016), *OECD Reviews of School Resources: Uruguay 2016*, OECD Reviews of School Resources, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264265530-en

Shlomo Mizrahi (2021), *Performance Funding and Management in Higher Education: The Autonomy Paradox and Failures in Accountability*, Public Performance & Management Review, 44:2, 294-320, DOI: 10.1080/15309576.2020.1806087

Schneider, M. (2002), *Do School Facilities Affect Academic Outcomes?,* Educational Resources Information Center, United States Department of Education, Washington, DC.

Shmis, Tigran; Ustinova, Maria; Chugunov, Dmitry (2020), *Learning Environments and Learning Achievement in the Russian Federation: How School Infrastructure and Climate Affect Student Success*, International Development in Focus; Washington, DC: World Bank. © World Bank. Retrieved from: https://openknowledge.worldbank.org/handle/10986/32598

Temple, P. (2007), *Learning Spaces for the 21st Century: A Review of the Literature*, Centre for Higher Education Studies, Institute of Education, University of London.

Thomson, D. (2016), *The short run impact of the building schools for the future programme on attainment at key stage 4*, UCL IOE Department of Social Science Working Paper, 1607.

Tyrefors, B. and Vlachos J. (2017) The impact of upper-secondary voucher school attendance on student achievment. Swedish evidence using external and internal evaluations. Labour Economics, Volume 47

UNESCO Institute for Statistics (2012), *A Place to Learn: Lessons from Research on Learning Environments*, UNESCO: Montreal.

US National Research Council (2006), *Green Schools: Attributes for Health and Learning*, Committee to Review and Assess the Health and Productivity Benefits of Green Schools, Washington, DC: The National Academies Press.

Velissaratou, J. (2017), *Utiliser les infrastructures scolaires au-delà du temps scolaire habituel: l' exemple des écoles ouvertes d' Athènes et deux autres exemples (Slovaquie et Uruguay)*, Revue Trimestrielle de l' Association Française des Acteurs de l' Education, Espaces scolaires et universitaires, usages et enjeux, 2017/4 (N° 156), p. 83-87, AFAE, Paris, https://www.afae.fr/produit/n-156-espaces-scolaires-universitaires-usages-enjeux/

Woessmann, Ludger (2016), *The Importance of School Systems: Evidence from International Differences in Student Achievement. International comparison of different school systems and students' results,* The Journal of Economic Perspectives, Vol. 30, No. 3 (Summer 2016), pp. 3-31.

Woolner, P., E. Hall, S. Higgins, C. McCaughey, and K. Wall, (2007), *A Sound Foundation? What We Know about the Impact of Environments on Learning and the Implications for Building Schools for the Future*, Oxford Review of Education 33 (1): 47–70.

Woolner, P. (2010), *The Design of Learning Spaces*, London: Continuum.

Equity and inclusion

Allen, R. (2007). Allocating pupils to their nearest secondary school: The consequences for social and ability stratification. *Urban Studies*, *44*(4), 751–770. https://doi.org/10.1080/00420980601184737

Allen, R., Burgess, S., Mckenna, L. (2013). The short-run impact of using lotteries for school admissions: early results from Brighton and Hove's reforms. *Transactions of the Institute of British Geographers*, *38*(1), 149–166. https://doi.org/10.1111/i.l475-5661.2012.00511.x

Ammermüller, A. (2005). Educational Opportunities and the Role of Institutions. Centre for European Economic Research Discussion Paper No. 05-44.

Ammermueller, A., & Pischke, J.S. (2009). Peer effects in European primary schools: Evidence from the Progress in International Reading Literacy Study. *Journal of Labor Economics, 27(3),* 315-348.

*Angrist, J.D. & Lang, K. (*2004). Does School Integration Generate Peer Effects? Evidence from Boston's Metco Program. *American Economic Review, 94 (5),* 1613-1634.

Ansell, B.W. (2008). University Challenges: Explaining Institutional Change in Higher Education. *World Politics, 60,* 189–230.

Akgündüz, Y.E. & Suzanne H. (2018). Impact of Funding Targeted Pre-school Interventions on School Readiness: Evidence from the Netherlands. *De Economist, 166,* 155–178.

Bandura, A. (1969). Social-Learning Theory of Identificatory Processes. *In* D.A. Goslin (Ed.), *Handbook of Socialization Theory and Research.* Chicago: Rand McNally & Company, 213-262.

Baier, T., & Helbig, M. (2014). Much ado about €500: Do tuition fees keep German students from entering university? Evidence from a natural experiment using DiD matching methods. *Educational Research and Evaluation, 20(2),* 98-121.

Basile, M. (2012) The Cost-Effectiveness of Socioeconomic School Integration, in Richard D. Kahlenberg (ed.) *The Future of School Integration as an education reform strategy.* Century Foundation Press, pp. 127-151.

Batruch, A., Autin, F., Bataillard, F., & Butera, F. (2019). School selection and the social class divide: How tracking contributes to the reproduction of inequalities. *Personality and Social Psychology Bulletin,* 45(3), 477-490.

Baysu, G., Celeste, L., Brown, R., Verschueren, K. & Phalet, K. (2016), Minority Adolescents in Ethnically Diverse Schools: Perceptions of Equal Treatment Buffer Threat Effects. Child Dev, 87: 1352-1366. https://doi.org/10.1111/cdev.12609

Benabou, R., F. Kramarz, and Prost, C. (2004). "Zones d'Education Prioritaire: Much Ado About Nothing?" CREST-INSEE working paper.

Benhenda, A. & Grenet, J. (2020). "Stay a Little Longer? Teacher Turnover, Retention and Quality in Disadvantaged Schools", Centre for Education Policy and Equalising Opportunities (CEPEO), Working Paper No. 20-03.

Betts, J. R. (2011). The economics of tracking in education. *In* E. A. Hanushek, S. Machin & L. Woessman (eds) *Handbook of the Economics of Education, Volume 3.* Elsevier. 341-381.

Betts, J. R., Kitmitto, S., Levin, J., Bos, J., & Eaton, M. (2015). *What Happens When Schools Become Magnet Schools ? A Longitudinal Study of Diversity and Achievement*. Retrieved from: http://www.air.org/sites/default/files/downloads/report/Magnet-Schools-Diversity-and-Achievement-May-2015.pdf%5Cnfiles/715/Magnet-Schools-Diversity-and-Achievement-May-2015.html

Billings, S., D. Deming, and J. Rockoff (2014), 'School Segregation, Educational Attainment, and Crime. Evidence from the End of Busing in Charlotte-Mecklenburg', *Quarterly Journal of Economics*, 129 (1): 433-475.

Bonal, X., & Bellei, C. (eds) (2018). *Understanding school segregation: patterns, causes and consequences of spatial inequalities in education*. London, UK: Bloomsbury Publishing.

Bonal, X. & Pagès, M. (2019). *Priority education policies in Catalonia: between ignorance and social assistance*. ECER 2019, Hamburg.

Bonal, X., Zancajo, A., & Scandurra, R. (2020). Student mobility and school segregation in an (un)controlled choice system: A counterfactual approach. *British Educational Research Journal*. https://doi.org/10.1002/berj.3694

Bruckmeier, K., Fischer, G. B., & Wigger, B. U. (2015). Tuition fees and the time to graduation: Evidence from a natural experiment. *Journal of Higher Education Policy and Management, 37(4),* 459-471.

Brunello, G., & Checchi, D. (2007). Does school tracking affect equality of opportunity? New international evidence. *Economic policy, 22(52)*, 782-861.

Cebolla-Boado, H., & Medina, L. G. (2011). The impact of immigrant concentration in Spanish schools: School, class, and composition effects. *European Sociological Review*, *27*, 606–623. https://doi.org/10.1093/esr/jcq024

Chmielewski, A. K. (2014). An international comparison of achievement inequality in within-and between-school tracking systems. *American Journal of Education, 120(3),* 293-324.

Claeys-Kullik, A.L. ja Estermann, T. (2015). *Define Thematic Report: Performance Based Funding of Universities in Europe.* European University Association. Brussels: Belgium.

Council of Europe (2017) *Fighting school segregation in Europe through inclusive education: a position paper*. Strasbourg: Council of Europe.

Davezies, L. & Garrouste, M. (2020). More Harm than Good? Sorting Effects in a Compensatory Education Program, *Journal of Human Resources*, 55(1), 240-277.

Deunk, M. I., Smale-Jacobse, A. E., de Boer, H., Doolaard, S., & Bosker, R. J. (2018). Effective differentiation practices: A systematic review and meta-analysis of studies on the cognitive effects of differentiation practices in primary education. *Educational Research Review, 24,* 31-54.

Dobbins, M. & Knill, C. (2014). H*igher Education Governance and Policy Change in Western Europe International Challenges to Historical Institutions.* London: Palgrave Mcmillian.

Dupriez, V; Dumay, X. & Vause, A. (2008) How Do School Systems Manage Pupils' Heterogeneity? Comparative Education Review, 52 (2), 245-273.

Duru-Bellat, M., Mons, N. and Suchaut, B. (2004), Caractéristiques des systèmes éducatifs et compétences des jeunes de 15 ans. L'éclairage des comparaisons entre pays. Les Cahiers de l'IREDU (Bourgogne, IREDU, CNRS-Université de Bourgogne).

Dwenger, N., Storck, J., & Wrohlich, K. (2012). Do tuition fees affect the mobility of university applicants? Evidence from a natural experiment. *Economics of Education Review, 31(1),* 155-167.

Estermann, T., & Claeys-Kulik, A. L. (2016). Performance-based funding of universities in Europe. *International Higher Education, (85),* 31-33.

European Commission (2015) *Guidance for Member States on the use of European Structural and Investment Funds in tackling educational and spatial segregation. Retrieved from:* https://ec.europa.eu/regional_policy/en/information/publications/guidelines/2015/guidance-for-member-states-on-the-use-of-european-structural-and-investment-funds-in-tackling-educational-and-spatial-segregation

European Commission. (2020). *Communication from the commission to the European parliment, the Council, the European Economic and Social Committee and the Committee of the Regions on achieving the European Education Area by 2025.* Retrieved from: https://ec.europa.eu/info/sites/default/files/communication-european-strategy-data-19feb2020_en.pdf

European Higher Education Area. (2015). *Widening participation for equity and growth: A strategy for the development of the social dimension and lifelong learning in the European Higher Education Area to 2020.*

Eurydice (2008), Higher Education Governance in Europe. Policies, structures funding and academic staff. Brussels: Eurydice, European Commission.

Eurydice. (2020a). *Equity in school education in Europe: Structures, policies and student performance.* Eurydice report. Luxembourg: Publications Office of the European Union.

Eurydice. (2020b). *National Student Fee and Support Systems in European Higher Education – 2020/21. Eurydice – Facts and Figures.* Luxembourg: Publications Office of the European Union.

Fack, G. & Grenet, J. (2015). Improving College Access and Success for Low-Income Students: Evidence from a Large Need-Based Grant Program. *American Economic Journal: Applied Economics, 7(2),* 1-34.

Feigenberg, B., Yan, R. and Rivkin, S. (2018). Illusory Gains from Chile's Targeted school voucher experiment, *The Economic Journal*, 129, 2805–2832.

Francia, G. (2013). The impacts of individualization on equity educational policies. *New approaches in educational research*, 2 (1), 17–22.

Frankenberg, E. and Orfield, G. (2012), The Resegregation of Suburban Schools A Hidden Crisis in American Education. Cambridge, MA: Harvard Education Press.

Garritzmann, J. (2016). *The Political Economy of Higher Education Finance: The Politics of Tuition Fees and Subsidies in OECD Countries, 1945–2015.* London: Palgrave Macmillan.

Garritzmann, J. (2017). The Partisan Politics of Higher Education. *PS: Political Science & Politics, 50(2),* 413-417. doi:10.1017/S1049096516002924.

González Motos, S. (2016). Friendship networks of the foreign students in schools of Barcelona: impact of class grouping on intercultural relationships. *International Journal of Intercultural Relations*, *55*, 66–78. https://doi.org/https://doi.org/10.1016/j.ijintrel.2016.08.005

Hanushek, E. A., Wößmann, L. (2006). Does Educational Tracking Affect Performance and Inequality? Differences-in-Differences Evidence across Countries. *Economic Journal, 116* (510), C63-C76.

Harris, J. R. (1995). Where is the child's environment? A group socialization theory of development. *Psychological review, 102(3),* 458.

Havranek, T., Irsova, Z., & Zeynalova, O. (2018). Tuition fees and university enrolment: a meta-regression analysis. *Oxford Bulletin of Economics and Statistics, 80(6),* 1145-1184.

Hendren, N., & Sprung-Keyser, B. (2020). A Unified Welfare Analysis of Government Policies. *Quarterly Journal of Economics, 135(3),* 1209-1318.

Herbaut, E., & Geven, K. M. (2019). *What Works to Reduce Inequalities in Higher Education? A Systematic Review of the (Quasi-)Experimental Literature on Outreach and Financial Aid.* Policy Research Working Paper No. 8802. Washington, DC: World Bank.

Jakubowski, M., Patrinos, H. A., Porta, E. E., & Wiśniewski, J. (2016). The effects of delaying tracking in secondary school: evidence from the 1999 education reform in Poland. *Education Economics, 24(6),* 557-572.

Johnson, Rucker (2011), 'Long-Run Impacts of School Desegregation & School Quality on Adult Attainments', NBER Chapter.

Kimbrough, E. O., McGee, A. D., & Shigeoka, H. (2017). How do peers impact learning? an experimental investigation of peer-to-peer teaching and ability tracking (No. w23439). National Bureau of Economic Research.

Lamont, M., & Pierson, P. (2019) Inequality Generation & Persistence as Multidimensional Processes in Dædalus. *Journal of the American Academy of Arts & Sciences, 148(3)*, 5-18.

Leuven, E., Lindahl, M., Oosterbeek, H. & Webbink, D. (2007). The Effect of Extra Funding for Disadvantaged Pupils on Achievement. *The Review of Economics and Statistics*, 89(4), 721–736.

Loveless, T. (2009). Tracking and Detracking: High Achievers in Massachusetts Middle Schools. Thomas B. Fordham Institute.

Machin, S., McNally, S. & Meghir. C. (2005). Evaluating 'Excellence in Cities'. *CentrePiece, the Magazine of The Center for Economic Performance, 10(3),* 18-21.

Makles, A., & Schneider, K. (2011). Segregation in primary schools - Do school catchment areas really matter ? Evidence from policy reforms. *Schumpeter Discussion Papers* 003. University of Wuppertal.

Marcucci, P. & Johnstone, D.B. (2007). Tuition fee policies in a comparative perspective: Theoretical and political rationales, *Journal of Higher Education Policy and Management, 29(1),* 25-40.

McCoy, S., Quail, A. & Smyth, E. (2014). The effects of school social mix: upacking the differences, *Irish Educational Studies*, 33(3), 307-330.

Mijs, J.J.B. (2021). The paradox of inequality: income inequality and belief in meritocracy go hand in hand. *Socio-Economic Review, 19(1)*, 7–35.

Moulin, L., Flacher, D., & Harari-Kermadec, H. (2016). Tuition fees and social segregation: lessons from a natural experiment at the University of Paris 9-Dauphine. *Applied Economics, 48(40),* 3861-3876.

Murphy, R., Scott-Clayton, J., & Wyness, G. (2019). The end of free college in England: Implications for enrolments, equity, and quality. *Economics of Education Review, 71,* 7-22.

Navarro-Palau, P. (2017). Effects of differentiated school vouchers: evidence from a policy change and date of birth cutoffs. *Economics of Education Review*, 58, 86–107.

Neilson, C. (2013). *Targeted vouchers, competition among schools, and the academic achievement of poor students.* Working Paper, Yale University

Noblit G.W. (2015), 'Introduction', in Noblit G.W. (ed.) School Desegregation. Breakthroughs in the Sociology of Education. SensePublishers, Rotterdam.

OECD (2012). *Equity and Quality in Education. Supporting Disadvantaged Students and Schools.* Paris: OECD Publishing.

OECD (2016). *PISA 2015 Results (Volume II.): Policies and Practices for Successful Schools.* Paris: OECD Publishing.

OECD (2017). *Education at a Glance 2017: OECD Indicators.* Paris: OECD Publishing.

Parker, P.D., Jerrim, J., Schoon, I. and Marsh, H.W. (2016). A Multination Study of Socioeconomic Inequality in Expectations for Progression to Higher Education: The Role of Between-School Tracking and Ability Stratification. *American Educational Research Journal, 53(1),* 6-32.

Patacchini, E., Rainone, E., & Zenou, Y. (2017). Heterogeneous peer effects in education. *Journal of Economic Behavior & Organization*, *134*, 190–227. https://doi.org/https://doi.org/10.1016/j.jebo.2016.10.020

Poder, K., Kerem, K., & Lauri, T. (2013). Efficiency and Equity Within European Education Systems and School Choice Policy: Bridging Qualitative and Quantitative Approaches. *Journal of School Choice, 7(1),* 1–36.

Saatcioglu, A. (2010) Disentangling School- and Student-Level Effects of Desegregation and Resegregation on the Dropout Problem in Urban High Schools: Evidence From the Cleveland Municipal School District, 1977–1998. *Teachers College Record*, 112 (5), 1391-1442.

Schuetz, G., Ursprung, H.W., & Wößmann, L. (2008). Education policy and equality of opportunity. *Kyklos 61(2),* 279-308.

Shapiro, J. & Treviño. J.M. (2004). Compensatory Education for Disadvantaged Mexican Students: An Impact Evaluation Using Propensity Score Matching. World Bank Policy Research, Working Paper 3334. Washington, DC: World Bank.

Smyth, E., McCoy, S. & Kingston, G. (2014). *Learning from the Evaluation of DEIS*, Dublin: ESRI.

Smyth, E., & McCoy, S. (2021). School Experience and Post-School Pathways in the Republic of Ireland, in J.E. Symonds, ed., *Young Adult Development at the School to Work Transition: International Pathways and Processes,* Oxford University Press.

Stark, T. H., Mäs, M., & Flache, A. (2015). Liking and disliking minority-group classmates: Explaining the mixed findings for the influence of ethnic classroom composition on interethnic attitudes. *Social Science Research*, *50*, 164–176. https://doi.org/https://doi.org/10.1016/j.ssresearch.2014.11.008

Steenbergen-Hu, S., Makel, M. C., & Olszewski-Kubilius, P. (2016). What one hundred years of research says about the effects of ability grouping and acceleration on K–12 students' academic achievement: Findings of two second-order meta-analyses. *Review of Educational Research, 86(4),* 849-899.

Strietholt, R., Gustafsson, J-E., Hogrebe, N., Rolfe, V., Rosén, M., Steinmann, I. & Yang Hansen, K. (2019). The Impact of Education Policies on Socioeconomic Inequality in Student Achievement: A Review of Comparative Studies. In: Volante, L., Schnepf, S.V., Jerrim, J. and Klinger, D.A., eds. *Socioeconomic Inequality and Student Outcomes: CrossNational Trends, Policies, and Practices.* Singapore: Springer, pp. 17-38.

Thrupp, M., Lauder, H., & Robinson, T. (2002). School composition and peer effects. *International Journal of Educational Research*, *37*(5), 483–504. https://doi.org/https://doi.org/10.1016/S0883-0355(03)00016-8

United Nations. (2019). *The Sustainable Development Goals Report 2019.* New York: United Nations.

Wößmann, L. (2007). Fundamental Determinants of School Efficiency and Equity: German States as a Microcosm for OECD Countries. CESifo Working Paper 1981.

Wößmann,, L. (2009). International evidence on school tracking: A review. *CESifo DICE Report, 7(1),* 26-34.

Zimmer, R. W., & Toma, E., F. (2000). Peer effects in private and public schools across countries. *Journal of Policy Analysis and Management, 19(1),* 75-92.

Cost-benefit analysis and evaluation methods

Angrist, J. D. (1998). Estimating the labor market impact of voluntary military service using social security data on military applicants. Econometrica, 66(2), 249–288.

Angrist, J. D., & Pischke, J. (2009). Mostly harmless econometrics. Princeton University Press.

Azevedo, J. P., Hasan, A., Goldemberg, D., Geven, K., & Iqbal, S. A. (2021). Simulating the potential impacts of COVID-19 school closures on schooling and learning outcomes: A set of global estimates. *The World Bank Research Observer*, 36(1), 1-40.

Bratti, M., Ghirelli, C., Havari, E. *et al.* Vocational training for unemployed youth in Latvia. *J Popul Econ* (2021). https://doi.org/10.1007/s00148-021-00877-8

Brent, R. J. (2017). *Advanced introduction to cost–benefit analysis*. Edward Elgar Publishing.

Caliendo, M. and S. Kopeinig (2008), Some practical guidance for the implementation of propensity score matching", Journal of Economic Surveys, 22(1): 31-72.

Cerulli, G. (2015). Econometric evaluation of socio-economic programs. Springer.

De Paola, M., Scoppa, V. The effectiveness of remedial courses in Italy: a fuzzy regression discontinuity design. *J Popul Econ* **27,** 365–386 (2014). https://doi.org/10.1007/s00148-013-0466-8

De Rus, G. (2021). *Introduction to cost–benefit analysis: looking for reasonable shortcuts*. Edward Elgar Publishing.

De Witte, K. and Smet, M. (2021). Financing Education in the Context of COVID-19. European Expert Network on Economics of Education - EENEE Ad Hoc Report 3. Pp. 27.

Duflo E., Glennerster R., Kremer M. (2007), "Using Randomization in Development Economics Research: A Toolkit," Handbook of Development Economics, Elsevier, Volume 4, 2007,Pages 3895-3962.

Engzell, P., Frey, A., & Verhagen, M. D. (2021). Learning loss due to school closures during the COVID-19 pandemic. *Proceedings of the National Academy of Sciences*, 118(17)

Gambi, L. and De Witte, K. (2021). The resiliency of school outcomes after the COVID-19 pandemic. Standardised test scores and inequality one year after long term school closures. *Department of Economics Discussion Paper Series* DPS21.12, pp. 50.

Hanushek, E. A., & Woessmann, L. (2020). The economic impacts of learning losses. OECD. Paris.

Iterbeke, K. and De Witte, K. (2021). Helpful or Harmful? The Role of Personality Traits in Student Experiences of the COVID-19 Crisis and School Closure. *Personality and Social Psychology Bulletin.* In Press.

Iterbeke, K., De Witte, K, and Schelfhout, W. (2021). The effects of computer-assisted adaptive instruction and elaborated feedback on learning outcomes. A randomized control trial. *Computers in Human Behavior* 106666, p. 1-19.

Konstantopoulos, S., T. Shen (2016) Class size effects on mathematics achievement in Cyprus: evidence from TIMSS. *Educational Research and Evaluation*, 22, 86–109. https://doi.org/10.1080/13803611.2016.1193030.

Lee, D., T. Lemieux (2010) Regression Discontinuity Designs in Economics. *Journal of Economic Literature*, 48 (2), p. 281-355.doi:10.1257/jel.48.2.281.

Li, W., S. Konstantopoulos (2016) Class Size Effects on Fourth-Grade Mathematics Achievement: Evidence From TIMSS 2011. *Journal of Research on Educational Effectiveness*, 9(4), 503–530. https://doi.org/10.1080/19345747.2015.1105893.

Maldonado, J. and De Witte, K. (2021). The effect of school closures on standardised student test outcomes. *British Educational Research Journal*. In press.

Mazrekaj, D., & De Witte, K. (2020). The effect of modular education on school dropout. *British Educational Research Journal* 46 (1), 92-121.

Nandrup A. (2016) Do class size effects differ across grades?. *Education Economics*, 24(1), 83-95, doi: 10.1080/09645292.2015.1099616.

Pindyck, R. S. (2020). COVID-19 and the welfare effects of reducing contagion (No. w27121). *National Bureau of Economic Research*.

Psacharopoulos, G., Collis, V., Patrinos, H. A., & Vegas, E. (2021). Lost wages: The COVID-19 cost of school closures. *Comparative Education Review*, 65(2), 271-287.

Sianesi, B. (2004). An evaluation of the Swedish system of active labor market programs in the 1990s. Review of Economics and Statistics, 86(1), 133–155.

Soncin, M. and De Witte, K. (2021). Do international classes pay off? A cost-benefit analysis of the internationalisation of higher education in Flanders. *Higher Education*. In Press.

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