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Methodological Guide for implementation and evaluation of open e-textbook programs

*Impact on costs and
learning outcomes*

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Foreword

This Methodological Guide is meant to provide assistance on conducting evaluations of digital education reforms, with a specific focus on the provision of open digital textbooks. Such textbooks are in a digital format and made available online. Since most of the initiatives in this area are funded with public money, it is important to have a proper understanding of the possible costs, savings and impacts on learning achievements, amongst others.

There is however, little evidence for doing such impacts assessments in the area of education. As OECD already noted in its "Education Policy Outlook 2015: Making Reforms Happen", only 10% of the 450 education reforms studied, had been evaluated for their impact. This makes it difficult to draw evidence-based conclusions about publicly funded programmes and interventions, which is important, also at European level, following the European Commission guidelines and principles for better regulation.

The aim of this Methodological Guide is therefore to raise awareness in favour of proper scientific evaluations of such initiatives in the future. It draws generic lessons from an independent evaluation of a Polish public program that produced open digital textbooks.

This report is part of the JRC research on "Learning and Skills for the Digital Era" which has been undertaken, since 2005, more than 25 major studies on these issues, resulting in more than 120 different publications. Recent work has focused on the development of digital competence frameworks for citizens ([DigComp](#)), educators ([DigCompEdu](#)), educational organisations ([DigCompOrg](#)) and consumers ([DigCompConsumers](#)). A framework for opening up higher education institutions ([OpenEdu](#)) was also published in 2016, along with a competence framework for entrepreneurship ([EntreComp](#)). Some of these frameworks are accompanied by self-reflection instruments, such as [SELFIE](#), focussed on digital capacity building of schools.

Additional research has been undertaken on Learning Analytics, MOOCs ([MOOCKnowledge](#), [MOOCs4inclusion](#)), Computational thinking ([Computhink](#)) and policies for the integration and innovative use of digital technologies in education ([DigEduPol](#)). In 2017, a report on the potential of [blockchain in education](#) was released and more recently, in November 2018, a report on the impact of [Artificial Intelligence on learning, teaching and education](#).

More information on all our studies can be found on the JRC Science hub: <https://ec.europa.eu/jrc/en/research-topic/learning-and-skills>.

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Abstract

In order to draw evidence-based conclusions about publicly funded programmes and interventions, there is an interest in impact assessment. This Methodological Guide is meant to provide assistance on conducting evaluations of public initiatives focused on the provision of open digital textbooks. Such textbooks are in a digital format and made available publicly online. When funded through public funds, it becomes important to understand the possible costs and savings. Therefore, the Guide focuses on exploring the costs and savings associated with such initiatives, and on the other hand, estimating their impact on learning outcomes (e.g. exemplified as academic achievements).

The Guide aims to be generic drawing on experiences gained from an independent evaluation of a Polish public program that produced open digital textbooks. Therefore, the methodology presented in this Guide can also be used to analyse programs focused on other types of digital content in education. The long-term aim of the Guide is to promote the proper evaluation of such initiatives in the future.

Executive summary

This Methodological Guide is meant to provide assistance on conducting evaluations of initiatives focused on the provision of open digital textbooks. Such textbooks are in a digital format and made available publicly online. The long-term aim of the Guide is to promote the proper evaluation of such initiatives in the future. Such textbooks

When open digital textbook initiatives are financed through public funds, it becomes interesting to understand the possible costs and savings. Therefore, the Guide focuses on exploring the costs and savings associated with such initiatives, and on the other hand, estimating their impact on learning outcomes such as academic achievements. An analysis of the cost-effectiveness and economic impact of open digital textbooks initiatives should include following steps:

1. Analysis of the regulatory and legislative framework.

Regulatory mechanisms that need to be analysed concern the financing, provision and use of textbooks and other educational resources. These can include both legislative measures and non-legislative policy mechanisms (such as long-term governmental programs for producing public e-resources). Particular issues worth analysing include:

- accreditation mechanisms for textbooks;
- rules determining obligatory teaching resources and the extent to which teachers and schools have the freedom to choose resources that they work with;
- price caps and level of public funding for purchases of textbooks and other resources;
- public policies and programs on content production, and their funding levels.

2. Analysis of the publishing market.

Data on the educational publishing market should provide a clear picture of the state of this market before the launch of the public intervention. Particular data sources include:

- overall worth of the textbook market, characteristics of key market players, market concentration, publishing volume and revenues;
- changes to the market over time, prior to the public intervention;
- the extent to which publishers have shifted from printed to digital resources, and cases where Open Educational Resources are either produced or used by market players;
- parental spending on textbooks and other educational resources.

3. Analysis of student demographics.

Since the size and characteristics of the educational publishing market are directly related to the size of the student population, demographic trends are an important factor for determining the condition of the market.

4. Analysis of penetration and use of new resources.

Statistics of penetration and use are particularly important for resources that are not obligatory. Scale of use determines the cost-effectiveness of public intervention, especially with regard to digital resources, for which marginal costs are close to zero. The popularity of public resources also determines to what extent they constitute competition for the commercial offer. Particular data sources include:

- Web traffic data from online repositories and platforms;

- Web traffic data collected at school level or within educational internet access infrastructure (if such exists);
 - Use of data from commercial publishers;
- Declarative data from user surveys (e.g. teachers).

5. Analysis of the economic impact of the open digital textbooks initiative.

Particular attention should be paid to measuring changes of key variables, in particular data concerning the state of the publishing market - not just market value, but also issues such as market concentration. This part of the analysis provides core evidence for evaluating the intervention based on its economic effects. In addition, the savings or cost for the initiator of the initiative (typically a government) have to be analysed, including the production costs but also the savings in subsidies and other types of resources. Moreover, the savings for parents and families need also to be considered.

6. Analysis of the impact of the open digital textbooks initiative on the outcomes of the education system.

There are several approximations to measure the impact of the open textbooks on the outcomes of the education system. A first one consists on analysing the content of the open textbooks compared to commercial textbooks (quality of content, curriculum match, pedagogical models and practices proposed). Another approximation is the measurement of the impact that the use of open textbooks has on learning outcomes (for example academic achievement, digital competence etc.). Additionally, evaluation from users (teachers and students) can be also integrated.

7. Analysis of the cost-effectiveness of the open digital textbooks initiative.

While market changes are important to the industry, cost-effectiveness is a key indicator for the public administration. The cost-effectiveness of an intervention can be determined by combining the cost of the intervention (production and distribution costs, changes in publisher revenues and market value etc.) and the impact that the intervention has on the education system (impact on learning outcomes of users, level of usage etc.). Post-reform indicators can be compared with hypothetical ones, predicted on the basis of previous trends and by assuming that the reform did not happen.

At each step, an attempt should be made to collect data for as long a time period as possible in order to determine key trends. Without an understanding of these trends, it will be difficult to determine whether the changes can indeed be attributed to the public intervention. Ideally the data collection should be planned before the beginning of the intervention.

The focus on the kinds of evaluations mentioned above becomes more and more important as the European Union is moving to a new era of financial instruments from 2021 onwards. For example, under the "InvestEU" proposal, new delivery mechanisms are proposed such as "Payment-by-Results (PbR)". This is a financing mechanism and tool for impact investing in which public procuring bodies purchase social impact based on pre-defined social outcomes in a number of areas (including access to education) ¹. With this in mind, we hope that the Guide approves useful for policy makers in their future endeavors.

¹ https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-investeu-impact-assessment_en.pdf

1 Introduction

There is an interest in impact assessment of publicly funded programmes and interventions in order for policy-makers to draw evidence-based conclusions regarding their effectiveness and efficiency. This Methodological Guide is meant to provide assistance on conducting evaluations of public initiatives focused on the provision of open digital textbooks. Such textbooks are in a digital format and made available publicly online. When funded through public funds, it becomes important to understand the possible costs and savings. Therefore, the Guide focuses on exploring the costs and savings associated with such initiatives, and on the other hand, estimating their impact on learning outcomes which can be exemplified as academic achievements. A broader guide to the topic of counterfactual impact evaluations is produced by the European Commission (EC, 2013)² whereas this Guide is more specific to an educational context and the use of digital resources.

The Guide is based on experiences gained from an independent evaluation of a Polish public program that produced openly-licensed digital textbooks (called in Poland 'e-textbooks') for primary and secondary education (see Annex I for more details about the initiative called Digital School program). The long-term aim of the Guide is to promote the proper evaluation of such initiatives in the future. The methodology presented in this Guide can also be used to analyse programs focused on other types of open and/or digital educational content.

This document is structured as follows: in the first part of this Guide, we provide advice on defining the general conceptual model for the analysis. In the second part, we focus on analysing the impact on economic outcomes of a public intervention aimed at providing digital textbooks in primary and secondary education. In the third part, we present an outline of a research design aimed at measuring the impact on students' learning outcomes using academic achievement as a proxy. In the last part, we address the issue of cost-effectiveness of digital textbook programs.

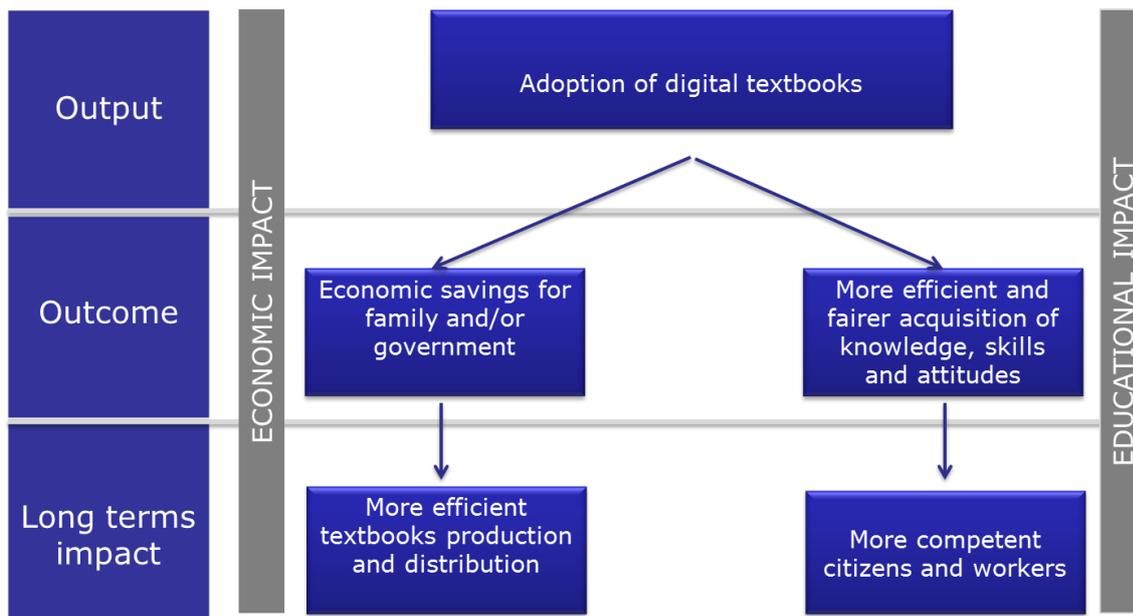
In this Guide, we present an ideal case scenario in which a broad range of data is available and allows for a full impact analysis on outcomes to be conducted. In reality, data availability will vary from country to country, and most probably not all types of data will be available. We therefore provide guidelines and good practices on data collection. Furthermore, we provide the example of the evaluation of the Polish open e-textbooks program as a guiding example.

Open digital textbooks are often propounded as the answer to the high costs of printed textbooks. There are also arguments that their use can improve students learning through increased student engagement, the increased possibility of customising the content for students' and teachers' individual needs, the increased possibilities of communication and feedback (Wiley, Hilton III, Ellington, & Hall, 2012)³, and the increased acquisition of digital competence. Still, the public provision of digital textbooks is often not properly evaluated and - consequently - the returns on this public investment cannot be correctly estimated. For example, when considering the impact of open digital textbooks, the mere number of digital textbooks produced is not enough evidence for policymakers, as preferably they were to be informed about the adoption of the digital textbooks (e.g. actual use in and out of school) and the impact of the initiative on various fronts, as is illustrated in Figure 1 and will be discussed below.

² <https://publications.europa.eu/en/publication-detail/-/publication/f879a9c1-4e50-4a7b-954c-9a88d1be369c/language-en>

³ <http://www.irrodl.org/index.php/irrodl/article/view/1153>

Figure 1. Categories of impact analysis- they should also be linked to the underlying theory of change



Firstly, the impact on economic outcomes has to be considered. It aims to provide a calculation of the financial net effect of the introduction of open digital textbooks, including:

1. The analysis of the related costs and savings from the perspective of the public budget in terms of expenditure on textbook production, distribution and provision.
2. The analysis of the impact on family spending (in countries where parents are required to pay for textbooks).
3. The analysis of the long-term impact of such an intervention upon the education publishing industry caused either by the changing level of public subsidies, or competition between publicly funded resources and commercial products.

Secondly, the analysis of the short-term impact of the produced digital materials on the efficiency and fairness of the acquisition of knowledge, skills and attitudes (e.g. measured as learning outcomes) is necessary, in order to check the quality and adequacy of the new materials. *Thirdly*, a joint analysis of the impact on economic and learning outcomes allows for the analysis of the cost-effectiveness which can better inform policy-makers on how the intervention in question compares with other alternative programs. *Finally*, the long-term changes (i.e. long-term impact) produced by the initiatives should be also taken into account when designing and evaluating future initiatives.

The focus on the kinds of evaluations mentioned above become more and more important as European Union is moving to a new era of financial instruments from 2021 onwards. For example, under the "InvestEU" proposal, new delivery mechanisms are proposed such as "Payment-by-Results (PbR)". This is a financing mechanism and tool for impact investing in which public procuring bodies purchase social impact based on pre-defined social outcomes in a number of areas, including access to education (EC, 2018)⁴. With this in mind, we hope that the Guide approves useful for policy makers in their future endeavors.

⁴ https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-investeu-impact-assessment_en.pdf

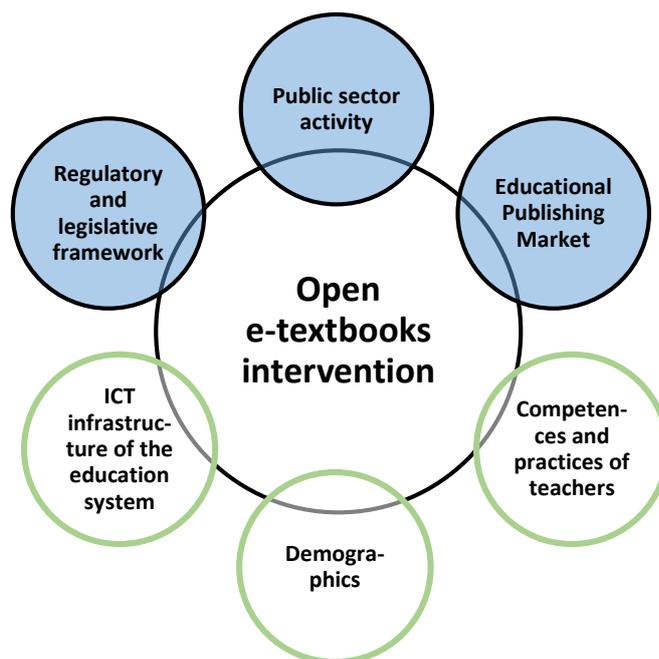
2 Analysing the impact on economic outcomes of an open digital textbook intervention

2.1 Defining the context for production, distribution and use of textbooks

In the first phase of research, the initial state of this ecosystem needs to be understood. This can be conducted by analysing institutional, regulatory and social factors that affect the economics of textbooks. As the next step - in relation to the initial state - changes happening in this ecosystem due to the open e-textbooks initiative can be analysed. Finally, the economic effects of these changes can be identified and measured.

The general ecosystem for the production, distribution and use of textbooks can be described through a model (Figure 2), in which six types of factors are taken into account. The analysis of the economic outcomes and long-term impact of public e-textbooks programs could consider such a model.

Figure 2. The context for the production, distribution and use of textbooks



The first three categories constitute major factors (in blue) that should be taken into account:

1. Regulatory and legislative framework including legislative measures: In particular, any legislation or policies that regulate the provision, selection, distribution and use of textbooks and other educational resources in schools;
2. Public sector activity with regards to textbooks provision, in particular the provision of textbooks and other resources that are either produced by public institutions or whose creation has been publicly funded;
3. The state of the educational publishing market, including its financial condition, market concentration, quality and variety of produced content, ability to adapt to the digital environment and level of public subsidies.

Moreover, we have considered three additional factors (in green):

4. Demographics, in particular changes in the student population which directly affect the size of the publishing market
5. Information and Communications Technology (ICT) infrastructure, including school-level equipment and access infrastructure, regional and national broadband infrastructure, and educational services or platforms;
6. Teachers' competences and practices including, in particular, the digital competence and teachers' preferences for textbooks or other types of resources; competences and practices of students and parents can also be taken into account, although teachers should be seen as key actors whose behaviour influences the success of e-textbook projects.

In order to better understand the factors above, it is necessary to formulate the proper research questions so that they can deliver the relevant data. The following questions should be considered at a country level:

1. Questions on public regulation and funding

- (a) What are the mechanisms with regard to the production of educational material (textbooks, digital material) and their compliance with the school curriculum, or the national frameworks that establish educational goals?
- (b) Are the textbooks certified or is there any other form of oversight of the production or use of the textbooks and any educational material in the school system? Which institution(s) is formally responsible for this?
- (c) Is the textbook production and distribution publicly or commercially funded? Are there public subsidies for purchases of textbooks on the commercial market?

2. Questions on market characteristics

- (a) How concentrated is the market both in terms of the share of market volume and value?
- (b) How varied is the available offer of textbooks? Is there any data on their quality?
- (c) Are there any specific practices of the commercial actors that affect textbook provision (e.g. in Poland publishers combined textbooks with exercise books, forcing schools to purchase new textbooks each year)?
- (d) What percentage of the overall national book market is comprised of textbook publishing and distribution?

3. Questions on textbook selection and teachers' practices

- (a) Who selects textbooks for use in a given school or classroom? This can be centralised at a state or regional level. Alternatively, the decision can be decentralised to the level of school teachers' bodies, or even individual teachers.
- (b) How much freedom does the teacher have to choose textbooks and other resources when teaching? Is the use of textbooks as a teaching material obligatory?
- (c) What is the importance of textbooks in relation to other types of educational materials? Is there a preference for a specific type of educational resource, either defined in official documents or established in practice?

4. Questions on the digital transformation of textbooks use

- (a) Have commercial digital textbooks been introduced, or are they being introduced? Is the model for digital textbook production and distribution similar to the one for printed textbooks?
- (b) What is the level of digital skills and competences among teachers? Is there any data in this regard?

The insights provided through an examination of this broader ecosystem give an initial understanding of how the development of an open e-textbooks program is influenced by contextual factors and vice versa - how it changed the market, behaviour of commercial actors and the decisions of schools and teachers concerning the use of textbooks.

Box 1. Case study: effects on institutional, regulatory and social factors of economics of textbooks in Poland

In Poland, the value of the educational publishing market changed directly due to the Government's decision in 2014 to pay for textbook purchases from the public budget, albeit at a certain market cap. In other cases, the effects might be indirect or not immediately visible - for example legislative changes that gave teachers greater freedom to teach with a variety of resources beyond commercial textbooks might, in the long run, change teachers' preferences regarding resources that they select. This, in turn, might affect the educational publishing market.

A detailed analysis creates an opportunity to study less obvious effects too. In Poland, public subsidies for textbook purchases led to increased market concentration: there was less competition, with fewer publishers active in the market. This was due to the fact that large publishers began offering bundles of textbooks for all subjects, and furthermore reached agreements with publishers of language learning textbooks. As a result, smaller publishers, who specialised for example in only one subject or subject area, could no longer find a profitable business model.

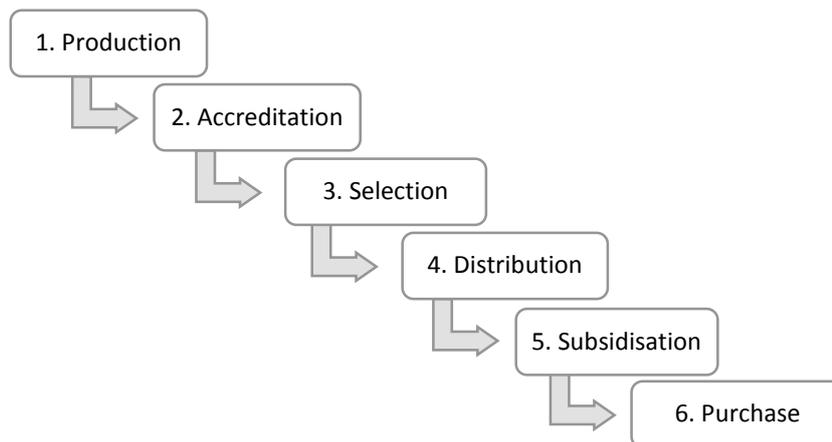
Economic context of the case study

The textbook market in Poland has been declining since 2010, both in terms of the number of published titles and units sold yearly. At the same time, the revenues of publishers continued to rise between 2010 and 2014. This trend changed in 2014 when the government introduced legislative changes that affected the textbook provision model. In that year, the revenues of publishers suddenly showed a 10.7% decrease. Two factors likely caused this sharp decline: the loss of revenue due to the nationalisation of part of the grades 1 - 3 market segment, and the lowering of prices for grade 4 - 9 textbooks (driven down by the government grant, serving as a price cap). In 2015, with the reform now including grades 1, 2, 4 and 6, the textbook market in Poland decreased by another 6%. The market became even more oligopolic, as smaller publishers were unable to adjust their business models to the new market conditions. As a result of publishers beginning to sell directly to schools, in 2014 the revenues of retail bookstores fell by 10 - 15% and they kept falling even further in 2015. The total amount lost by publishers in 2014 - 2016 is estimated at PLN 545 million. The loss for distributors is estimated at PLN 163 million. A full PLN 708 million stayed in the parents' pockets.

2.2 Roles of stakeholders in the textbook market

Relationships between actors can be understood through a model that defines roles in the process of producing and distributing textbooks. The model proposed in Figure 3 can be used for mapping the roles of particular actors (public institutions at different levels of government, commercial actors, teachers, parents) and the functions that they are taking care of.

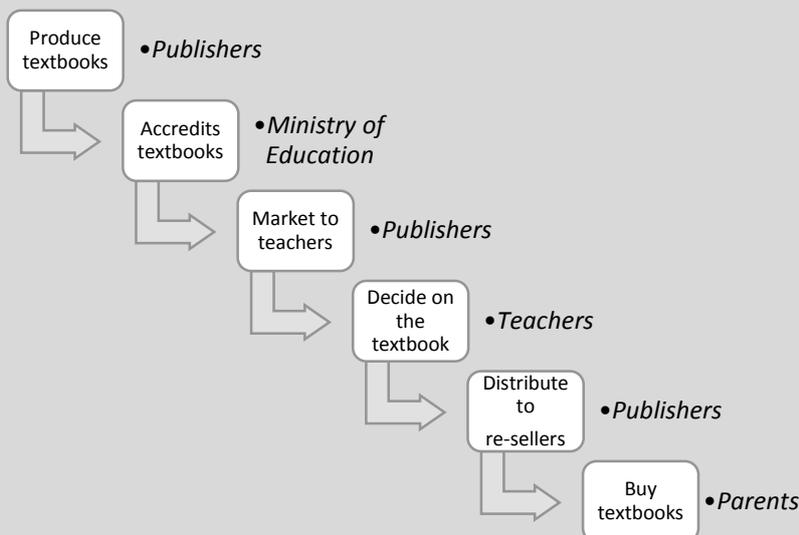
Figure 3. Model for the process of production and distribution of textbooks⁽⁵⁾



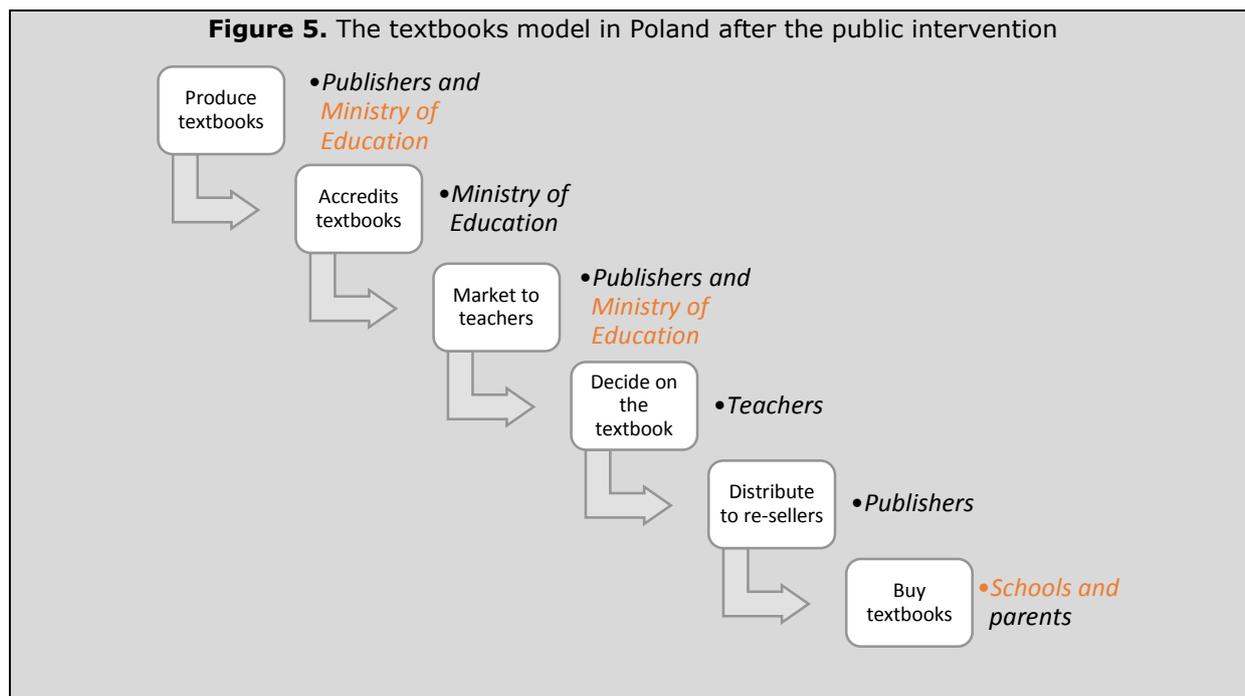
This model can also be used to map how different functions around textbooks and roles of different actors change as an effect of the analysed public intervention.

Box 2. Case study: changing roles in the process of textbook production and distribution in Poland
Below we present the changing life cycle of textbooks in Poland as a result of the regulatory changes introduced alongside the e-textbooks program.

Figure 4. The textbooks model in Poland before the public intervention.



⁵ Not all steps apply to all countries in the same order. Steps 1, 3 and 4 apply to all countries. Other steps depend on national or regional legislation (e.g. in some countries there is no accreditation of textbooks by the government).



2.3 Analysing the economic consequences of an e-textbooks initiative

These three categories could be considered when designing an evaluation of open e-textbook initiatives:

1. Governmental spending. This category depends on educational policy and legislation. In some countries, the government subsidises 100% of textbooks costs. This category should include all data sources relevant from the perspective of public expenditure on textbooks and other educational resources. Data should include spending at all levels of the education system - central, regional and local - and take into account national specificity (for example, the federal structure in Germany).

Government spending can be analysed as an element of broader public financing of schools. Funding systems of primary and general secondary education have been analysed in 2014 by the Eurydice network and presented in the report 'Financing Schools in Europe: Mechanisms, Methods and Criteria in Public Funding' (EC/EACEA/Eurydice, 2014)⁶. As the authors of the Eurydice report note, there is great variety across Europe with respect to funding systems. Of interest are also the findings from the OECD project on the Review of Policies to Improve the Effectiveness of Resource Use in Schools (School Resources Review) in which policies on textbooks are discussed as part of the distribution of school facilities and materials⁷.

2. Industry cash flows change due to regulatory changes and due to the size of public funding for textbook purchases; they are also affected by demographic changes. Indirectly, they change due to competition from freely available e-textbooks and changing teachers' demand and practices. The educational

⁶<https://publications.europa.eu/en/publication-detail/-/publication/466ef2cd-97aa-4753-b854-6cf9b88379d4/language-en>

⁷ See: <http://www.oecd.org/education/schoolresourcesreview.htm>

publishing sector can be divided into two broad categories of producers and distributors of content. Furthermore, publishers of traditional and digital content need to be distinguished. (In Poland, there are no publishers of purely digital content. Digital content produced by traditional publishers has mainly marketing value, as all sales are made on print copies). Discussions about the economic consequences of open textbooks often focus upon publishers – therefore it is important to remember that these public interventions may also have an effect upon distribution and, in particular, the retail market. In Poland, the educational publishing sector constitutes approximately one third of the whole publishing market – therefore changes in this sector affect the market as a whole. Effects upon industry cash flows can also result in structural changes in the publishing market that can lead to unemployment. In Poland, it has been argued that open digital textbooks are a factor affecting the closure of small bookstores (no data is publicly available on this issue).

3. Parental spending depends on the level of public subsidies for the purchase of textbooks, as well as the availability of freely available resources that are used in place of commercial ones. This data category is relevant only in those countries where parents finance or co-finance the purchase of textbooks. In those countries where textbooks are already subsidised or publicly produced, the introduction of public open textbooks will not have a direct effect on household budgets. Furthermore, accurate and timely data on parental spending is not readily available.

In empirical terms, the above-mentioned 3 categories should be operationalised in terms of key variables for the study, considering all the specificities that, for example, digital production and distribution of material bring along.

Table 1. Examples of data sources and key variables for the analysis of the economic consequences of an e-textbook initiative

Category of data	Examples and sources of data
Governmental spending on textbooks	Spending on writing and publishing public textbooks, spending on accreditation or evaluation of textbooks, subsidies for purchasing textbooks, licensing costs, support programs for disadvantaged families.
Governmental spending on digital resources	Costs of upkeep of online repositories, costs of hosting and technical maintenance, costs of software development costs.
Industry cash flows	Data on publishers' cash flows (income and expenditures), data on quantity and variety of the textbooks, measures of market concentration, data on volume, variety and quantity of commercial textbooks, employment data.
Parental spending (optional)	Data on parents' investments in textbook purchases.

An important difference between printed and e-textbooks is the timing of investments. Traditional textbook production relies on ready-made comprehensive content in which there is high investment in a prior design, development and printing of materials. In the case of e-textbooks, investments can and should be made during the exploitation phase. Ideally, the usage data and feedback from users can lead to a more flexible, demand-driven adaptation and development of new supplementary content.

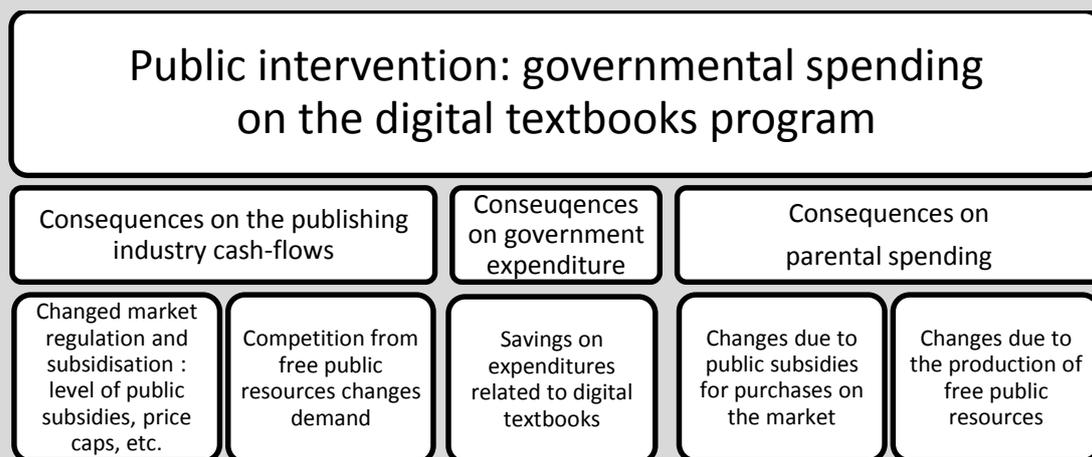
When analysing the long-term effects of open e-textbooks initiatives, one other data category becomes important - usage and penetration data. In the case of digital resources, granular usage data can be collected either from online repositories or at the school level. Optimally, data on public resources services should be compared with statistics related to commercial content - although the latter are not readily available. This data is particularly important in the case of resources, whose use is not obligatory. Their cost-effectiveness will therefore depend on the scale of penetration among teachers and students.

Box 3. Case study example: The Polish model for the analysis of the impact on economic outcomes of the e-textbooks initiative

As previously explained, the introduction of open e-textbooks should be considered in the context of an ecosystem that includes not just public institutions and teachers but also the commercial actors, students and their parents. Economic outcomes depend not just on economics of public and private provision and distribution of textbooks but also on the regulatory aspects, state of the ICT infrastructure, penetration and usage patterns of resources, and the skills and competences of individuals.

In the case of the Polish study, three relevant categories of financial flows were identified as those that define the economics of production, distribution and consumption of school textbooks in Poland. Governmental expenditures related to the public intervention affects these three flows: (1) publishing industry cash flows, (2) other governmental spending, and (3) parental spending. They are the following: (1) Governmental spending, (2) Industry cash flows, and (3) Parental spending. They are illustrated in Figure 6 which can be used to analyse the economic consequences of the given initiative in Poland.

Figure 6. Analysis of the economic consequences of open e-textbooks based on three categories of financial flows



It is clear that limitations to access relevant data will vary from country to country. Research methodology therefore needs to be adjusted in each case to address local specificity. In the Polish evaluation study, most challenges were related to data availability. Both public institutions and commercial actors either do not collect, or are not willing to provide, all the data necessary to obtain full evidence of the economics of open e-textbooks. With regard to public institutions, data has been successfully obtained through access to information requests. Nevertheless, non-aggregated data on the use of the e-textbooks platform was not made available due to concerns regarding protection of users' privacy. With regard to the commercial actors, data collection depended on resources made available by a single consultancy that publishes yearly analyses of the publishing industry.

3 Evaluating the impact of open digital textbooks initiatives on student outcomes

In this part, we present the framework for analysing the impact of digital textbooks on learning outcomes, as well as other additional factors (such as school engagement). We focus here on research design and data selection.

3.1 Defining uses of digital textbooks and their impact on learning outcomes

E-textbooks that are the subject of the impact analysis defined in this guide are both open and digital resources. The impact of their use on either student learning outcomes or the economics of textbooks depends on both of these characteristics. As digital resources they can be made available to schools and teachers at much lower costs than printed materials, provided that appropriate ICT infrastructure is available. They also offer new functionalities - including interactive components - that potentially can transform the way students are taught in classrooms. New pedagogical models and practices can be introduced through the use of e-textbooks. As open resources, they can be freely distributed and reused, further affecting the economics of textbooks. Freedom to reuse open resources potentially also creates space for teachers to actively modify and share content.

At the same time, use of public digital textbooks should be seen in the broader context of the impact of e-resources, and the effects of using ICT in education in learning outcomes. Potential effects related to open digital textbooks do not differ from the introduction of other types of digital resources or technologies. For this reason, it might be difficult to capture the impact on learning outcomes of just a specific type of resource (in the Polish case, the open e-textbooks made available in 2015).

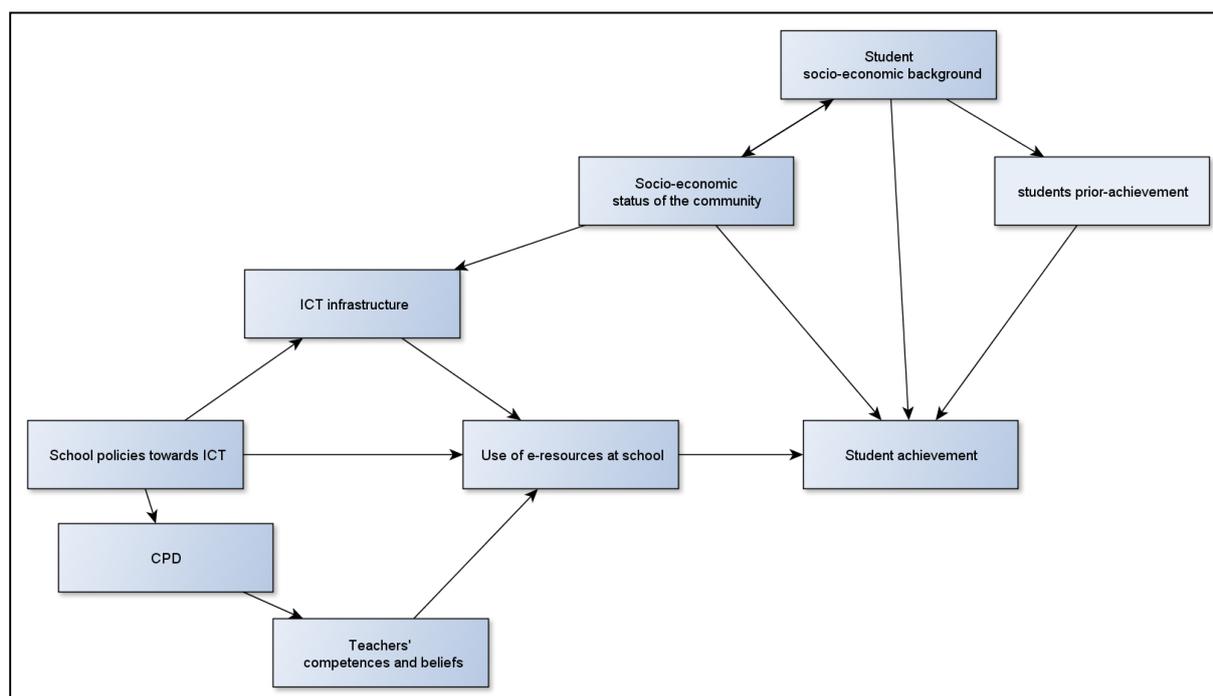
The deployment of digital textbooks depends on a complex infrastructure that includes the online digital textbooks platform, internet access infrastructure for schools (including both broadband access and wireless capacity within schools) and the availability of necessary digital equipment. The extent to which digital textbooks are used also depends on broadly understood digital skills and competences of teachers and learners that determine their ability to make use of digital resources and employ proper methods to make full use of them in the classroom. In order to establish a framework for analysing the impact of digital textbooks on learning outcomes, their functionalities also need to be understood. Digital textbooks range from simple conversions of printed resources to digital publications that make use of interactive capacity of the medium.

Finally, the impact on learning outcomes of any resources depends upon their quality, also in relation to other available resources, including other digital resources. The uptake of digital textbooks in schools depends on teachers' decisions that are often informed by the availability and relative quality of alternatives. (In Poland, there are no systematic assessments of the quality of accredited textbooks).

3.2 Data collection and relevant categories of data

The impact of the use of e-resources on student learning outcomes is influenced by a range of additional factors that can be divided into following categories: the socio-economic status of individual students and communities in which a school is based, the general school characteristics, the state of the ICT infrastructure and the ICT competence of teachers. Figure 7 shows a general model of relationships between the various variables used for determining the choice of variables and data sources for a given country.

Figure 7. Conceptual model of variables affecting the impact of digital textbooks on student learning outcomes (e.g. achievement)



The table below presents possible data sources for each category of data - the availability of relevant data will differ between countries. In some cases, proxy variables can be used. For example, due to lack of data on ICT competences of teachers, age was used as a proxy variable for estimating their potential skill levels (assuming that lower skills correlate with higher age of teachers).

Table 2. Examples of data sources and key variables for the analysis of the impact of a digital textbook initiative on learning outcomes

Category of data	Examples and sources of data
Use of e-resources by teacher and/or student	Data on frequency of visits, types of resources accessed, downloads of content, time spent on a site, number of devices accessing content from a given school. Data should be at best collected at the individual or classroom level. Source: Traffic data from digital textbook repositories or survey data on the use of these resources (declarative).
Student achievement	Examination data or data from sample-based national assessments (at different school levels and for different subjects and competences, depending on characteristics of the education system). Data should be at best collected at the individual level.

Socio-economic status	<p>Data on the school budget, total income of the administrative unit in which the school is located, unemployment levels, share of families entitled to social benefits.</p> <p>Source: Public statistics (aggregated data, available at some scale of the locality: county, etc.).</p>
General characteristics of schools	<p>Data on school size, number and size of classes, percentage of students repeating classes, ownership (public/private).</p> <p>Source: Education statistics</p>
State of ICT infrastructure	<p>Data on the availability and speed of broadband connections at schools, availability of wireless infrastructure, availability of computers and mobile devices, share of classrooms with devices, school policies on individual ICT use. Data on the availability of educational repositories and services.</p> <p>Source: Education statistics or school survey.</p>
Characteristics and quality of teachers	<p>Skills in relation to competence frameworks, data on teaching practice, data on professional development.</p>
ICT competences of teachers	<p>Data on the ICT skills and competencies of teachers to use digital equipment and digital resources.</p> <p>Source: Research based on digital competence frameworks (such as DigCompEdu).</p>

Box 4. Case study: data selection for the Polish impact on learning outcomes assessment

In the case of Poland the following datasets were used to assess how e-textbooks impact on student learning outcomes, based on the above-mentioned general conceptual model:

- Data on the use of e-textbooks and other e-resources (e.g. commercial ones) from a survey-based evaluation study of publicly funded e-resources, conducted in 2017;
- Data on the availability of ICT equipment in schools, from the above-mentioned survey;
- Data on the accessibility of the Internet in schools, from a survey conducted by the Ministry of Digital Affairs in 2016;
- General data on schools collected by the System of Educational Information (SIO) between 2014 -2016;
- School-level data from final exams, collected between 2014 - 2017;
- Contextual data on the socio-economic status of the community in which a school is located, from the BDL database of the Central Statistical Office.

Data on usage of e-textbooks was available for specific subjects (since the textbooks program covered the whole curriculum). Only data for subjects that had corresponding examination results could be used for assessing the effectiveness of e-textbooks use.

We differentiated between use of an e-textbook as the main textbook or an additional teaching resource. Furthermore, we also analysed the use of e-resources from commercial publishers and other resources from the Internet. In each case, for each school we established whether all, some or none of the teachers used a given type of e-resources.

Important research questions concern not only the overall effects of e-textbooks on learning outcomes, or other outcomes such as school engagement, but also distributional aspects. For example, the use of e-textbooks might be more likely in schools that have more IT resources or schools that already use e-resources in teaching. An important part of the Polish study was to look at the differences between schools that used/did not use e-textbooks. These types of analyses can provide important evidence for developing programs that promote and support the use of e-textbooks in specific segments of the educational system.

4 Analysis of the cost-efficiency of a digital textbooks initiative

Cost-effectiveness measures the relationship between the investment made and the results of the intervention, measured through selected metrics. In the case of the Polish study, the cost-effectiveness of competing textbook production models was measured by comparing the cost of the investment with the number of students reached.

Cost-efficiency is one of the main factors determining the result of an evaluation of a digital textbook initiative. The cost-efficiency of a program depends on the one hand on the level of (governmental) spending on a program, and on the other on usage statistics and the associated effects on the short and long term situation such as the structure of the publishing market, the quality of the education system and its impact on learning outcomes. Only accurate information about the costs and benefits of the programs can inform policy-makers on how this intervention compare with other alternative programs.

A more detailed analysis of cost-effectiveness is possible by collecting data on the use of textbooks in schools. In terms of digital resources, such data can be collected from repositories or platforms where these resources are made available, or by analysing school-level online traffic. With regard to print resources, purchase data can be used to obtain a general understanding of which textbooks are chosen and used in schools.

Public institutions are in a position to provide detailed data on some aspects of a digital textbook project's performance, especially regarding the long-term effects of the program. Care should be taken to secure collection mechanisms for usage data by appropriately designing ICT platforms. Similarly, since the textbook market is in most cases is a regulated one, public administration could require commercial actors to share key data and metrics (especially with regard to digital resources).

Box 5. Case study: cost-effectiveness of the open e-textbooks initiative in Poland

The cost-effectiveness of the open e-textbooks initiative in Poland can be established by comparing the economics of different approaches to production and dissemination of educational content. In 2013 - when solely free market actors were producing content - 4.6 million students were provided with textbooks at the approximate cost of PLN 1.1 billion. This meant an average per student cost of PLN 250.5.

With the 2013 reform, the government began producing public, printed textbooks for 880.6 thousand students at the average cost of PLN 60.3 per student. Since the textbooks were meant to be used for three years, the average cost per year equalled PLN 20.1 per student. An additional 50 PLN was spent equipping each student with activity textbooks, bringing the cost to PLN 70.1 per student per school year.

The third approach was based on the provision of open e-textbooks in digital form. The effectiveness of this initiative depends on the penetration rate of these new resources. If the government made the use of these materials mandatory, the average cost of equipping one student with the necessary materials would be brought down to PLN 10.7. The real penetration rates have been much lower, making the initiative a lot less cost-effective. Current rates are at approximately 1% of a potential user base of around 5.3 million teachers and students. Taking into account the cost of producing the textbooks, estimated at PLN 48 million, we see that the cost-effectiveness of this initiative is relatively low.

The cost efficiency of the public initiative can be compared with that of the commercial publishers. In 2013, the second most successful Polish publisher had a market share of 23% and bore costs of PLN 223 million. Penetrating the market at the level of 1% cost this particular publisher c.a. PLN 9.7 million (including all borne costs). This means that the publisher was five times more efficient in penetrating the market.

5 Recommendations related to data selection, collection and aggregation

Data collection for the evaluation should be planned before the initiative's start. This can avoid the lack of good data for a proper evaluation. When selecting what data to use and data sources for evaluation, the following issues should be taken into account:

1. Collect data at the lowest unit of analysis possible. Since the impact of e-resources on learning outcomes might vary at the individual, class and school level, a full evaluation should be based on an analysis of all three levels. A limitation of the Polish study was that schools - and not classes or individuals - were chosen as units of analysis (due to data availability issues). Individual data (e.g. on ICT skills of teachers or on outcomes of final exams) was therefore aggregated at school level.
2. Collect data for all schooling levels in which digital textbooks has been provided. In the Polish study, the impact of e-textbook use on student learning outcomes has been measured at three levels (primary, lower secondary and upper secondary) of schools, with schools treated as units of analyses.
3. Promote the use of log file and digital trace data. Preferentially, web traffic statistics should be used to analyse patterns of actual use of e-resources. If such data is unavailable, declarative data can be obtained, for example through online surveys of schools or teachers.
4. Respect privacy. Concerns regarding privacy of users can arise when collecting web traffic data on the use of e-resources. This largely depends on whether individual users can be identified based on the data. Log data should either be anonymised or aggregated at classroom or school level.
5. Use subject and competence specific data. The evaluation can be much more precise if data for specific school subjects or competence evaluations are available, both regarding use of resources and student achievement. In the Polish case the assessment concerned only subjects for which we could collect both types of data which can be a good proxy but not necessarily the most accurate measurement of learning outcomes. Furthermore, some school levels had to be omitted as no final examination data was available.
6. Facilitate easy data linking. Attention needs to be paid from the beginning to properly linking data from different sources in order to ensure that the data for a particular school are properly identified and linked.
7. Analyse data in a meaningful way. Analysis should include more than just simple correlations. The relationship between use of digital textbooks and students' learning outcomes is likely to be confounded by the effects of other variables. For example, schools with a better ICT infrastructure are more likely to use digital textbooks, or use of such textbooks might be related to teachers' characteristics, such as their computer literacy skills. The assessment of the impact on learning outcomes is most straightforward with randomized control trials. Since such experiments are usually not feasible, other counterfactual analyses can be conducted comparing digital textbook use with traditional textbook use as a control. This may include matching methods, Difference-in-difference, Regression discontinuity, use of instrumental variables, natural experiments among others (Misuraca, Centeno & Torrecillas, 2014)⁸.

⁸<http://publications.jrc.ec.europa.eu/repository/bitstream/JRC89462/jrc89462%20-%20toolkit.pdf>

6 Glossary

In this project we use the terminology developed by previous JRC-B4 Unit (Human Capital and Employment) research. The original source is: Misuraca, G; Centeno, C; & Torrecillas, C. (2014): *Measuring the Impact of eInclusion Actors: Impact Assessment Framework. Annex-the MIREIA el2-IAF Toolkit*:

<http://publications.jrc.ec.europa.eu/repository/bitstream/JRC89462/jrc89462%20-%20toolkit.pdf>

Counterfactual impact assessment methodologies. These aim at evaluating the existence and the intensity of the cause-effect relationships between intermediaries' interventions and their expected impacts. There are essentially six main counterfactual impact assessment methodologies including: Randomised controlled trials; Matching.(including the propensity score matching); Difference-in-Difference (DID); Regression Discontinuity Design (RDD); Instrumental variables and natural experiments; and Self-reported counterfactuals;

Effectiveness. It provides a measure of the outcomes produced by a given intervention in relation with the output generated by the intervention itself. It can be evaluated only when outcomes are available, thus after a certain period from the completion of the intervention,

Efficiency. It describes the extent to which time, effort or cost is used for the implementation of a given intervention. It is often used with the specific purpose of relaying the capability of a specific intervention to produce a specific outcome effectively with a minimum amount or quantity of waste, expense, or unnecessary effort.

Evaluation. In general, it consists of an in-depth study of an intervention which is carried out at a discrete point in time. It is distinguished in ex-ante evaluation - an evaluation conducted before the implementation of an intervention, also often referred to as an 'appraisal'; in-itinere or interim/mid-term evaluation - an evaluation conducted during the implementation of an intervention; and ex-post evaluation - an evaluation conducted either on or after completion of an intervention

Long-term Impacts. It relates to the broader and aggregate longer term changes for the target individual and the economy and society as a whole, to which interventions contribute together with several other intervening variables. Two notions of impact can be distinguished, depending on whether these are effects occurring after a certain lapse of time (specific impacts) but are directly linked to the intervention; or longer term effects affecting a larger population (global impacts)., For instance, in the case of an ICT training course, an example of specific impact could be the percentage of trained people that have actually found a job (ICT related), while global impact could be the overall increase in the local system productivity and competitiveness or decreased unemployment.

Outcomes. It refers to the direct and intermediate changes produced for specific constituencies as a result of the initiatives, whose occurrence depends also on some intervening variables. These can be distinguished in direct and indirect outcomes according to their distance from the output in terms of the number of possible intervening variables. For instance, taking the example of an ICT training course, direct outcomes could be the percentage of trained people that have actually improved their ICT skills, while indirect outcome could be the increase in self-confidence, or the increase in job offers received due to the improved skills in the use of ICT for job search.

Variables. A characteristic, number, or quantity that increases or decreases over time, or takes different values in different situations.

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Annexes

Annex 1. Background to the intervention and general context in the Polish textbook market

In 2011, the Polish Ministry of Education initiated the 'Digital School program', or as it was officially known, the 'Governmental program for the Development of Information and Communication Technology Competencies among Students and Teachers'. The program was a major intervention related to the introduction of ICT in schools, co-financed through European Social Funds. A multi-pronged approach was based on providing, in parallel, (1) teacher training, (2) equipment, and (3) new digital resources for primary and lower secondary schools.

As a part of this program, the digital textbooks initiative was launched, with the aim of providing a full set of open and digital textbooks for core subjects in grades 1 - 12. In late 2015, a dedicated online platform was launched (epodreczniki.pl) through which these textbooks were made available publicly as Open Educational Resources.

In the meantime, in 2014 the Polish Government initiated another and much larger-scale project related to the public provision of textbooks (introduced through the amendment of the Educational System Act). Printed textbooks for grade 1, created by the Ministry and funded with public funds, were offered to all 1st grade students in the school year 2014/2015, with the aim of extending the project further to grades 2 and 3.

Together, these initiatives marked a fundamental shift in the Government's approach to funding educational resources for public education. Previously, the general rule was that parents paid for textbooks, which they purchased individually on the commercial market. Firstly, the change of the Educational System Act in 2014 introduced a complex financing model that includes publicly funded e-textbooks and publicly funded and printed textbooks for grades 1-3 in addition to commercially produced content. Furthermore, in the case of grades 1 – 9, schools received subsidies to purchase commercial textbooks and other educational resources. Spending caps introduced on a per-student basis meant a radical reduction of the financial value of the educational books market, which should be seen as highly regulated and dependent on the level of public spending on textbooks and other educational resources. Only in grades 10 - 12 did pupils and their parents still have to purchase textbooks and exercise books, if a teacher decides to use not just the free e-textbook resources.

Secondly, the reformed Act now gives teachers a choice regarding resources: to use public textbooks, a mix of public and commercial textbooks, only commercial textbooks, and even not to use textbooks at all and support their teaching with other educational resources.

These reforms therefore meant a major shift in the framework for textbook production and distribution. The impact of these changes has been noted by a range of stakeholders, including educational publishers, civil society organisations and public administration. The impact of this reform can be analysed in terms of several key factors:

- Cost-effectiveness of the public intervention
- Impact on the educational publishing market, and more broadly on the publishing market
- Impact on parents' spending
- Quality of the public resources, in comparison with commercial alternatives
- Reach and scale of use in schools
- Impact of the public resources on academic performance

Annex 2. Note on the economics of open educational resources

In the case of Poland, the impact analysis concerns public resources that are open e-textbooks that meet the strong definition of openness as defined, for example, by the Hewlett Foundation: "Open Educational Resources are teaching, learning and research materials in any medium – digital or otherwise – that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation, and redistribution by others with no or limited restrictions"⁹.

Yet the economic impact that we have observed in Poland is to a large extent due solely to the fact that public investment has been made in textbook production, and that afterwards these textbooks have been made publicly and freely available online. Free availability of such resources can lead to market disruption. The unique impact of Open Educational Resources - differentiated by the fact that they are available under an open licence - occurs only when reuse of these resources happens.

Ultimately, market impact depends on the regulatory framework determining what types of resources are used by teachers, which resources are obligatory, and which resources are subsidised. The size of the textbook publishing market is directly related to student demographics - provided that some resources are regulated as obligatory ones for the school system. In the case of Poland, where public funds are spent on the purchase of commercial textbooks by schools, the value of the market depends largely on the value of the public subsidy.

As long as public funds are spent on the purchase of commercial resources, public content - such as the e-textbooks introduced in Poland in 2015 - should be seen as complimentary teaching resources. While in principle a teacher could decide to teach solely from free public digital textbooks, the availability of subsidised commercial textbooks means that they are also free from the perspective of the teacher or the school. The situation would be very different if the government decided to substitute a commercial offer with public resources - for example by treating the latter as obligatory, and lowering the value of the public subsidy for purchases of commercial resources. In such a case, we could consider the open digital textbooks program as having a direct effect on the market.

Teachers' preferences and consumption patterns with regard to textbooks represent another important factor affecting the impact of new public resources upon the market. In Poland, for over 20 years teachers depended almost solely on commercially produced textbooks and resources. They have been the subject of prolonged marketing campaigns, and obtained additional benefits such as free training provided by the publishers. Any shift in their choice of resources should be seen in this context of historical consumption patterns.

This methodological guide can therefore be used to analyse the impact of any publicly produced textbooks or educational resources, even if they do not meet the standard of openness. Yet with regard to fully open resources, legal permissions ensured by free licences (such as Creative Commons Attribution, Creative Commons Attribution-Share Alike or equivalent) create the potential for additional, long-term impact. These licences allow free reuse of resources, both by commercial companies and individuals making non-commercial uses - for example teachers. Thus, two long-term effects are possible. Firstly, one can imagine that the commercial actors begin reusing public open resources in order to lower their own costs. Publishers could produce supplementary resources to be used with textbooks and benefit from the fact that part of the resource pack is available for free. In the case of distributors, freely available resources mean an easy way to enlarge their offer - especially in the case of online distribution, for example through repositories that combine free and paid resources.

Secondly, proponents of Open Educational Resources argue that in the long term, an alternative ecosystem of resources can be created, one that depends on the reuse and

⁹ <https://www.hewlett.org/strategy/open-educational-resources/>

sharing of resources by teachers themselves. It could be non-commercial or even based on some sort of payments, but in any case it would disrupt the educational publishing market. Similarly, in the long term, openness of textbooks can support a shift in teachers' practices away from traditional textbooks towards much more varied and individual selection of teaching resources.

These additional effects of the adoption of open digital textbooks go beyond the impact of public investment in textbooks, which is the core effect considered in our methodology. We have not yet observed them in Poland in the two-year period since the launch of the open digital textbooks platform. This is largely due - in our opinion - to the lack of necessary competences among teachers. Schools will make effective use of new e-resources only if proper teacher development programs are implemented in parallel with the production of open public resources.

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