

van de Laar, Mindel; Marotta, Julieta; De Graaf, Lisa

Working Paper

Higher Educational Systems and E-resilience

UNU-MERIT Working Papers, No. 2024-003

Provided in Cooperation with:

Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT),
United Nations University (UNU)

Suggested Citation: van de Laar, Mindel; Marotta, Julieta; De Graaf, Lisa (2024) : Higher Educational Systems and E-resilience, UNU-MERIT Working Papers, No. 2024-003, United Nations University (UNU), Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), Maastricht

This Version is available at:

<https://hdl.handle.net/10419/326899>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-sa/4.0/>

Working Paper Series

#2024-003

Higher Educational Systems and E-resilience

Mindel van de Laar, Julieta Marotta and Lisa de Graaf

Published 23 February 2024

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)

email: info@merit.unu.edu | website: <http://www.merit.unu.edu>

Boschstraat 24, 6211 AX Maastricht, The Netherlands

Tel: (31) (43) 388 44 00

UNU-MERIT Working Papers

ISSN 1871-9872

**Maastricht Economic and social Research Institute on Innovation and Technology
UNU-MERIT**

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT to stimulate discussion on the issues raised.



Higher Educational Systems and E-resilience*

Mindel van de Laar, PhD

Julieta Marotta, PhD

Lisa de Graaf

Abstract

This paper explores how e-resilience in educational systems is understood by the current literature and what are the main drivers and challenges mentioned which are relevant for the e-resilience of those educational systems. To answer the research questions, the paper follows the scoping literature review structure, which consists of a literature identification, a literature screening, and literature analysis. A total of 241 papers were identified through a literature search and screened for relevance, of which 53 papers were included in the analysis. Based on the literature, the concept of e-resilience in education is conceptualised in a comprehensive way taking into account the system levels that interact and the technological, human, and interactive dimensions through which drivers and challenges of e-resilience manifest. The current literature focuses primarily on the enumeration of drivers and challenges experienced by specific levels and actors in the educational systems to overcome shocks. Further empirical research is needed to understand how those educational systems can utilise drivers and deal with the challenges in a systemic way to become more e-resilient.

Keywords: E-resilience, educational systems, digital technology, COVID-19

1. Introduction

The right to education, a basic right included in the United Nations Sustainable Development Goal 4, needs to be ensured even when shocks occur (United Nations 2015). Educational systems refers to the structure where different stakeholders in education interact. The systems are composed by levels of society (macro, meso, or micro) and by sector (technological, human, or intersections of the two). These systems need to be prepared to

* An earlier version of this paper was published as a [Conference paper](#) at the 14th International Conference on Society and Information Technologies (ICSIT 2023). The authors are grateful to Rita Bakunda, Radhika Raturi, Ahmed Hussain and Mathias Weidinger for their research assistance.

overcome shocks as quickly and effectively as possible, as they have done during the global health pandemic COVID-19 (COVID-19). At that time, information and communication technologies (ICT) and informational technology were the main elements that enabled educational systems in most countries to continue instructing their population. In this context, the concept of e-resilience became relevant because the capacity of educational systems to overcome such shocks was linked not only to the resilience of the actors but also to the system's ICT capacity as well as the actors ability to use ICT (Ramos and Hynes 2022). This paper attempts to shed light on the current academic understanding of e-resilience in educational systems. A systematic literature review has been undertaken in order to achieve this aim. This paper found a limited number of studies that address e-resilience in education. These studies were categorized and presented in section 3 while the main findings were addressed in section 4.

The Economic and Social Commission for Asia and the Pacific (ESCAP), the organisation that coined the term of e-resilience, defines it as “the ability of ICT systems to withstand and recover from and change in the face of an external shock” (ESCAP 2022). Yet, already in 2013, Weller and Anderson considered that the digitalisation of higher education changes the practice of education but not its function (2013, 53). Within the scope of education, e-resilience can thus be considered a multidimensional concept that focuses on the information and communications technology (ICT) or digital capacity of systems and individuals to absorb change and recover (Beale 2020). With the outbreak of COVID-19, the digitalisation of educational systems became a tool for overcoming the shock brought about by the pandemic, which gave rise to the concept of e-resilience in educational systems.

The operation and use of digital infrastructures was a critical element for educational systems to cope with the impact of COVID-19. When physical education was disrupted during spells of lockdown, educational systems needed to have a functioning digital infrastructure as well as actors in the system with adequate digital capabilities. Inclusivity and intersectionality between the different stakeholders and system levels became crucial to overcome shocks. Therefore, the concept of e-resilience in education need to take into account the roles and capabilities of the many stakeholders (e.g. students, parents, teachers, and institutions), in addition to the ICT infrastructure in and of itself (OECD 2020).

Despite the importance of e-resilience in education during COVID-19, this concept has not been studied in itself nor in the context of educational systems (Heeks and Ospina 2019). While there are several case studies that examine the responses of countries or institutions to COVID-19 (Daly 2021; Eri et al. 2021), as well as studies focusing on the impact of COVID-19 on the learning outcomes of students (Beale 2020; Cassidy 2016), the systematic picture regarding the factors that drive and challenge a system to be e-resilient remains unclear. Consequently, this research employs a scoping review of the relevant literature to understand how e-resilience in educational systems is understood by the current literature and what are the main drivers and challenges mentioned by the current literature which are relevant for the e-resilience of those educational systems.

2. Methodology

The main research questions of this paper are how e-resilience in educational systems is understood by the current literature and what are the main drivers and challenges mentioned by the current literature which are relevant for the e-resilience of those educational systems.

The paper follows the Prisma scoping literature approach, which consists of a three-step process: (i) literature identification using 3 different identification methods, (ii) literature screening, and (iii) literature analysis (Page et al. 2021) (see Figure 1). The analysis of the literature is done through qualitative thematic analysis.

(i) Literature Identification

During the “identification” of the relevant literature, we approached the literature search in three complementary and sequential ways, which we refer to as Tier 1 (Systematic search), Tier 2 (Litoscope search) and Tier 3 (Traditional search). Tier 1 and Tier 2 searches were undertaken in summer and fall of 2020, in the still early stages of the COVID-19 pandemic. Our aim with the Tier 1 and Tier 2 searches was to collect a wide range of articles from both the ICT and educational field, as the concept of digital resilience falls within ICT research and our contextual case falls within the discipline of educational research. By including both fields, we aimed to collect a maximum number of potentially relevant articles to be screened.

Firstly we performed a systematic search using a multitude of platforms and screened those articles for relevance (Tier 1). After content screening of the findings we considered the number of relevant articles from the Tier 1 search (13 articles) insufficient to base a literature

review on, hence we added as a search mechanism the use of a Litoscope toolkit to increase our article base for the analysis (Tier 2). The Litoscope toolkit comprehensively searches Web of Science abstracts of articles, which includes more databases than we selected for our Tier 1 search.

For our Tier 1 search, the sources queried were [EBSCO](#), [Emerald Insight](#), [Information Technologies and International Development](#) (ITID), [JSTOR](#), [OECD iLibrary](#), [Services for Science and Education](#) (PKP), [ScienceDirect](#), [Springer Link](#), and [Taylor and Francis](#). Because there is no consistent terminology across disciplines for the terms “e-resilience in education”, we queried for several key concepts, in order to retain the maximum possible number of relevant e-resilience publications. The terms queried for were: *e-resilience*, *digital resilience*, *cyber resilience*, *information systems*, *information technology*, *educational resilience*, *academic resilience*, and *ICT*. The time frame for the search was for the period 2011-2020, dating 10 years back from the year that we initiated the search. We acknowledge that the term e-resilience is a relatively recent term, yet we wanted to allow for inclusion earlier references that may have led to the shaping of the term. Upon listing the search results, we cross-referenced for duplications and accessibility. This resulted in 158 articles.

Our second search activity involved a search tool called Litoscope (Türkeli 2020) to query the [Web of Science](#) using identical key words as used in Tier 1. This search yielded 54 results (Tier 2). After eliminating of duplications / non-downloadable / non-English articles, 50 papers were screened for relevance.

The third literature search action is based on more traditional search of the literature (Tier 3). As Tier 1 and Tier 2 searches took place in the first year of the pandemic, we acknowledged that the growing body of relevant literature that was published on the topic as response to the pandemic was not included for the analysis. In order to allow for inclusion of publications that came out while doing the literature analysis as much as possible, we scanned the literature from August 2020 to June 2021 to add relevant articles, also using forward or backward referencing techniques. An additional 33 articles were added. The final set of articles included in the literature review thus includes articles published in 2011-2021.

(ii) Literature Screening

In the second step of the Prisma approach, the literature screening, we double checked for the inclusion criteria, which required articles to be peer-reviewed and book chapters, academic literature published between the years 2011–2021 and accessible (e.g. downloadable) to us. In addition, we read through abstracts, and where necessary screened the core text to distinguish those publications that were relevant to our focus on e-resilience in the educational context. In order for an article to be relevant, articles had to cover both: an educational offering or performance analysis *and* included an ICT factor as explanatory component or contextual setting that is considered important for the educational system.

This resulted in 13 papers from Tier1, 12 papers from Tier 2 and 28 papers from Tier 3 search strategies to be included in the analysis. The list of the 53 references by search method (tier) level of analysis (micro, meso, macro, system or a combination of those), and methodology is included in Annex 1.

	Systematic Search (Tier 1)	Lit Scope Search (Tier 2)	Traditional Search (Tier 3)
Identification	Papers identified from (n=160): EBSCO (n = 13) Emerald Insight (n = 11) ITID (n = 7) JSTOR (n = 69) OECD Library (n = 1) PKP (n = 1) Springer (n = 16) Web of Science (n = 12) ScienceDirect (n = 1) Taylor & Francis (n = 29)	Papers identified by Litoscope: Web of Science (n = 54)	Paper/Book chapters identified (including latest publications) through traditional search (n = 33)
	Removed before screening: Duplicate papers (n = 2)	Removed before screening: Not accessible (n = 2) Not in English (n=2)	Removed before screening: Not accessible (n = 0)
Screening	Assessed for relevance (n = 158)	Assessed for relevance (n = 50)	Assessed for relevance (n = 33)
	Papers excluded: Not education and ICT-related (n = 145)	Papers excluded: Not education and ICT-related (n = 38)	Papers excluded: Not education and ICT-related (n = 5)
Analysis	Included from Tier 1 (n = 13)	Included from Tier 2 (n = 12)	Included from Tier 3 (n=28)
	Total Papers Included for the analysis (n = 53)		

Figure 1: Literature search and inclusion overview

(iii) Literature Analysis

The selected papers categorised as either relevant to retrieve the understanding of the concept of e-resilience in educational systems (Section 3a) or relevant to identify the main drivers and challenges of e-resilience of educational systems (Section 3b). In total, twelve papers and three book chapters were examined as part of the conceptual review. As the

number of conceptual papers is limited, we present the analysis following a traditional literature review structure. Moreover, 41 papers were identified to address the drivers and challenges experienced by educational systems. We categorize the drivers and challenges in one of three levels of society: macro (country), meso (institutional), or micro (individual), and analysed whether the drivers or challenges were considered within the dimensions of technology, human, or human/technological intersections (see Table 1). This classification is novel and helped us to understand the drivers and challenges of e-resilience within an educational system.

3. Results

a. Conceptualizing E-resilience in Education Systems

There is limited research on the concept of e-resilience in education. However, there is extensive research on the dimensions and dynamics of resilience and reliance in education. Some authors understand resilience as a concept that focuses on one of the following four dimensions: individual, process, context, or system (Beltman 2021). Other authors view resilience as a dynamic and interactive concept that needs to be considered in all dimensions, particularly context (Shafi and Templeton 2020). This is in line with the organisational resilience literature that stresses that the stages of anticipation, coping and adaption require different organisational skills to build resilience and the iterative nature of the system (Duchek 2020; Lengnick-Hall, Beck, and Lengnick-Hall 2011). Measurement of resilience is done empirically on individual level, yet that does not cover actual measurements of resilience within a system (Ahern et al. 2006).

Studies that focus on the individual dimension generally focus on dimensions and qualities that influence the capacity of an individual to overcome challenges (e.g., teacher resilience). Studies that understand resilience as a process consider it essential to explore how individuals build resilience over time and how they take ownership of the transition period in order to overcome obstacles. Studies that focus on the context recognise that resilience allows for multiple assessments or measurements to be taken depending on the context in which the shock occurs (Beltman 2021). The system focused approach to resilience considers it essential to include various level in the systems that are interconnected within a larger context (Beltman 2021). Recent studies support this last approach, highlighting the need to study the interaction between the individual and the context in which they find themselves (Shafi and

Templeton 2020, 32–35). Within this interactive system, resilience “considers both individual agency as well as the range of complex systems that the individual is part of” (Shafi and Templeton 2020, 32).

The concept of resilience has been studied in the context of education. Several studies highlight that resilience is a significant predictor for understanding the capacity of the educational system to overcome a shock, as well as the ability of students and teachers to maintain their level of performance in class (Beale 2020; Gu 2018; Mansfield et al. 2018; Shafi and Templeton 2020). For example, Schwarze and Woznitza and Mansfield et al. build on the model of Bronfenbrenner, presented in 1979, and propose a contextual model of resilience in which resilience encompasses the interaction of different levels or systems (Mansfield et al. 2018, 56; Schwarze and Wosnitza 2018). Hence, resilience in education is understood as a process in which the micro, meso, exo, and macro levels or systems interact with one another (Schwarze and Wosnitza 2018). This approach, similarly to the most recent approach mentioned by Shafi and Templeton, highlights the importance of the individual agency as well as the complex systems in which the interaction occurs (2020, 32–35). Resilience is defined by the “quality of both individuals and their environments” (Gu 2018, 29 referring to the work of Ungar et al (2013)).

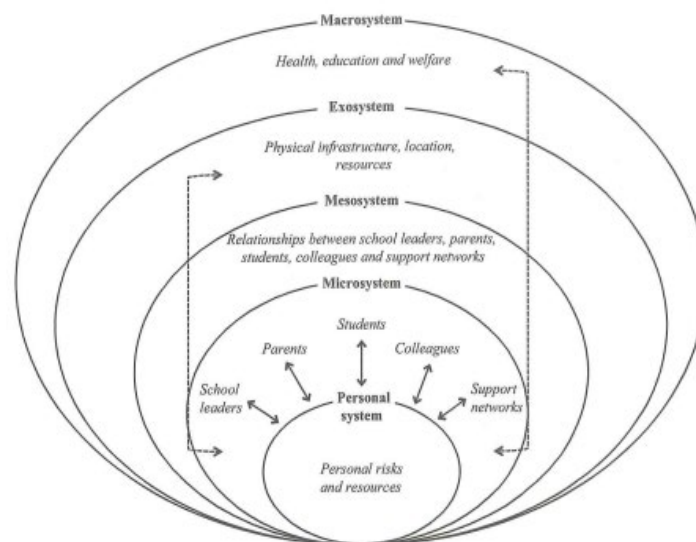


Figure 2: “A systems approach to understanding teacher resilience (adaptation of Bronfenbrenner 1979)” (Mansfield et al. 2018, 56)

The approach to resilience of a system (e.g. educational system) has been well accepted since 2004 (Cassidy 2016; Gu 2018; Mansfield et al. 2018; Martin and Marsh 2006; Shafi and

Templeton 2020; Walker et al. 2004). This approach refers to the ability of an educational system to absorb the change and quickly adapt to the altered environment while preserving its core function, namely the delivery of education (Cassidy 2016; Gu 2018; Mansfield et al. 2018; Martin and Marsh 2006; Walker et al. 2004). Within this approach, resilience in educational systems include a time dimension, which refers to the capacity of those systems to overcome a shock both during and after it has occurred and to build back up to a higher standard (innovate). Hence, these studies of the educational systems focus on the capacity of the systems to ensure continuity of education during a shock, as well as their capacity to recover and adapt after the shock (Heeks and Ospina 2019).

The ability of educational systems to adapt and improve is based on their capacity to learn from the shocks they encounter (Heeks and Ospina 2019). For example, studies conducted in higher education have found that resilient educational systems need to capture the ability of the system to maintain the efficient delivery of education while adjusting to the change in the environment and the means of delivering education (Beale 2020; Gu 2018). Additionally, teachers are considered unique agents capable of adjusting to shocks due to the “strength and conviction of teachers’ vocational commitment [...] which distinguishes teaching from many other jobs and occupations” (Gu 2018, 17).

It is noticed that the approach to system resilience in educational systems changed with the outbreak of COVID-19. In 2019, a sudden lockdown affected educational systems around the world. Students and instructors were not allowed to go to the building where education was delivered while educational systems were obliged to continue providing their services due to the essential role that education plays in modern societies. Hence, educational systems needed to change the way they imparted education and rely on technology to succeed in doing so.

With COVID-19, there is a shift in the literature on resilience in education, shifting to addressing the concept of e-resilience in educational systems. This new approach to the concept incorporates the importance of technology factors in achieving resilient educational systems. In educational systems, there is mainly a focus on human-centric technologies which builds in the human requirements, desires, and capacities to deal with the system (Agarwal et al. 2020). Weller and Anderson have already included the digital dimension in their concept of resilience in educational systems (2013). They addressed the capacity of the educational

system to innovate by adjusting to digitalisation; specifically through the use of Massive Open Online Courses (MOOCs) and Open Access Publishing. They named this ability “digital resilience” and evaluated the system’s potential to improve educational offerings by adapting to changes in evolving technology (Weller and Anderson 2013). In 2016, UN-ESCAP introduced the concept of “e-resilience” to a system. This concept was used to understand the extent to which an ICT infrastructure was effective in overcoming challenges associated with disaster management (ESCAP 2022). Therefore, the concept of technology as an important element in assisting societies to overcome a shock was introduced.

In 2017, Rothrock highlighted several elements that are relevant to understanding the transformation that systems undergo to adjust to shocks (that is to say, panarchy) and addressed the need to frame the concept within a larger system strategy (Rothrock 2017). The system strategy includes the country, institutions (e.g., the educational system), and individuals. Hence, technology has to be considered in the context of the larger system’s goals (outcome). This approach takes into account the complexity of digital systems and emphasizes that technology has to be functional and flexible in order to respond to shocks and to ensure the continued operation of the larger system, such as an educational system.

Heeks and Ospina point out that while the notion of “what is resilience” is well-established in the literature of information systems (IS), the question “resilience of what” remains to be more clearly identified (2019). Their categorisation includes several different identities of resilient systems, including a human system (with mainly more or less resilient human input in an IS), a resilient information system itself (with a focus on the resilience of ICT infrastructure and digital networks), and a resilience of the outcome system – evaluating the impact of IS on the resilience of other external systems. These systems are capable of being resilient in and of themselves, but clearly, they also interact with one another. The concept of e-resilience is operationalised in their work, and it includes both foundational and enabling attributes. The foundational attributes included the system’s robustness, self-organisation, and learning, whereas the enabling attributes included redundancy, rapidity, scale, diversity, and equality (Heeks and Ospina 2019, 72).

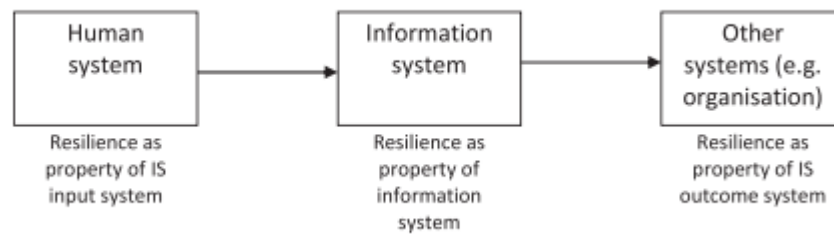


Figure 3: Resilience of what: different identities of resilient systems in information systems literature (Heeks and Ospina 2019)

Additionally, van de Laar addressed the importance of reviewing e-resilience as a systems approach and proposed a framework, more in line with the educational resilience system literature, where educational systems consist of four different levels (individual, programme, institutional, and macro), each of which interacts with ICT systems (2020). Each level includes various stakeholders and takes into account their skills to use these systems.

Within that framework, the individual level includes actors such as students, parents, and teachers, who need to access and use technology to overcome a shock and be able to receive or provide education. The programme level includes the educational programmes that deliver education and that use ICT systems as a way to provide education. The institutional level provides the general ICT infrastructure of an organization (e.g., services and support). The macro level provides beyond educational legislation and policy also the telecommunication infrastructure that allows the other three levels to function. Hence, the e-resilience system is nested, with macro level factors (such as ICT infrastructure) highly influencing the e-resilience of the individual, programme, and institutional levels.

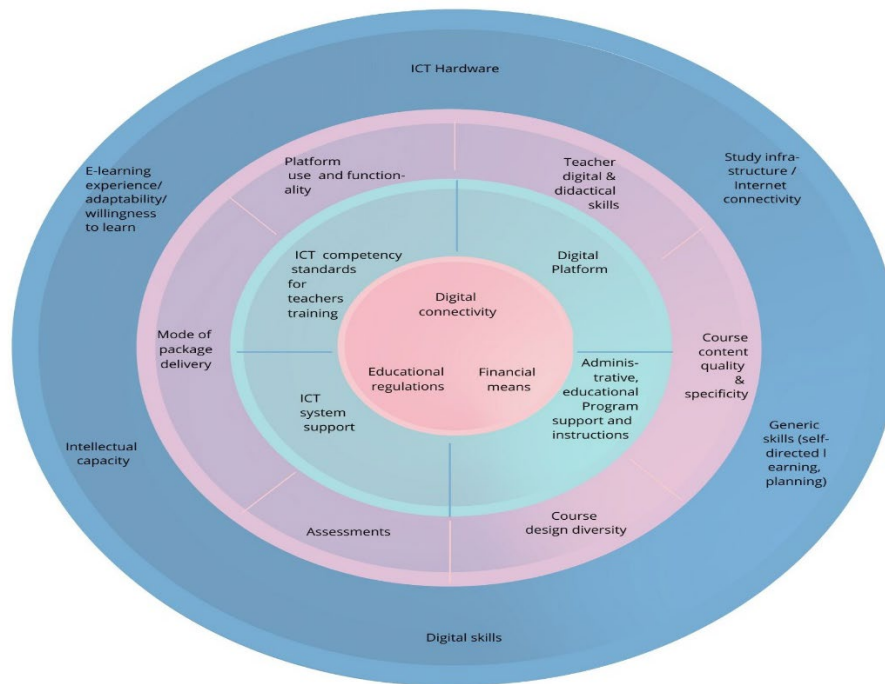


Figure 4: E-Resilience in a higher educational framework (van de Laar 2020)

In practice, the categorisations of Heeks and Ospina (2019) and (van de Laar 2020) are mutually compatible and can be transposed from one to the other. At their core, both approaches aim at identifying elements that contribute to or challenge e-resilience within a system composed of different levels. The framework on e-resilience in higher education provides a framework to describe the functional aspects of a system. Some of the factors present in the framework are more fundamental to e-resilience in educational systems than others, though they all feature a degree of complementarity, which should be analysed in its own right .

In sum, the literature shows a transition from resilience in education, to resilience in educational systems, to e-resilience in educational systems. Within e-resilience in educational systems a framework is proposed to analyse the different levels and dimension of the system. Such levels and dimensions will be used in the section below to analyse the drivers and challenges of e-resilience in educational systems mentioned by the literature.

b. Drivers and Challenges in E-Resilience in Education

In this section, the identified reading are analysed to identify drivers and challenges at different levels of the educational system (micro, meso, and macro) and reflects on the importance of the dimensions of ICT within the concept of resilience in education. In terms of

levels, the micro level refers to the drivers and challenges faced by individual students or teachers (Beale 2020; Cassidy 2016), while the meso level refers to institutional drivers or challenges. The macro level refers to drivers or challenges that are contextually determined, for instance, the network resilience of a country (Sterbenz et al. 2013).

As for the dimensions, the study identifies a technological (ICT) and a human dimension, along with a dimension consisting of the intersection of the two.

The technological dimension refers to the availability and functioning of hardware and software and presence of sufficient connectivity. Examples include a lack of electronic devices, which prevents students working from home from using the educational materials provided online, or a lack of internet connectivity in a region, which inhibits students from participating in online classes (Moore, Vitale, and Stawinoga 2018; Starr, Hayes, and Gao 2022). The term “human dimension” refers to the individual characteristics or experiences that support or limit the capacity of an individual to learn or to provide education. This primarily refers to the ability to learn or teach in a setting favourable to provide or receive education. Examples are inability to attend classes due to personal health or caregiver obligations (Binod Sinha 2021). The intersectional dimension refers to the interaction between humans and technology. For example, when infrastructural settings are favourable (i.e., the technological dimension), yet the digital capacity and skills of the users (both students and teachers, i.e., the human dimension) do not enable them to use the infrastructure (Assareh and Hosseini Bidokht 2011).

Table 1 summarizes the drivers and challenges identified in the literature on e-resilience in education. The drivers and challenges are categorized by levels and dimensions.

<div>Dimension</div> <div>Level</div>	Technological	Human	Intersection
Micro	Challenges <ul style="list-style-type: none"> - Hardware/ software not accessible to everyone (Assareh and Hosseini Bidokht 2011; Daly 2021; Moore, Vitale, and Stawinoga 2018) - Internet connection not accessible to everyone (Arora et al. 2020; Daly 2021; Nadler 2020; Weller and Anderson 2013; Williams 2021; Zusman 	Challenges <ul style="list-style-type: none"> - Students flying back to their country and not being allowed back (Daly 2021) - Students find difficulties to create social connections and friendships (Baxter 2012) - Educators’ wellbeing negatively affected (Gao and Zhang 2020; OECD 2020) - Teachers find difficulties to 	Challenge <ul style="list-style-type: none"> - Limited digital literacy in the population and among students and educators. Digital literacy affected by age (Assareh and Hosseini Bidokht 2011; Martzoukou et al. 2020; Portillo et al. 2020; Reynolds and Parker 2018) - Digital divide / Triple vulnerability of students from low social-economic background: health risk, inappropriate working environment, and insufficient access to hard/software (Bozkurt et al. 2020; Neuwirth, Jović, and Mukherji

	et al. 2020)	<p>adjust to new needs based on specialized disciplines and fields (OECD 2020)</p> <ul style="list-style-type: none"> - Students show limited resilience character (Beale 2020; Cassidy 2016; Eri et al. 2021; Martin and Marsh 2006) - Students receive less monitoring of and support on study progress which derived in disengagement (Nadler 2020; OECD 2020) - Teachers lack needed empathy towards students (Arora et al. 2020; Bozkurt et al. 2020; Neuwirth, Jović, and Mukherji 2021) - Students dropout through lower per capita spending on education (4% less in Africa) (Daly 2021) - Individuals experience difficulties to overcome social distancing hardships, e.g. share feelings of isolation (Ando 2021) - Individuals experience difficulties to cope with additional home responsibilities when studying from home (Baxter 2012; Neuwirth, Jović, and Mukherji 2021) - Individuals experience detrimental effect of shock in health and employment, e.g. trauma, anxiety (Bozkurt et al. 2020; Neuwirth, Jović, and Mukherji 2021; Sarra, Fontanella, and Di Zio 2019; Martin and Marsh 2006) - Parents experience difficulties to also undertake the educational role of schools (Bozkurt et al. 2020; Neuwirth, Jović, and Mukherji 2021) <p>Drivers</p> <ul style="list-style-type: none"> - Individuals enhance self-discipline (Gelles et al. 2020) - Individuals open up and recognize importance of sharing emotions and vulnerabilities (Ando 2021) 	<p>2021; OECD 2020)</p> <ul style="list-style-type: none"> - Lower confidence of mainly women and elder learning to use computers (Assareh and Hosseini Bidokht 2011; Bozkurt et al. 2020) - The same content in a different format (electronic vs. paper) can create a different relation with the learning process (Bozkurt et al. 2020; Nadler 2020) - Reduced e-learning competencies of teachers and instructors and reduced availability of training in e-learning didactics (Assareh and Hosseini Bidokht 2011; Quaicoe and Pata 2020) - Students and educators dealing with Zoom fatigue (Nadler 2020; Williams 2021) - Students participate less and teachers have limited ability to engage students during online education (Nadler 2020; Neuwirth, Jović, and Mukherji 2021; Williams 2021) - Teachers and students experience privacy breach (Nadler 2020) <p>Driver</p> <ul style="list-style-type: none"> - Experience social and technical support from the community (Bozkurt et al. 2020) - Gamification techniques implemented by teachers to improve student's motivation and participation (Meza-Mejía 2017) - Development of online education etiquette (Neuwirth, Jović, and Mukherji 2021) - Teachers feel stimulated with new opportunities to upgrade online skills (Gao and Zhang 2020)
Meso	<p>Challenges</p> <ul style="list-style-type: none"> - Limited available system capacity for digital education (Eri et al. 2021; Heeks and Ospina 2019; Hopkins and Lipman 2019; Ramos and 	<p>Challenges</p> <ul style="list-style-type: none"> - Individuals find difficulties to adjust due to the (lack of) institutional autonomy based on state intervention (OECD 2020) 	<p>Challenges</p> <ul style="list-style-type: none"> - Lack or limited training for teachers to teach online (Abdullah, Husin, and Haider 2020; Beale 2020; Dias and Diniz 2012; Niculescu, Rees, and Gash 2017; OECD 2020; Quaicoe and Pata 2020)

	<p>Hynes 2022)</p> <ul style="list-style-type: none"> - Limited access to hard/software allocation (Arora et al. 2020; Daly 2021; Zusman et al. 2020) - Limited free data for students in cooperation with tele companies (Apuke and Iyendo 2018; Daly 2021) - Limited adaptation of core academic processes (Abdullah, Husin, and Haider 2020) <p>Drivers</p> <ul style="list-style-type: none"> - Advantages of online platforms (Abdullah, Husin, and Haider 2020) - Well-functioning social media platforms to enhance communication (AI-Youbi et al. 2020) - Fast-pace digitalisation at institutional level to adjust to shock (Appolloni et al. 2021) - Circular and sustainable characteristics of online education (Appolloni et al. 2021) - Institutional support in resources and logistics, and in leadership support (Gotangco et al. 2020) 	<ul style="list-style-type: none"> - Limited possibilities to care for most vulnerable members (including students) (Abdullah, Husin, and Haider 2020; Nadler 2020; OECD 2020; Williams 2021) - Limited coordination between stakeholders and resources (OECD 2020) <p>Drivers</p> <ul style="list-style-type: none"> - Individuals build partnerships beyond the institutions and including the community, parents, employers (OECD 2020) - Individuals make use of the wider role of educational institution, which many times goes beyond delivering education (OECD 2020) 	<ul style="list-style-type: none"> - Lack of electronic library and platform to access scientific research papers and data bases needed in the classroom (Apuke and Iyendo 2018) - Limited support for educators to develop their competencies (Grant and Clarke 2020; OECD 2020) - Focus on academic integrity, ethics and privacy concerns related to online education (Abdullah, Husin, and Haider 2020; Bozkurt et al. 2020) - Educational institutions are often slowly changing institutions (OECD 2020) - Institutions experience a localised approach while still maintaining state consistency (OECD 2020; Zusman et al. 2020) <p>Drivers</p> <ul style="list-style-type: none"> - Implementation of online education etiquette and teacher guidelines (Neuwirth, Jović, and Mukherji 2021; Niculescu, Rees, and Gash 2017) - Institution, staff and students make use of social media platforms for fast and efficient communication (AI-Youbi et al. 2020)
Macro	<p>Challenges</p> <ul style="list-style-type: none"> - Effective technological infrastructure to ensure sustainable connectivity (Arora et al. 2020; Daly 2021; Sterbenz et al. 2013; Weller and Anderson 2013; Zusman et al. 2020) - Digital divide and unequal access to online learning sources due to, for example, location (urban vs rural areas), and wealth of country (lower income countries vs. high income countries) (Bacher-Hicks, Goodman, and Mulhern 2021) 	<p>Challenges</p> <ul style="list-style-type: none"> - Individuals experience limited funding allocated to cope with the shock (Daly 2021) - International students flying back to their home country and not being allowed back due to visa restrictions (Daly 2021) <p>allowed out of the house (Abbasi 2021)</p> <p>Drivers</p> <ul style="list-style-type: none"> - Investment of public funds in higher education (Daly 2021) 	<p>Challenge</p> <ul style="list-style-type: none"> - Digital divide: reaching out to marginalised groups, especially young girls, to continue their education while not being - Digital divide: online education often provided in the national language, triggering a language barrier for minority groups (e.g. indigenous groups) (Abbasi 2021) <p>Drivers</p> <ul style="list-style-type: none"> - Coordination from the state to enact laws or ensure appropriate mechanisms that enable actions from educational institutions (Appolloni et al. 2021; Daly 2021; Eri et al. 2021; OECD 2020; Weller and Anderson 2013)

Table 1: Drivers and challenges of e-resilience in education (Authors' compilation)

The literature highlights several elements that challenge the possibility of continuing with education in an “ideal” way (see Table 1). The challenges at the micro within the human

dimension relate mainly to logistical challenges, health caring tasks or motivational challenges individuals face or the lack of social connectivity experienced due to lockdown and isolation. In the intersection of human responses to dealing with technological change more elements are covered, including inability to use technology or the difficulties experienced to didactically offer educational materials. Also the need to include digital channels in our policy frameworks, or the challenges to provide and receive support and monitoring services online were mentioned. Lastly, the health phenomenon “Zoom fatigue” is a clear challenge that exists specifically due to overuse of technology by students and teachers. The technological challenges can be summarised as connectivity, hardware and software issues, and are less often mentioned. However, that does not mean that in the degree of their impact they may be equally or even more disruptive. The drivers of e-resilience are mentioned less frequently and mainly address the importance of a supportive infrastructure that coordinates efforts and the individual impetus to be resilient.

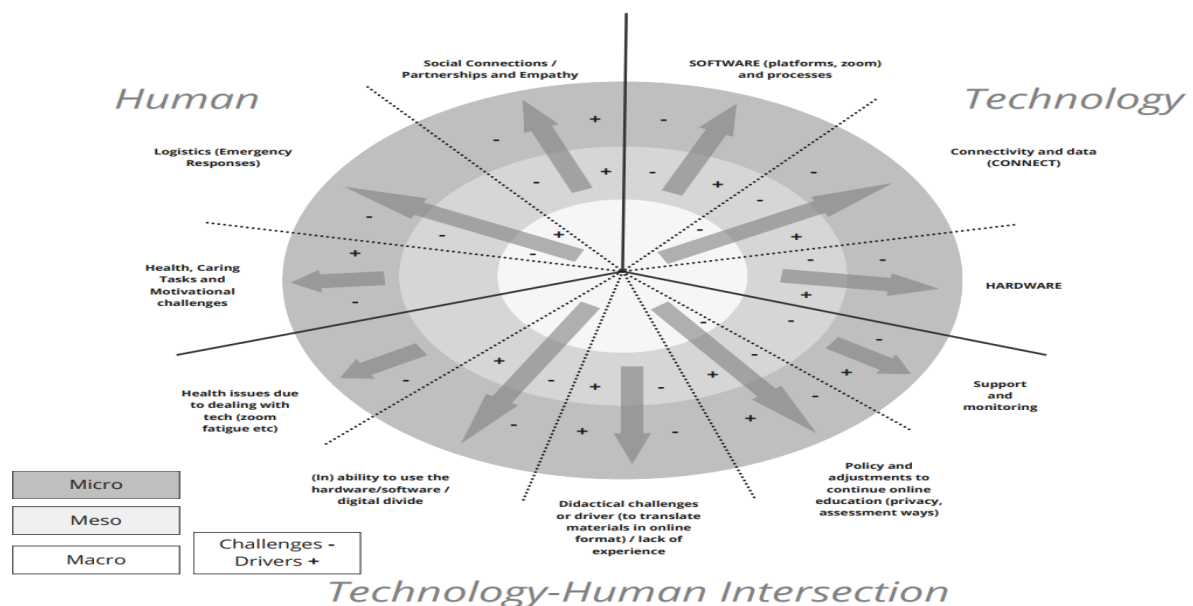


Figure 5: E-Resilience drivers and challenges

As was highlighted in section 3a, in a system perspective all levels and dimensions are interconnected and thus challenges at higher levels will influence performance and wellbeing at lower levels. Figure 5 summarises the literature review findings in a conceptual framework including drivers and challenges, by dimension and level. The systematic overview evidenced that most factors do appear at two or three levels of the educational system, with the arrows indicating that challenges at macro and meso level will impact micro level resilience. At the

micro-level, all categories of challenges are found relevant in the literature. At meso level most drivers were observed, indicating that educational institutions find – even though forced by the shock – new ways to use technology to offer their education. Individuals may also find ways to become more efficient, and build new networks to rely on.

4. Discussion

Our inventory of challenges reveals that the literature addresses technological challenges at the micro, meso, and macro levels and are similar at all levels. Available hardware and software, combined with network security and connectivity in case of shock, determines educational resilience at all levels. Without a well-functioning technological infrastructure and sufficient connectivity, ensuring high quality education for all – in line with SDG4 – becomes difficult (Arora et al. 2020; Daly 2021; Sterbenz et al. 2013; Weller and Anderson 2013; Zusman et al. 2020). The nestedness of the e-resilience system is a significant bottleneck, as a lack of macro-level infrastructure directly impacts the e-resilience of lower level actors. It is beyond any individual or institutional ability to overcome insufficient macro level infrastructure and services. As Mengistie (2021) in his case study on students' learning in COVID-19 pandemic Ethiopia clearly states "Internet and network problems might be the dominant challenge in the universities' response to the education situation caused by the pandemic. With students at home, to manage online or remote learning, Ph.D., undergraduate, graduate, and Ph.D. students need internet access." (Mengistie (2021), pp. 3). This observation is confirmed by the South African case, as described by Hlatshwayo (2022, pp. 18), concluding that "the study links the crisis of online learning to the failure of the state to carry to its logical conclusion the second technological revolution for the provision of efficient and reliable electricity and related to that, the third technological revolution in the form of ICTs".

The literature also identified micro and meso-level specific didactical challenges for teachers, resulting from the lack of well-functioning learning management platforms, the lack of software licences at the educational institutional level or the need to be skilled in new software. But also technological issues at the student level, such as lack of devices or internet access do not enable teachers to educate nor students to learn. Without sufficient e-learning systems in place, such as electronic library services or video-conferencing software licences, institutions, in the event of a shock, will need to invest in technology in order to ensure that

the educational system continues to function. Equally, teaching staff trained to use those e-learning facilities are quicker to adjust and thus better able to overcome the first stages after the shock. Resilient pedagogy with flexible didactical approaches can be considered crucial, and a large driver for an e-resilient system response, as Clum et al. (2022) found in their case studies in the USA and New Zealand. However, if the online infrastructure and didactical skill are not up to par at the onset of the shock, institutional investments will take time, often resulting in educational losses in the short run after a shock.

On the positive side, the literature review also highlighted that the need to rely on ICT can push people into providing high-level education in times of shock. Shocks can encourage stakeholder to engage in new partnerships (OECD, 2020), which is observed by Amrullah et al (2022), in their case study of emerging student-student interaction in online learning in Indonesia. As reported by Amrullah et al: “Research from the data interview showed online learning enhances smooth interactions among students, they tend to avoid demotivating languages and withdrawal. Students enjoy themselves as they really feel safe rather than talk directly which seems to be a bit frightening” (Amrullah et al, pp. 188)

Poorer countries, institutions, and households, in general, will face greater technological challenges. The lack of a sufficiently developed technological infrastructure will prevent optimal learning, leading to an increased inequality in educational attainment in the short run and, most likely, also to increased socio-economic inequality in the long run. The challenges mentioned in the literature in relation to the intersectional dimension are more apparent at the meso and micro levels. Even when all technological facilities are available at an institutional level, we still need to be mindful about the skill development needed to use the services (Beale 2020; OECD 2020). In the event that there is no didactical support for teachers to offer materials in an effective manner or didactical training for students to use the materials effectively, the learning through the use of online educational offerings may not actually happen. In contexts where in-person top-down teaching was more prevalent, the transition to interactive online education is simply harder (Mengistie, 2021).

Globally, digital literacy is still lower among vulnerable groups, which results in an unequal negative impact on educational attainment following a shock (Zelezny-Green, Ronda; Vosloo, Steven; Conole, Gainne; Curran, Susan 2022). As Aristovnik et al (2020) find in their global study among 62 countries, female students and students with financial problems were

impacted more in terms of their emotional and personal situation, whereas male students with lower living standards from Africa and Asia were less satisfied with their academic work/life balance. Digital literacy is not gender balanced with women being disadvantaged and it is generally lower for vulnerable groups such as older workers, minority groups, indigenous people, and migrants (ITU 2022; Starr, Hayes, and Gao 2022).

The digital divide is more apparent in poorer regions or countries, owing to a lack of access to technology and its benefits, as well as greater inequality (Quaicoe and Pata 2020; Zelezny-Green, Ronda; Vosloo, Steven; Conole, Gainne; Curran, Susan 2022). In view of those facts, the less digitally literate a group is, the less likely it is to be e-resilient. This barrier could be overcome with a strong educational system that has the capacity to train students quickly and provide them with the technology they need. However, the individual barriers, such as a lack of quiet in a household or the impossibility of being granted a visa to re-enter a country, go beyond the possibilities of the educational systems. Cooperation amongst levels in the system becomes essential to allow individuals and educational systems to attain e-resilience.

It is interesting to note, however, that even when technological access and necessary skills are in place, effective learning may still not take place. A large number of the drivers and challenges mentioned in the literature are found in the human dimension, indicating that even with well-functioning ICT, an educational system can still fail to provide education well to individuals. At the macro level, sustainable investments in the education sector, as well as rapid policy adjustment in the aftermath of a shock, are needed (Eri et al. 2021; Weller and Anderson 2013). If that speedy response is not present, policymakers at the institutional level will be challenged, as they will not have sufficient flexibility to accommodate the needs of their staff and students. At the micro level, the most significant challenges that can arise after a shock are mainly those pertaining to health, stress, and uncertainty (see Table 1). In particular, students that benefit from strong guidance and interaction will suffer more when faced with uncertain situations (Beale 2020; Cassidy 2016; Eri et al. 2021; OECD 2020; Martin and Marsh 2006). In times of shock, therefore focus on the wellbeing of the individual student and teacher remain essential.

5. Conclusions

The literature shows that e-resilience in education is defined comprehensively as the ability of an educational system to overcome shocks and deliver and receive education while taking into account the dimensions of technology, human capabilities, and the interactions thereof. Adapting to provide relevant solutions requires extensive coordination (and consensus) across levels and dimensions within the system. Educational systems should be able to learn from and evolve around a crisis. A proper technological infrastructure to sustain the delivery of education through technological pathways is essential. However, this alone does not guarantee the e-resilience of an educational system. The large number of the challenges mentioned in the literature come from within the human dimension, which refers to the actual capacity of the individual to overcome the shock. And equally large number of challenges are found in the intersection of human and technology – which relates to the ability of human to manage and work with technology to overcome handle of the shock well. Up to now, there is not enough understanding of how individuals manage to overcome those challenges and how technological advancements in the educational system and the country as a whole affect their capacity to overcome. Hence, further empirical studies are needed for an in-depth understanding of the challenges and motivations of the individuals who are an essential part of an educational system.

References

- Abbasi, Salma. 2021. 'Overview and Insight: Resilience across the Education Ecosystem During the COVID-19 Pandemic (Unpublished, in File with the Authors)'. <http://e-www.com/>.
- Abdullah, Mokhtar, Nor Azilah Husin, and Ameer Haider. 2020. 'Development of Post-Pandemic Covid19 Higher Education Resilience Framework in Malaysia'. *ABR* 8 (5): 201–10. <https://doi.org/10.14738/abr.85.8321>.
- Agarwal, Sonali, Narinder Singh Pun, Sanjay Kumar Sonbhadra, M. Tanveer, P. Nagabhushan, K K Soundra Pandian, and Praveer Saxena. 2020. 'Unleashing the Power of Disruptive and Emerging Technologies amid COVID-19: A Detailed Review'. *ArXiv E-Prints* 2005 (May): arXiv:2005.11507.
- Ahern, Nancy R., Ermalynn M. Kiehl, Mary Lou Sole, and Jacqueline Byers. 2006. 'A Review of Instruments Measuring Resilience'. *Issues in Comprehensive Pediatric Nursing* 29 (2): 103–25. <https://doi.org/10.1080/01460860600677643>.
- Al-Youbi, Abdulrahman Obaid, Abdulmonem Al-Hayani, Hisham J. Bardesi, Mohammed Basher, Miltiadis D. Lytras, and Naif Radi Aljohani. 2020. 'The King Abdulaziz University (KAU) Pandemic Framework: A Methodological Approach to Leverage Social Media for the Sustainable Management of Higher Education in Crisis'. *Sustainability* 12 (11): 4367. <https://doi.org/10.3390/su12114367>.
- Amrullah, A., Sahuddin, S., Lalu Nurtaat, L. N., Sribagus, S., Fadji, M., Nanzah, Z. (2022). Student-student interaction in online learning during the COVID-19 pandemic: A case study. *Education Quarterly Reviews*, 5(2). <https://doi.org/10.31014/aior.1993.05.02.479>
- Ando, Sachi. 2021. 'University Teaching and Learning in a Time of Social Distancing: A Sociocultural Perspective'. *Journal of Human Behavior in the Social Environment* 31 (1–4): 435–48. <https://doi.org/10.1080/10911359.2020.1814928>.
- Appolloni, Andrea, Nathalie Colasanti, Chiara Fantauzzi, Gloria Fiorani, and Rocco Frondizi. 2021. 'Distance Learning as a Resilience Strategy during Covid-19: An Analysis of the Italian Context'. *Sustainability* 13 (3): 1388. <https://doi.org/10.3390/su13031388>.
- Apuke, Oberiri Destiny, and Timothy Onosahwo Iyendo. 2018. 'University Students' Usage of the Internet Resources for Research and Learning: Forms of Access and Perceptions of Utility'. *Heliyon* 4 (12): e01052. <https://doi.org/10.1016/j.heliyon.2018.e01052>.
- Aristovnik, A., Keržič, D., Ravšelj, D., Tomaževič, N., Umek, L. (2020, October 13). Impacts of the COVID-19 pandemic on life of Higher Education Students: A global perspective. MDPI. <https://www.mdpi.com/2071-1050/12/20/8438>
- Arora, Madhu, Lalit Mohan Goyal, Nalini Chintalapudi, and Mamta Mittal. 2020. 'Factors Affecting Digital Education during COVID-19: A Statistical Modeling Approach'. In 2020 5th International Conference on Computing, Communication and Security (ICCCS), 1–5. Patna, India: IEEE. <https://doi.org/10.1109/ICCCS49678.2020.9277370>.
- Assareh, A., and M. Hosseini Bidokht. 2011. 'Barriers to E-Teaching and e-Learning'. *Procedia Computer Science* 3: 791–95. <https://doi.org/10.1016/j.procs.2010.12.129>.
- Bacher-Hicks, Andrew, Joshua Goodman, and Christine Mulhern. 2021. 'Inequality in Household Adaptation to Schooling Shocks: Covid-Induced Online Learning Engagement in Real Time'. *Journal of Public Economics* 193 (January): 104345. <https://doi.org/10.1016/j.jpubeco.2020.104345>.
- Baxter, Jacqueline Aundree. 2012. 'Who Am I and What Keeps Me Going? Profiling the Distance Learning Student in Higher Education'. *The International Review of Research in Open and Distributed Learning* 13 (4): 107–29. <https://doi.org/10.19173/irrodl.v13i4.1283>.
- Beale, Jonathan. 2020. 'Academic Resilience and Its Importance in Education after Covid-19'. *Eton Journal for Innovation and Research in Education* 4: 1–6.
- Beltman, Susan. 2021. 'Understanding and Examining Teacher Resilience from Multiple Perspectives'. In *Cultivating Teacher Resilience*, 11–26. Springer. 10.1007/978-981-15-5963-1_2.

- Binod Sinha. 2021. 'Mohalla Classes to Tide through the Pandemic'. Oxfam Novib Featured Stories (blog). 23 September 2021. oxfamindia.org/featuredstories/mohalla-classes-tide-through-pandemic.
- Bozkurt, A., I. Jung, J. Xiao, V. Vladimirschi, R. Schuwer, G. Egorov, S. R. Lambert, et al. 2020. 'A Global Outlook to the Interruption of Education Due to COVID-19 Pandemic: Navigating in a Time of Uncertainty and Crisis'. *Asian Journal of Distance Education* 15 (1): 1–126.
- Cassidy, Simon. 2016. 'The Academic Resilience Scale (ARS-30): A New Multidimensional Construct Measure'. *Frontiers in Psychology* 7 (November). <https://doi.org/10.3389/fpsyg.2016.01787>.
- Clum, K., Ebersole, E., Wicks, D., Shea, M. (2022). A Case Study Approach to Exploring Resilient Pedagogy During Times of Crisis. *Online Learning - The Official Journal of OJL*.
- Daly, Sarah. 2021. 'Mind the Gap: COVID-19'S Impact on Higher Education in Africa and Abroad'. AFRICA WATCH: COVID-19 Edition. Institute for Defense Analyses. <http://www.jstor.org/stable/resrep29557.4>.
- Dias, Sofia B., and José A. Diniz. 2012. 'Blended Learning in Higher Education: Different Needs, Different Profiles'. *Procedia Computer Science* 14: 438–46. <https://doi.org/10.1016/j.procs.2012.10.050>.
- Duchek, Stephanie. 2020. 'Organizational Resilience: A Capability-Based Conceptualization'. *Business Research* 13 (1): 215–46. <https://doi.org/10.1007/s40685-019-0085-7>.
- Eri, Rajaraman, Prasad Gudimetla, Shaun Star, Josh Rowlands, and Anit Girgla. 2021. 'Digital Resilience in Higher Education in Response to COVID-19 Pandemic: Student P Student Perceptions Fr Ceptions from Asia and A Om Asia and Australia'. *Journal of University Teaching & Learning Practice* 18 (5). <https://doi.org/10.53761/1.18.5.7>.
- ESCAP. 2022. 'ICT and Disaster Risk Reduction E-Resilience'. UNESCAP. 2022. <https://www.unescap.org/our-work/ict-and-disaster-risk-reduction/eresilience>.
- Gao, Lori Xingzhen, and Lawrence Jun Zhang. 2020. 'Teacher Learning in Difficult Times: Examining Foreign Language Teachers' Cognitions About Online Teaching to Tide Over COVID-19'. *Frontiers in Psychology* 11. <https://doi.org/10.3389/fpsyg.2020.549653>.
- Gelles, Laura A., Susan M. Lord, Gordon D. Hoople, Diana A. Chen, and Joel Alejandro Mejia. 2020. 'Compassionate Flexibility and Self-Discipline: Student Adaptation to Emergency Remote Teaching in an Integrated Engineering Energy Course during COVID-19'. *Education Sciences* 10 (11): 304. <https://doi.org/10.3390/educsci10110304>.
- Gotangco, Charlotte Kendra, Jean Meir Jardeleza, Crisanto Lopez, Elirozz Carlie Labaria, Julia Wickert, and Fathmath Shadiya. 2020. 'Factors Influencing Disaster Risk and Resilience Education in Asian HEIs'. *International Journal of Disaster Resilience in the Built Environment*, January. <https://doi.org/10.1108/IJDRBE-05-2020-0040>.
- Grant, C., and C. Clarke. 2020. 'Digital Resilience: A Competency Framework for Agile Workers'. In *Agile Working and Well-Being in the Digital Age*, 117–30. Cham: Palgrave Macmillan.
- Gu, Qing. 2018. '(Re)Conceptualizing Teacher Resilience: A Social-Ecological Approach to Understanding Teachers' Professional Worlds'. In *Resilience in Education. Concepts, Contexts and Connections*, 13–34. Springer.
- Heeks, Richard, and Angelica V. Ospina. 2019. 'Conceptualising the Link between Information Systems and Resilience: A Developing Country Field Study'. *Information Systems Journal* 29 (1): 70–96. <https://doi.org/10.1111/isj.12177>.
- Hlatshwayo, M. (2022). Online learning during the South African covid-19 lockdown: University students left to their own devices. *Education as Change*, 26. <https://doi.org/10.25159/1947-9417/11155>
- Hopkins, Rob, and Peter Lipman. 2019. 'Who We Are and What We Do'. The Transition Network Ltd, 2019. <https://transitionnetwork.org/sites/www.transitionnetwork.org/files/WhoWeAreAndWhatWeDo-lowres.pdf>.

- IEEE. 2022. 'IMeet Central'. IEEE IC Digital Resilience Structure. 22 July 2022. <https://ieeesa.imeetcentral.com/digres/doc/WzIsNzI0MDkzMTFd/w-FrontPage>.
- ITU. 2022. 'Digital Inclusion Pages'. 29 April 2022. <https://www.itu.int/en/ITU-D/Digital-Inclusion/Pages/Digital-Inclusion-Publications.aspx>.
- Laar, Mindel van de. 2020. 'E-Resilience in Education: A Conceptual Framework'. Policy Brief UNU-MERIT, 6, , 8.
- Lengnick-Hall, Cynthia A., Tammy E. Beck, and Mark L. Lengnick-Hall. 2011. 'Developing a Capacity for Organizational Resilience through Strategic Human Resource Management'. *Human Resource Management Review* 21 (3): 243–55. <https://doi.org/10.1016/j.hrmr.2010.07.001>.
- Mansfield, Caroline F., Liesel Ebersöhn, Susan Beltman, and Tilda Loots. 2018. 'Great Southern Lands: Making Space for Teacher Resilience in South Africa and Australia'. In *Resilience in Education: Concepts, Contexts and Connections*, 53–71. Springer. https://doi.org/10.1007/978-3-319-76690-4_4.
- Martin, A.J., and H.W. Marsh. 2006. 'Academic Resilience and Its Psychological and Educational Correlates: A Construct Validity Approach'. *Psychology in the Schools* 43 (3): 267–81.
- Martzoukou, Konstantina, Crystal Fulton, Petros Kostagiolas, and Charilaos Lavranos. 2020. 'A Study of Higher Education Students' Self-Perceived Digital Competences for Learning and Everyday Life Online Participation'. *Journal of Documentation* 76 (6): 1413–58. <https://doi.org/10.1108/JD-03-2020-0041>.
- Meza-Mejía, M. D. C. 2017. 'The Gamification: Strategy of Teaching-Learning to Develop the Resilience in Students University'. In . Universidad Panamericana Publicaciones. <http://dx.doi.org/10.21125/iceri.2017.2230>.
- Mengistie, T. A. (2021). Higher education students' learning in COVID-19 pandemic period: The Ethiopian context. *Research in Globalization*, 3, 100059. <https://doi.org/10.1016/j.resglo.2021.100059>
- Moore, Raeal, Dan Vitale, and Nycole Stawinoga. 2018. 'The Digital Divide and Educational Equity. A Look at Students with Very Limited Access to Electronic Devices at Home'. *Insights in Education and Work*. Center for Equity in Learning. <https://files.eric.ed.gov/fulltext/ED593163.pdf>.
- Nadler, Robby. 2020. 'Understanding "Zoom Fatigue": Theorizing Spatial Dynamics as Third Skins in Computer-Mediated Communication'. *Computers and Composition* 58 (December): 102613. <https://doi.org/10.1016/j.compcom.2020.102613>.
- Neuwirth, L. S., S. Jović, and B. R. Mukherji. 2021. 'Reimagining Higher Education during and Post-COVID-19: Challenges and Opportunities'. *Journal of Adult and Continuing Education* 27 (2). <https://doi.org/10.1177/1477971420947738>.
- Niculescu, I., R. Rees, and D. Gash. 2017. 'An Exploration into Pedagogic Frailty: Transitioning from Face-to-Face to Online'. *Knowledge Management & E-Learning: An International Journal* 9 (3): 392–403. <https://doi.org/10.34105/j.kmel.2017.09.024>.
- OECD. 2020. 'Lessons for Education from COVID-19: A Policy Maker's Handbook for More Resilient Systems'. Paris: OECD Publishing. <https://doi.org/10.1787/0a530888-en>.
- Page, Matthew J, JE McKenzie, PM Bossuyt, I Boutron, TC Hoffmann, CD Mulrow, and et al. 2021. 'The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews'. *BMJ* 372 (71). <https://doi.org/10.1136/bmj.n71>.
- Portillo, Javier, Urtza Garay, Eneko Tejada, and Naiara Bilbao. 2020. 'Self-Perception of the Digital Competence of Educators during the COVID-19 Pandemic: A Cross-Analysis of Different Educational Stages'. *Sustainability* 12 (23): 10128. <https://doi.org/10.3390/su122310128>.
- Quaicoe, James Sunney, and Kai Pata. 2020. 'Teachers' Digital Literacy and Digital Activity as Digital Divide Components among Basic Schools in Ghana'. *Education and Information Technologies* 25 (5): 4077–95. <https://doi.org/10.1007/s10639-020-10158-8>.
- Ramos, Gabriela, and William Hynes. 2022. 'A Systemic Resilience Approach to Dealing with Covid-19 and Future Shocks: New Approaches to Economic Challenges'. OECD. 15 July 2022.

- <https://oecd.org/coronavirus/policy-responses/a-systematic-resilience-approach-to-dealing-with-covid-19-and-future-shocks-36a5bdfb/>.
- Reynolds, Louis, and Lucie Parker. 2018. *Digital Resilience: Stronger Citizens Online*. London, UK: Institute for Strategic Dialogue.
- Rothrock, Ray A. 2017. 'Digital Network Resilience: Surprising Lessons from the Maginot Line' 2 (3): 33–40.
- Sarra, Annalina, Lara Fontanella, and Simone Di Zio. 2019. 'Identifying Students at Risk of Academic Failure Within the Educational Data Mining Framework'. *Social Indicators Research* 146 (1): 41–60. <https://doi.org/10.1007/s11205-018-1901-8>.
- Schwarze, Jennifer, and Marold Wosnitza. 2018. 'How Does Apprentice Resilience Work'. In *Resilience in Education, Concepts, Contexts and Connections*, 35–52. Springer.
- Shafi, Adeela Ahmed, and Sian Templeton. 2020. 'Towards a Dynamic Interactive Model of Resilience'. In *Reconsidering Resilience in Education: An Exploration Using the Dynamic Interactive Model of Resilience*, 17–38. Switzerland: Springer.
- Starr, Darriya, Joseph Hayes, and Niu Gao. 2022. 'The Digital Divide in Education'. Fact Sheet. PPIC. <https://www.ppic.org/publication/the-digital-divide-in-education/>.
- Sterbenz, J. P., E. K. Çetinkaya, M. A. Hameed, A. Jabbar, S. Qian, and J. P. Rohrer. 2013. 'Evaluation of Network Resilience, Survivability, and Disruption Tolerance: Analysis, Topology Generation, Simulation, and Experimentation'. *Telecommunication Systems* 52 (2): 705–36. <https://doi.org/10.1007/s11235-011-9573-6>.
- Türkeli, Serdar, dir. 2020. *Litoscope (Version Issue 2.0)*. Maastricht: the Lab of UNU-MERIT. <https://lab.merit.unu.edu/toolkits/>.
- United Nations. 2015. 'The 17 Goals'. 2015. <https://sdgs.un.org/goals>.
- Walker, B., C.S. Holling, S.R. Carpenter, and A. Kinzig. 2004. 'Resilience, Adaptability and Transformability in Social–Ecological Systems. *Ecology and Society*' 9 (2).
- Weller, M, and T Anderson. 2013. 'Digital Resilience in Higher Education'. *European Journal of Open. Distance and e-Learning* 16 (1): 53–66.
- Williams, Nerys. 2021. 'Working through COVID-19: “Zoom” Gloom and “Zoom” Fatigue'. *Occupational Medicine* 71 (3): 164–164. <https://doi.org/10.1093/occmed/kqab041>.
- Zelezny-Green, Ronda; Vosloo, Steven; Conole, Gainne; Curran, Susan. 2022. 'A Landscape Review: Digital Inclusion for Low-Skilled and Low-Literate People | VOCEDplus, the International Tertiary Education and Research Database'. 15 July 2022. http://www.unesco.org/ulis/cgi-bin/ulis.pl?catno=261791&set=005B764DD4_2_333&gp=1&lin=1&ll=1.
- Zusman, Eric, Erin Kawazu, André Mader, Atsushi Watabe, Tomoko Takeda, So-Young Lee, Matthew Hengesbaugh, et al. 2020. 'A Sustainable COVID-19 Response, Recovery, and Redesign: Principles and Applications of the Triple R Framework'. Institute for Global Environmental Studies. <https://www.iges.or.jp/en/pub/tripler/en>.

Annex 1: Literature Summary by Tier, Level and Methodology.

Tier	Level	Title	Authors	Year	Methodology
Tier1	System	Unleashing the power of disruptive and emerging technologies amid Covid 2019: a detailed review.	Agarwal, S., Pun, N. S., Sonbhadra, S. K., Nagabhushan, P., Pandian, K. K., & Saxena, P.	2020	Literature review of emerging, future, and disruptive technologies that can be utilized to mitigate the impact of Covid-19. Detailed technological specific use cases have been presented through SWOT analysis.
Tier1	Micro	A profile of MPA students' perceptions of online learning: What MPA students value in online education and what they think would improve online learning experiences	Anna Ya Ni, Montgomery Van Wart, Pamela Medina, Kimberly Collins, Ernest Silvers & Hang Pei	2021	Survey in USA, 160 students of which 145 took online classes. Descriptive statistical analysis.
Tier1	Micro	Inequality in household adaptation to schooling shocks: Covid-induced online learning engagement in real time.	Bacher-Hicks, A., Goodman, J., & Mulhern, C.	2021	USA: National and regional regression analysis, regressing google search intensity on SES, race, rurality, broadband and computer penetration rate, all interacted with pre- and post- Covid dummies. The author's use a Difference in Differences design to establish a widening gap in search intensities and math scores post-Covid, along SES indicators.
Tier1	Macro, Meso and Micro	A global outlook to the interruption of education due to Covid -19 pandemic: Navigating in a time of uncertainty and crisis	Bozkurt, A., Jung, I., Xiao, J., Vladimirsch, V., Schuwer, R., Egorov, G., ... & Paskevicius, M.	2020	Qualitative, collective case studies China, Japan, India, Russia, Saudi Arabia, South Korea, Philippines (Asia) Algeria, Egypt, Kenya, Ghana, Namibia, South Africa, Uganda (Africa) Australia (Oceania) France, Greece, Ireland, Romania, Spain, Sweden, Netherlands, Turkey, UK (Europe) Canada, US (North America) Argentina, Brazil, Mexico, Peru, Uruguay (South America)
Tier1	Micro	Compassionate flexibility and self-discipline: Student adaptation to emergency remote teaching in an integrated engineering energy course during Covid-19	Gelles, L. A., Lord, S. M., Hoople, G. D., Chen, D. A., & Mejia, J. A.	2020	Qualitative case study in the US
Tier1	Meso	Digital Resilience: A Competency Framework for Agile Workers. In Agile Working and Well-Being in the Digital Age	Grant, C., & Clarke, C.	2020	Analysis of three research studies including qualitative and mixed methods approach are analysed to develop Digital Resilience Competency Framework to support e-workers.
Tier1	System	Conceptualising the link between information systems and resilience: A developing country field study	Heeks, R., & Ospina, A. V.	2019	Realist evaluation, San Jose, Costa Rica

Tier1	Micro	A study of higher education students' self-perceived digital competences for learning and everyday life online participation.	Martzoukou, K., Fulton, C., Kostagiolas, P., & Lavranos, C.	2020	Scotland, Ireland, and Greece
Tier1	Macro	Reimagining higher education during and post- Covid-19: Challenges and opportunities.	Neuwirth, L. S., Jović, S., & Mukherji, B. R.	2020	New York Qualitative
Tier1	Micro	Digital resilience: Stronger citizens online	Reynolds, Louis, and Lucie Parker.	2018	The methodology used in the report involves a quantitative evaluation of the impact of a series of three classes on participants' confidence levels. The evaluation involved the delivery of pre- and post-surveys to both participant and comparison groups, which were completed anonymously using a Likert scale to indicate agreement with a series of confidence statements. The surveys included 16 impact measures and demographic questions to provide insights into the background of participants. The anonymous code generator was used to match pre- and post-surveys to ensure evaluators did not have access to participants' identifying information.
Tier1	Macro	Evaluation of network resilience, survivability, and disruption tolerance: analysis, topology generation, simulation, and experimentation.	Sterbenz, J. P., Çetinkaya, E. K., Hameed, M. A., Jabbar, A., Qian, S., & Rohrer, J. P.	2013	Theory - The methodology used in this paper is a comprehensive approach to evaluate network resilience. It involves a combination of topology generation, analytical, simulation, and experimental emulation techniques. The goal of this methodology is to improve the resilience and survivability of the Future Internet.
Tier1	Meso	A multilevel framework to enhance organizational resilience	Tasic Justyna , Sulfikar Amir, Jethro Tan & Majeed Khader	2020	The paper does not provide a detailed description of the methodology used. However, it mentions that the paper presents an empirical study to probe the impact of multilevel elements on an organization's capacity for responding to critical situations. Therefore, it can be inferred that the methodology used in the paper is empirical research. However, the paper does not provide any further details on the research design, data collection, or analysis methods used in the empirical study
Tier1	Meso	Digital resilience in higher education.	Weller, M., & Anderson, T.	2013	Qualitative, open university UK
Tier2	Meso	The King Abdulaziz University (KAU) pandemic framework: A methodological approach to leverage social media for the sustainable management of higher education in crisis.	Al-Youbi, A. O., Al-Hayani, A., Bardesi, H. J., Basher, M., Lytras, M. D., & Aljohani, N. R.	2020	mixed methods
Tier2	Micro	University teaching and learning in a time of social distancing: A sociocultural perspective	Ando, S.	2020	Japan, qualitative
Tier2	Macro	Distance Learning as a Resilience Strategy during Covid-19: An Analysis of the Italian Context.	Appolloni, A., Colasanti, N., Fantauzzi, C., Fiorani, G., & Frondizi, R.	2021	Qualitative Case Study using document analysis - very informal and non-standardised! The case chosen is the Italian Higher Education Sector, comprised of all Universities in Italy.

Tier2	Micro	University students' usage of the internet resources for research and learning: forms of access and perceptions of utility.	Apuke, O. D., & Iyendo, T. O.	2018	The paper uses both quantitative and qualitative research approaches to investigate the place of the internet in academic research and learning of students. The study was conducted using 250 undergraduate students in three selected universities within North-Eastern Nigeria. To gain an in-depth understanding of the perception of the students' views, a focus group was conducted with 18 students
Tier2	Micro	Who am I and what keeps me going? Profiling the distance learning student in higher education	Baxter, J.	2012	The methodology used in this paper is a case study format. The literature review pursued three lines of inquiry: literature on online retention, literature on retention in conventional higher education institutions, and literature on identity formation. The research used qualitative research methods and involved conducting 16 qualitative interviews, each lasting between 60 and 75 minutes.
Tier2	Meso	Blended learning in higher education: Different needs, different profiles.	Dias, S. B., & Diniz, J. A.	2020	Qualitative, focus group
Tier2	Macro	Factors influencing disaster risk and resilience education in Asian HEIs	Gotangco, C. K., Jardeleza, J. M., Lopez, C., Labaria, E. C., Wickert, J., & Shadiya, F.	2020	Mixed methods (desktop scoping, online survey, small-group workshop) Asian HEIs (8 countries: Bangladesh, China, Hong Kong, Indonesia, Japan, Malaysia, Philippines, Sri Lanka)
Tier2	Micro	An exploration into pedagogic frailty: Transitioning from face-to-face to online.	Niculescu, I., Rees, R., & Gash, D.	2017	Qualitative, UK - The methodology used in this paper is concept mapping, which is effective in gaining access to academics' beliefs, values, and assumptions about teaching
Tier2	Micro	Self-Perception of the Digital Competence of Educators during the Covid -19 Pandemic: A Cross-Analysis of Different Educational Stages.	Portillo, J., Garay, U., Tejada, E., & Bilbao, N.	2020	BASQUE COUNTRY (SP): The authors compose a likert-scale survey and disseminate it among Basque teachers of all levels, conducting a non-probabilistic sampling. Although not a strictly random sample, their survey reached approximately 10 % of the relevant population and can therefore be considered as good as representative goes. They part their sample in half and conduct confirmatory Factor Analysis over it, disaggregating the underlying structure into latent variables that may drive observed correlational differences. Lastly, for model validation, they conduct a hierarchical regression analysis, checking which of the coefficients are significant when added to the model one after another. I should add here that this type of analysis is not able to infer causal relations.
Tier2	Micro	Making distance visible: Assembling nearness in an online distance-learning programme.	Ross, J., Gallagher, M. S., & Macleod, H.	2013	Interview data, Scotland
Tier2	Micro	Identifying students at risk of academic failure within the educational data-mining framework.	Sarra, A., Fontanella, L., & Di Zio, S.	2019	Statistical technique called Bayesian Profile Regression is used on the real data collected through an online questionnaire filled in by undergraduate students of an Italian University
Tier2	Micro	The gamification: strategy of teaching-learning to develop the resilience in students university	Meza-Mejía, M. D. C.	2017	Questionnaire of resilience for College Students (CRE-U) in Spain.
Tier3	Macro	Overview and insight: Resilience across the education ecosystem during the Covid-19 pandemic.	Abassi Salma	2021	The paper does not mention a specific methodology used. Instead, it examines critical aspects across the educational ecosystem, highlights gaps in essential components, and poses alternative approaches and policy reforms to achieve a resilient education system. The recommendations are based on multiple dimensions necessary for an e-resilient education system.

Tier3	Meso / System	Development of Post-Pandemic Covid-19 Higher Education Resilience Framework in Malaysia	ABDULLAH, M., Husin, N. A., & Haider, A.	2020	Methodology used in this paper is a conceptual framework based on the propositions developed by Duchek (2020) to measure the resilience of Malaysian higher education institutions in the face of the Covid-19 pandemic
Tier3	Micro	A Review of Instruments Measuring Resilience.	Ahern, N. R., Kiehl, E. M., Lou Sole, M., & Byers, J.	2020	The study included 141 participants, consisting of 39 male and 102 female university students which participated in three tests and regression models are used analyse the data and determine the relationship between mindfulness, academic self-efficacy, and resilience.
Tier3	Micro	Factors affecting digital education during Covid-19: A statistical modelling approach.	Arora, M., Goyal, L. M., Chintalapudi, N., & Mittal, M.	2020	Interviews - The methodology used in this paper involves data collection and software tools for simulation purposes. Data collected from 1218 students using a structured questionnaire with a 5-point linear scale. Correlation analysis and linear regression are used to identify the factors affecting online learning during the Covid-19 pandemic.
Tier3	Micro and System	Barriers to E-Teaching and e-Learning	Assareh, A., and M. Hosseini Bidokht.	2011	Qualitative interview study. The data for the study were collected through semi-structured interviews with 11 EFL teachers.
Tier3	System	Academic Resilience and its Importance in Education after Covid-19	Beale, J.	2020	Theoretic research
Tier3	Micro and System	Understanding and Examining Teacher Resilience from Multiple Perspectives	Beltman, Susan.	2021	The methodology used in this paper is primarily qualitative and involves the analysis of interviews and data from previous studies.
Tier3	System	The Academic Resilience Scale (ARS-30): A New Multidimensional Construct Measure.	Cassidy, S.	2016	The methodology used in this paper involves the development and validation of the ARS-30. The study involved a sample of undergraduate students (N = 532) who completed the ARS-30
Tier3	Macro	Mind the Gap: Covid-19's impact on higher education in Africa and abroad.	Daly, S.	2021	No methodology mentioned - Information mainly discusses the economic benefits of hosting international students and the impact of Covid-19 on higher education opportunities in Africa.
Tier3	Meso	Organizational resilience: a capability-based conceptualization	Duchek, S.	2020	The paper follows a conceptualization methodology to deepen the understanding of the complex and embedded construct of organizational resilience. The authors decompose the construct into its individual parts and suggest three successive resilience stages (anticipation, coping, and adaptation) based on process-based studies.
Tier3	Macro	Digital resilience in higher education in response to Covid-19 pandemic: Student Perceptions from Asia and Australia.	Eri R., Gudimetla P., Star S., Rowlands J., Girgla A.	2021	The study data derived from student perspectives in five different countries (7 different sites) across Australia and Asia brings out interesting aspects of the Covid-19 pandemic's impact on digital competencies and resilience.
Tier3	Micro	Teacher Learning in Difficult Times: Examining Foreign Language Teachers' Cognitions About Online Teaching to Tide Over Covid-19'	Gao, Lori Xingzhen, and Lawrence Jun Zhang.	2020	Qualitative in-depth interviews with 3 teachers from a Chinese university and analysed the data thematically to identify the teachers' cognition about online teaching.
Tier3	Macro	'(Re)Conceptualizing Teacher Resilience: A Social-Ecological Approach to Understanding Teachers' Professional Worlds'.	Gu, Qing.	2018	The paper does not provide information about the methodology used. This conceptual paper builds upon and extends current understanding of teacher resilience from a social-ecological perspective. The authors draw on existing research and literature to develop their framework for understanding teacher resilience.

Tier3	System	Resilience: The capacity of a system to absorb disturbance and reorganise while undergoing change, to retain essentially the same function, structure, identity and feedbacks.	Hopkins, R.	2019	The paper does not any specific methodology or method but rather draws on existing theory and examples to develop its arguments. Examples are used to clarify, explain, and diagnose known examples of regional development, regional poverty, and regional sustainability
Tier3	System	E-Resilience in Education: A Conceptual Framework	Laar, Mindel van de	2020	The paper does not mention a specific methodology used in the research. Instead, it presents a conceptual framework for e-resilience in education. The framework is based on a review of literature and existing research in the field of educational technology and psychological resilience.
Tier3	Meso	Developing a capacity for organizational resilience through strategic human resource management	Lengnick-Hall Cynthia A., Tammy E. Beck, Mark L. Lengnick-Hall	2020	The paper is more focused on proposing a methodology rather than using a specific research method. It proposes a methodology for developing an organization's capacity for resilience through strategic human resource management.
Tier3	System	'Great Southern Lands: Making Space for Teacher Resilience in South Africa and Australia'	Mansfield, Caroline F., Liesel Ebersohn, Susan Beltman, and Tilda Loots.	2018	Therefore, the paper does not use any specific methodology, but rather a conceptual framework to analyse the data.
Tier3	Micro	Academic resilience and its psychological and educational correlates: A construct validity approach	Martin, A. J., & Marsh, H. W.	2006	The methodology used in this paper is a construct validity approach to examine the educational and psychological correlates of academic resilience.
Tier3	Micro	'The Digital Divide and Educational Equity. A Look at Students with Very Limited Access to Electronic Devices at Home'	Moore, Raeal, Dan Vitale, and Nycole Stawinoga.	2018	The methodology used in this paper is survey research. The authors surveyed a random sample of high school students who took the ACT test as part of a national administration in April 2017
Tier3	Micro	Understanding "Zoom fatigue": Theorizing spatial dynamics as third skins in computer-mediated communication.	Nadler, R.	2020	It leverages the experience of education systems from around the world. In these times, educators and policy makers need not just look forward, but also outward. The difference between education systems that are open to the world and ready to learn from and with other experiences and those that feel threatened by being exposed to alternative ways of thinking and working is likely to be a key differentiator in the educational progress that we will see around the world. The world is indifferent to tradition and past reputations, unforgiving of frailty, and ignorant of custom or practice.
Tier3	System	Lessons for Education from Covid-19: A Policy Maker's Handbook for More Resilient Systems.	OECD	2020	N/A

Tier3	Micro and Meso	'Teachers' Digital Literacy and Digital Activity as Digital Divide Components among Basic Schools in Ghana'	Quaicoe, James Sunney, and Kai Pata.	2020	Survey
Tier3	System	Digital Network Resilience: Surprising Lessons from the Maginot Line.	Rothrock R. A.	2017	The methodology used in this paper is a quantitative research approach using a survey. The survey instrument was adopted from the UNESCO-IICBA, Teacher ICT Competency Framework, ICT-enhanced Teacher Standards for Africa -ICTeTSA, and European Union rubrics for teacher/school ICT activities
Tier3	System	'How Does Apprentice Resilience Work'. In Resilience in Education. Concepts, Contexts and Connections	Schwarze, Jennifer, and Marold Wosnitza	2018	The methodology used in this paper is theoretical and conceptual, rather than empirical, as it aims to develop a model of resilience rather than test hypotheses or collect data.
Tier3	System	Towards a Dynamic Interactive Model of Resilience	Shafi, Adeela Ahmed, and Sian Templeton.	2020	There is no mention of any specific methodology used in this chapter.
Tier3	System	Resilience, Adaptability and Transformability in Social-Ecological Systems	Walker, B., C.S. Holling, S.R. Carpenter, and A. Kinzig.	2004	The paper does not describe a specific methodology. Instead, it provides an interpretation and explanation of the concepts of resilience, adaptability, and transformability in social-ecological systems (SESs) and how they interact with each other
Tier3	Micro	Working through Covid-19: 'Zoom' gloom and 'Zoom' fatigue.	Williams, N.	2021	It only discusses the impact of the Covid-19 pandemic on the way we work and the rise in usage of video platforms for remote work.
Tier3	Meso	'A Sustainable Covid-19 Response, Recovery, and Redesign: Principles and Applications of the Triple R Framework'	Eric Zusman, Erin Kawazu, Andre Mader, Atsushi Watabe, Tomoko Takeda, So-Young Lee, Matthew Hengesbaugh, Takashi Otsuka, Rajeev Kumar Singh, Premakumara Jagath Dickella Gamaralalge, Kazunobu Onogawa, Mark Elder, Zhou Xin, Mustafa Moinuddin, Satoshi Kojima, Pankaj Kumar, Sudarmanto Budi, Nugroho, Nandakumar Janardhanan, Neil Aaron Waters, Fernando Ortiz-Moya, Junichi Fujino, Yatsuka Kataoka, Togo Uchida, Hideyuki Mori, and Yasuo Takahashi	2020	The methodology used in this paper is the Triple R Framework, which stands for Response, Recovery, and Redesign. This framework is applied to several environmental concerns such as waste, air quality, water/wastewater management, sustainable lifestyles, and ecosystem preservation.

The UNU-MERIT WORKING Paper Series

- 2024-01 *The green transformation as a new direction for techno-economic development* by Rasmus Lema and Carlota Perez
- 2024-02 *Evidence on an endogenous growth model with public R&D* by Thomas H.W. Zieseimer
- 2024-03 *Higher Educational Systems and E-resilience* by Mindel van de Laar, Julieta Marotta and Lisa de Graaf