

## Global Studies in Digital Transformation Phases in School Settings: A Bibliometric Analysis

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**ABSTRACT** New emerging technologies promoting digital transformation in areas of life, like in education are unexceptional. Digital transformation is not a simple process of transforming existing materials into digital ones but also about digitising the operations of the educational institutions. This study explores studies on digital transformation in schools (DTS) by applying bibliometric analysis to 142 Scopus-indexed documents from 2001 to 2022. The finding shows that the annual publication growth has increased rapidly in the last few years. The research community has expanded, but the cooperation of scholars is still limited. Germany, Sweden, USA, Italy and Russia have the most publications. Sustainability is the most relevant source. Six themes in DTS were investigated, including school digitalisation, educational policies, learning in the digital age, digital literacy, future school, and school leadership. Among the three phases of digital transformation, digitalisation is currently the issue that receives the most research community attention. Although COVID-19 contributes to the promotion of DTS, it is not an important factor in the research field. In addition, some suggested research directions are stakeholder roles, program development, digital education, and school library roles. The findings contribute to clarifying the field of DTS research and suggest new approaches for the research community in the coming time.

### INTRODUCTION

When it comes to transforming every aspect of an organisation, especially when a pandemic or risk appears, technology has become more important than ever. Information technology and the digitalisation process have diversified and profoundly affected all aspects of human life, leading to diverse changes not only in the attitude and behaviour of each individual when performing work. Many scientists throughout the world are now concerned with all concerns relating to technology and the digital transformation, particularly how it is changing educational institutions' activities in favour of quality, efficiency and speed.

Internet, mobile divisions, mobile applications, social networks, and artificial intelligence are achievements of information and communication technology development. They have already reshaped individual and large parts of the world's behaviour (Hanna 2016) and to some extent, promoted digital transformation in areas worldwide.

In the education sector, digital transformation can enhance the quality and relevance of learning, strengthen inclusion, and improve education administration and governance (UNESCO n.d.). Digital transformation is not only about transforming existing materials into digital ones but also about digitising the operations of the educational institution, such as, setup courses and examinations, and management of information and communication technology (ICT) equipment. The application of ICT in edu-

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cation has led to changes in ways of teaching and learning (like, blended learning, online assessment), and innovative teaching methodologies (like, gamification, adaptive learning, microlearning) (Zain 2021).

Recently, some studies have used bibliometric analysis to review issues related to digital transformation in education. These studies are interested in digital transformation in higher education. For example, Cruz-Cárdenas et al. (2020) reviewed existing knowledge on digital transformation in higher education. Díaz-García et al. (2022) studied digitalisation, and digital transformation in higher education. Abad-Segura et al. (2020) were interested in sustainable digital transformation management in higher education. Trevisan et al. (2023) explored the research area of digital transformation towards sustainability in higher education. More recently, Jimenez-Pitre et al. (2022) considered digital transformation in the education sector during the COVID-19 pandemic. However, there is almost no bibliometric review of digital transformation in general education.

### Objectives

Realising this research gap, the authors applied the bibliometric method to elucidate the knowledge base of digital transformation in schools (DTS). The research questions answered in this study are as follows:

1. What is the annual number of DTS publications from 2001 to 2022? Which countries play an important role in this research field?
2. What are the characteristics of the DTS research community from 2001 to 2022?
3. What publishing sources have the most DTS publications between 2001 and 2022? What are the topics published by the publishing sources?
4. What are the research topics about DTS from 2021 to 2022?
5. What are the current DTS research topics? What are the possible future research directions?

### Background

Scholars have approached understanding digital transformation in a rather diverse way.

Digital transformation can be understood as the application of technology to increase the effectiveness or reach of businesses significantly (Westerman et al. 2011), the application of cutting-edge digital technologies, such as social media, mobile technology, analytics, or embedded devices, to enable significant business improvements, such as improved customer experiences, simplified processes, or new business models (Fitzgerald et al. 2014), the combined effects of several digital innovations create new actors (and actor constellations), structures, practices, values, and beliefs that change, threaten, replace, or complement existing game rules within organisations, ecosystems, industries, or fields (Hinings et al. 2018), an accelerated evolution (Gama 2018), change, people, processes, strategies, structures, and competitive dynamics (Rodrigues 2017). DT should focus on modernising corporate IT architecture management in the education sector, which could help structure education innovation (Kaminskyi et al. 2018).

Digital transformation is divided into three phases, that is, digitisation, digitalisation, and digital transformation (Verhoef et al. 2019). According to this approach, **digitisation** is a fundamental phase that encodes analogue information into a digital format that computers can store, process and transmit (Loebbecke and Picot 2015). Digitalisation describes how IT or digital technologies can be used to alter existing business processes (Li et al. 2016), and digital transformation is the systems-level restructuring of economies, institutions and society that occurs through digital diffusion (Kiron and Unruh 2017).

In the school settings, digital transformation is not only related to IT infrastructure, IT platforms, digital transformation model, and digital transformation process but also the role of stakeholders (that is, students, teachers, librarians, principals, parents) and the school's educational activities. The relevant topics of each phase were detailed as follows.

**In the digitisation phase**, Bennett and Sandore (2001) were interested in digitising materials from museums, archives, and libraries in central Illinois for incorporation into elementary school social science curricula. Moreover, Evans and Savard (2008) focused on digitising collections in Canadian libraries. From a different perspective, Behrooz et al. (2014) pointed out the

role of librarians in digital libraries. Besides, Menna et al. (2017) introduced an image-based 3D reconstruction system that uses automated photogrammetric acquisitions and processing.

**Next in the digitalisation phase**, Motschnig et al. (2017) showed how well K2 and K6 students in 17 Australian schools could learn with the help of social presence and digital technologies. Høydal and Haldar (2022) try to find out what the strategy for digitising the Norwegian education system says about the values of the digital school. Salmieri (2019) researched the digital skills of Italian teachers who are being pushed to go digital by their European counterparts. Hartong (2019) focused on changing how monitoring systems are run at the state level. Daniela and Rüdolfa (2019) researched learning platform solutions to scaffold student learning in a digitalised learning process. Mynaščíková and Novotný (2020) examined the obstacles to using ICT in teaching among Czech teachers. Salmérón et al. (2021) examined tablets' impact on elementary students' reading comprehension.

**Last is digital transformation**, wherein Deryabin et al. (2021) examined Russian school principals' perceptions of the demands that stakeholders face due to the digital transformation of schools (that is, students, parents, educators and administrators). Pata et al. (2022) explored the self-evaluation factors for Estonian schools' digital maturity, such as teachers' roles, digital competencies, learning organisation culture, participatory management, and structural change issues. Dvoretzkaya et al. (2022) referred to schools as "smart" because of how they use technology. This was based on small correlations between expert evaluation scale scores and indicators of the digital environment. Kalogeratos and Pierrakeas (2022) looked into the role of Greek primary school principals and how their ICT skills and knowledge affected learning organisations in the context of digital transformation.

## METHODOLOGY

To conduct this paper, the bibliometric method was chosen because this method is common at higher education level, for example, digitalisation and digital transformation in higher education (Díaz-García et al. 2022), digital transformation towards sustainability in higher education

(Trevisan et al. 2023), and sustainable management of digital transformation in higher education (Abad-Segura et al. 2020).

Among academic sources, the researchers selected Scopus as a gathering database. There are two reasons for this choice, that is, it is the largest multidisciplinary database of social science research literature (Donthu et al. 2020), and the second one is the accessibility of the author.

To select eligibility documents, the researchers follow the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) (Moher et al. 2009), which was applied in different fields, like tourism, hospitality, and education sector (Pham et al. 2021). Figure 1 describes the steps of the data-gathering process. First, in the identification phase, the initial dataset was obtained. Based on the scope of the topic, statistics at the research time, that is at 2300 hours on January 08, 2023, there were 1,442 documents satisfying two conditions, that is, the title/abstract/keywords contain at least one keyword of *digitisation*, *digitalisation*, *digital transformation*, and that the title/abstract/keywords include the keyword of *school*. Second, in the screening phase, the initial dataset was narrowed following the criteria set:

- ◆ Publication stage limitation: Final
- ◆ Document type limitation: Article, Conference paper, Book, Book chapter
- ◆ Subject area limitation: Social sciences
- ◆ Language limitation: English
- ◆ Published year exclusion: 2023

At the end of this phase, the screening dataset consisted of 547 documents. Last, in the eligibility phase, each document in the screening dataset met the requirements for eligibility. A document was removed when the title and abstract are unrelated to educational issues and the digital transformation phase in school, for example, Burrell (2007), McMullen (2007). The eligibility dataset has 143 documents left.

Due to the answer RQs, the researchers used descriptive statistics and science mapping. Based on the number of publications, the statistical results have shown the publishing trend of the research field, the countries, the authors, and the publishing sources with the most publications. Besides, the most important documents are identified based on the citation index. On the other hand, co-author analysis was examined to

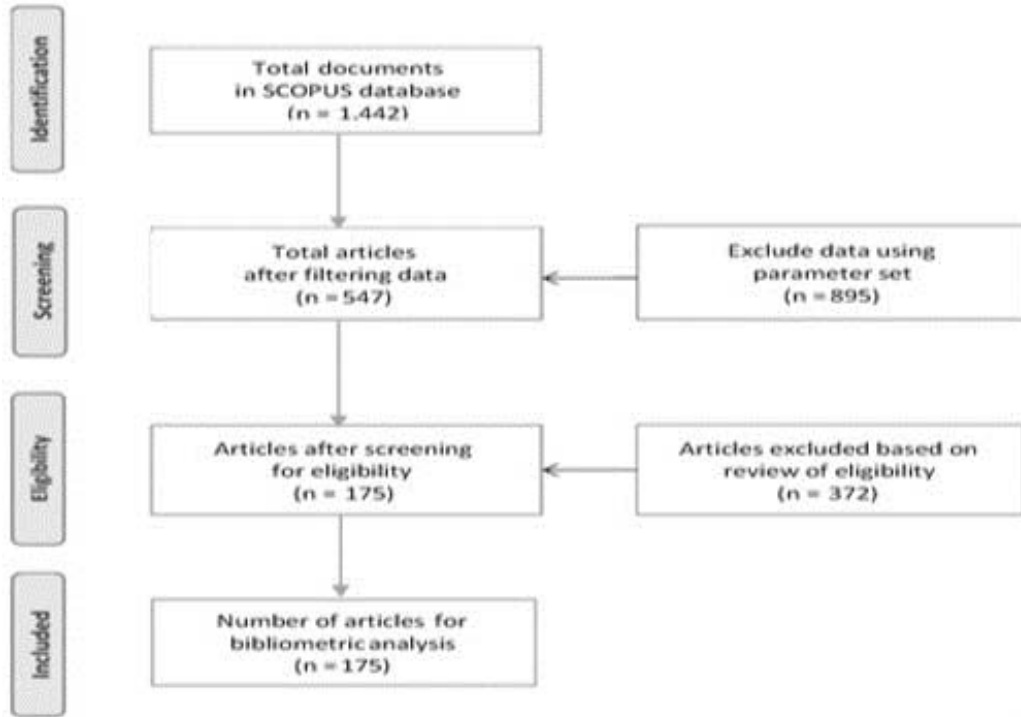


Fig. 1. Data gathering process follows PRISMA guidelines

depict the characteristics of the research community and countries' collaboration. This was followed by co-word analysis to explore topics and bibliographic coupling analyses to investigate research themes. Data visualisation and analysis were supported by VOS viewer (<https://www.vosviewer.com/>) and Microsoft Excel.

## RESULTS

### What is the annual number of DTS publications from 2001 to 2022? Which countries play an important role in this research field?

From 2001 to 2022, 142 documents related to DTS were indexed in the Scopus database. The majority of document types is articles (89 documents or 62.68%), followed by conference papers (21, 14.79%), book chapters (22, 15.49%), and books (10, 7.04%).

An upward trend over time can be seen based on the number of annual publications. Table 1 shows 23 documents from 2001 to 2017 (16.08% of the total) in the yearly document less than five, except in 2016 with seven. From 2018 to 2019, there were 25 documents (17.48%), with an annual number of more than ten documents. From 2020 to 2022, there were 94 documents (65.74%), yearly of more than 20. Along with the general growth trend, funded research has also increased over recent years, and the proportion is 22.38 percent, corresponding to 32 publications.

Research cooperation among 47 countries in the field of DTS study for the period from 2001 to 2022 is depicted in Figure 2, which was visualised by co-author analysis. Of the 20 independently studied countries, Norway and Finland had the most prominent studies, with eight papers. The remaining 27 countries are divided into three clusters. The first cluster consists of 18 countries, with the centre in Europe. The coun-

Table 1: The annual publication in the knowledge base of DTS from 2001 to 2022

Year	2001	2003	2005	2006	2007	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
No fund	1	2	1	1	1	1	1	1	1	1	1	1	7	1	10	11	18	30	20
Funded															2	2	5	10	11

tries with the most publications are Germany (14 documents), Sweden (14), the USA (13), and Italy (11). The second cluster consists of 7 countries centred on countries in Asia, with the Russian Federation having the most publications (11), followed by China (5) and Indonesia (5). The third cluster comprises two countries, namely, Japan (3) and Vietnam (1).

The cooperation between countries is at a low level. The frequency of cooperation between countries is mostly one time, corresponding to one publication. Regular collaboration occurred between the USA and the United Kingdom (3 documents) and the USA and Australia (3). These countries are also the first countries in the field of study. However, when looking at the role of countries in each cluster, Germany, Italy and China are at the centre of the cooperation network. Emerging countries (yellow nodes in Fig. 3) in DTS tend to cooperate with Spain (for example, Honduras, Morocco), Poland (for example, Serbia, Kazakhstan) and China (for example, India, Greek, Turkey).

**What are the characteristics of the DTS research community from 2001 to 2022?**

The ten authors with the most publications in the field of DTS research for the period from 2001 to 2022 are listed in Table 2. They researched diverse areas, like education, science, information technology, humanities and social sciences. The first place in Table 1 is Łukasz Tomczyk with three papers, and the following positions are Marián Kireš (3), Dušan Šveda (3), Fanny Pettersson (2), Thomas Hillman (2), and Sigrid Hartong (2).

The community of 370 DTS researchers from 2001 to 2022 is shown in Figure 3. The data show that the research community was mainly independent authors and small research groups. There were 131 authors/author groups, including 31 independent authors, 31 two-author groups, 28 three-author groups, 16 four-author groups, 17 groups of 5-8 authors, and 17 authors at most. Based on colour, the majority of the community has emerged in recent years and is mainly composed of independent authors and small research groups. The authors in Table 1 play a role as a centre in the research groups,

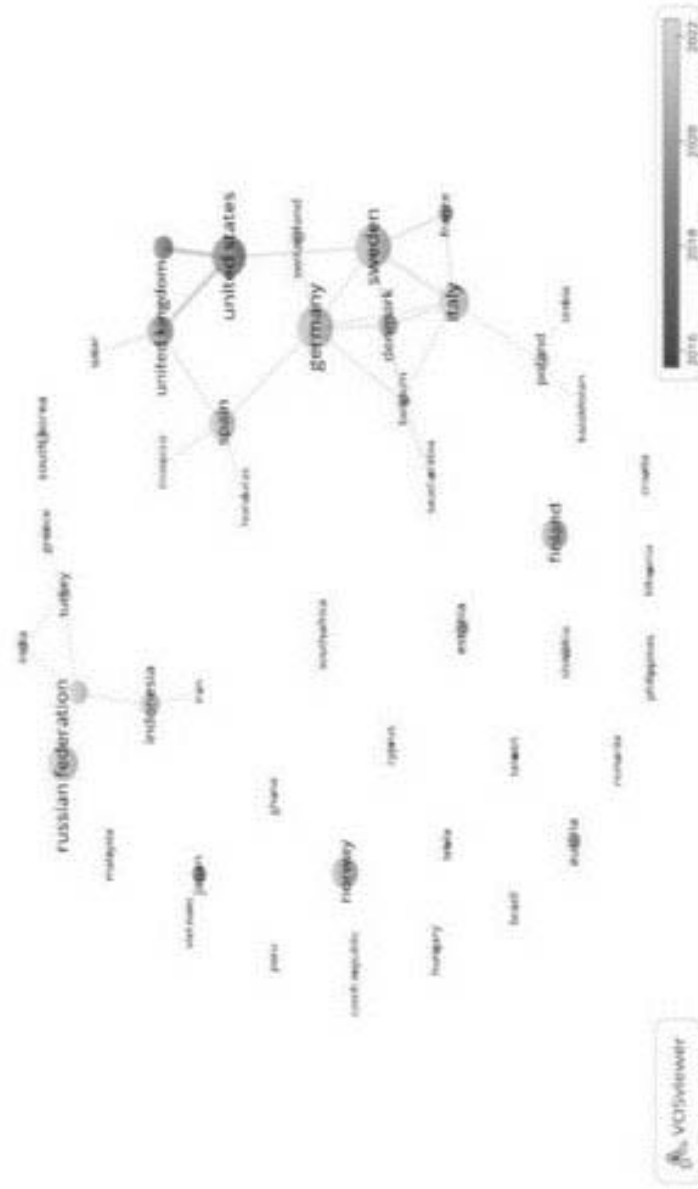


Fig. 2. Collaboration of 47 countries in the Knowledge base of DTS from 2001 to 2022  
Source: Authors

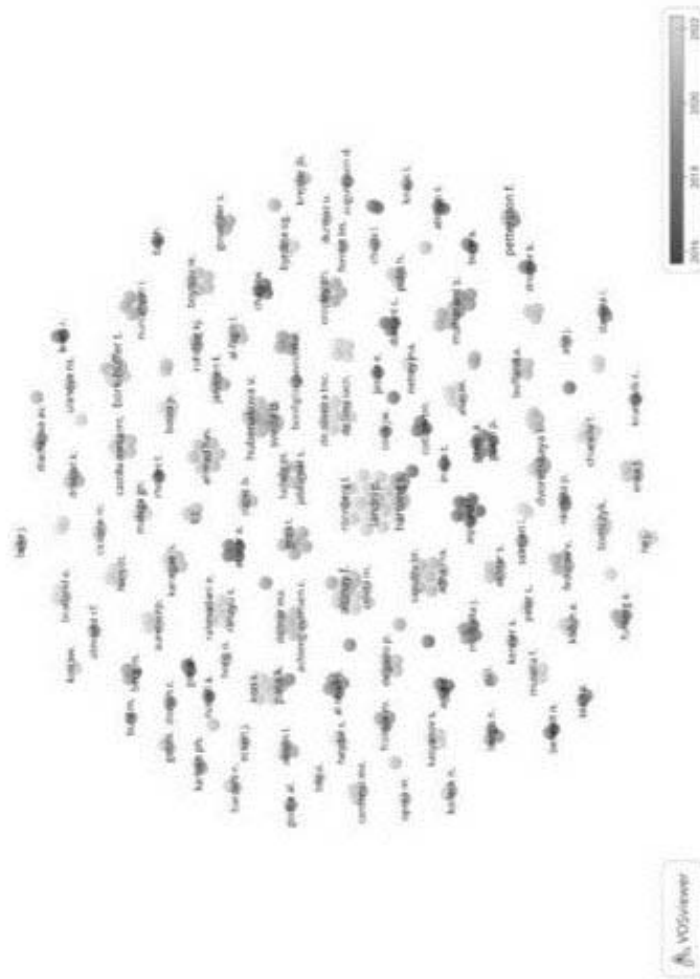


Fig. 3. Research community of DTS between 2001 and 2022  
Source: Authors

**Table 2: Top 10 authors in DTS based on the number of documents**

S. No	Author	Affiliation	Documents	Citations	Years
1	Łukasz Tomczyk	Institute of Pedagogy, Jagiellonian University, Poland	3	32	2017-2022
2	Marián Kireš	Faculty of Science, Pavol Jozef Šafárik University in Košice, Slovakia	3	3	2020-2021
3	Dušan Šveda	Faculty of Science, Pavol Jozef Šafárik University in Košice, Slovakia	3	3	2020-2021
4	Fanny Pettersson	Department of Education, Umeå University, Sweden	2	49	2019-2021
5	Thomas Hillman	Department of Applied Information Technology, University of Gothenburg, Sweden	2	26	2016-2022
6	Sigríd Hartong	Faculty of Humanities and Social Sciences, Helmut-Schmidt-University Hamburg, Germany	2	25	2019-2022
7	Paolo Landri	Institute of Research on Population and Social Policies, National Research Council, Italy	2	17	2021-2022
8	Swasti Maharani	Mathematics Education, Universitas PGRI Madiun, Indonesia	2	15	2019-2020
9	Tabea Bork-Hüffer	Institute of Geography, University of Innsbruck, Austria	2	12	2020-2022
10	Belinda Mahlknicht	Institute of Geography, University of Innsbruck, Austria	2	12	2020-2023

Source: Authors

and their groups always have new scientists, for example, Tomczyk, Hartong, and Kires.

### What Publishing Sources Have the Most DTS Publications between 2001 and 2022? What Are the Topics Published by the Publishing Sources?

During 2001 to 2022, 111 sources published 143 documents related to DTS. Table 3 lists the

top 10 sources ordered by the number of documents. Topping the list is Sustainability with nine, then Education and Information Technologies (6), and Educational Governance Research (4). These sources published 37 documents, comprising 21.14 percent of the total. Most published sources are journals, except Proceedings of the European Conference on E-Learning, which is of the Conferences format. According to published years, these sources began to pub-

**Table 3: Top 10 sources in DTS based on the number of documents**

S.No.	Source	Type	Scope	Documents	Citations (Ranking)	Years
1	Sustainability	Journal	Multidiscipline	10	88 (2)	2018-2022
2	Education and Information Technologies	Journal	ICT in Education	7	61 (3)	2017-2022
3	Educational Governance Research	Journal	Educational Governance	4	5(29)	2021-2021
4	International Journal of Emerging Technologies in Learning	Journal	Educational Technology	3	48 (4)	2020-2020
5	Learning, Media and Technology	Journal	Educational Technology	3	45 (5)	2014-2020
6	Proceedings of the European Conference on E-Learning	Conferences	E-Learning	3	8(21)	2016-2019
7	Lecture Notes in Educational Technology	Journal	Educational Technology	3	6(28)	2016-2022
8	European Educational Research Journal	Journal	Educational Research	2	40 (6)	2018-2022
9	Media and communication	Journal	Communication	2	39 (7)	2019-2019
10	International Journal of Information and Learning Technology	Journal	ICT in Education	2	20 (8)	2019-2020

Source: Authors



lish DTS publications in recent years. Based on the scope, most sources are related to education issues, that is, ICT in education, educational technology, e-learning, educational research, and educational governance.

### **What Are the Research Topics about DTS from 2021 to 2022?**

Research topics in DTS from 2001 to 2022 are illustrated in Figure 4, which was rendered by bibliographic coupling analysis. The data shows that 50 documents are clustered in 6 colours, corresponding to 6 research topics. The first theme is school digitalisation (red cluster), for example assessment of digitalisation in primary and secondary schools (Buffardi et al. 2021), enhancing the digital learning experience (Matter et al. 2020), and schools overcoming the digital divide (Drossel et al. 2020).

Second is educational policies and school governance (green cluster), for example, emergency digitalisation of European education in COVID-19 (Cone et al. 2022), Swedish educational policy development in digital education (Gu and Lindberg 2021), and governance through digital formations in Norwegian education context (Lunde and Gunnulfsen 2021).

Third is learning in the digital age (blue cluster), for example, teaching Math from a distance (Barlovits et al. 2021), barriers to using ICT in Czech (Mynaøiková and Novotný 2020), and learning languages in the digital age (Gee and Hayes 2011).

Fourth is digital literacy (orange cluster), for example, media and information literacies (Drotner and Kobbernagel 2014), digital competencies of teachers (Ko•uh et al. 2021), and use of logic and mathematics through digital literacy of elementary school students (Nogueira et al. 2022).

Fifth is future schools (violet cluster), for example, the socioemotional effects of school computers and draws lessons for sustainable education in the e-learning era (Ahn 2020), digitalisation of education through paradoxes of societal participation, paradoxes of participatory pedagogics, and paradoxical politics of participation (Mertala 2020), and four qualitatively different future images of technology in future schools (Nikula et al. 2020).

Sixth is school leadership (yellow cluster) had relevant issues wherein school leaders understand digitalisation and the digital competencies needed in leading for digitalisation in Swedish schools (Håkansson Lindqvist and Pettersson 2019), perspectives and experiences of teachers regarding their school principal's digital leadership roles and technology capabilities during the COVID-19 pandemic (Karakose et al. 2021), and support Swedish teachers to meet the curriculum requirements for digitalisation (Leino Lindell 2020).

The ten DTS documents with the most citations from 2001 to 2022 are listed in Table 4. Topping the list is a book-type document from Gee and Hayes (2011) with 273 citations. Only the study by Liu et al. (2020) in the list is funded by the Guangxi Natural Science Foundation of China. Two documents are not shown in Figure 4, namely, Tuomi et al. (2018) and Greenhow, Sonnevend and Agur (2016). These documents are related to 5-6 themes described above, and the theme that was not mentioned is school digitalisation.

### **What Are The Current DTS Research Topics? What Are the Possible Future Research Directions?**

The science mapping of 477 keywords is shown in Figure 5, in which a cluster of 345 keywords with co-word relationships is in the centre of the Figure. As for 'digitisation', this keyword has no direct association with both digitalisation and digital transformation. Traditional keywords include literacy training, applications, smartphone, digital teaching and learning, digital space. In contrast, new keywords related to digitisation are digital education governance, mathematics education, distance learning, and COVID-19. Considering each phase of digital transformation, the topics are defined as follows.

Regarding digitalisation, there is a direct relation to the keyword 'digital transformation'. Among 72 related keywords, traditional keywords include ICT, digital technology, school leadership, digital communication, design of distance interaction, education policy, challenge, digital literacy, digital tools, digital media, curriculum requirements, ethnocultural education, and school development. Besides, emerging

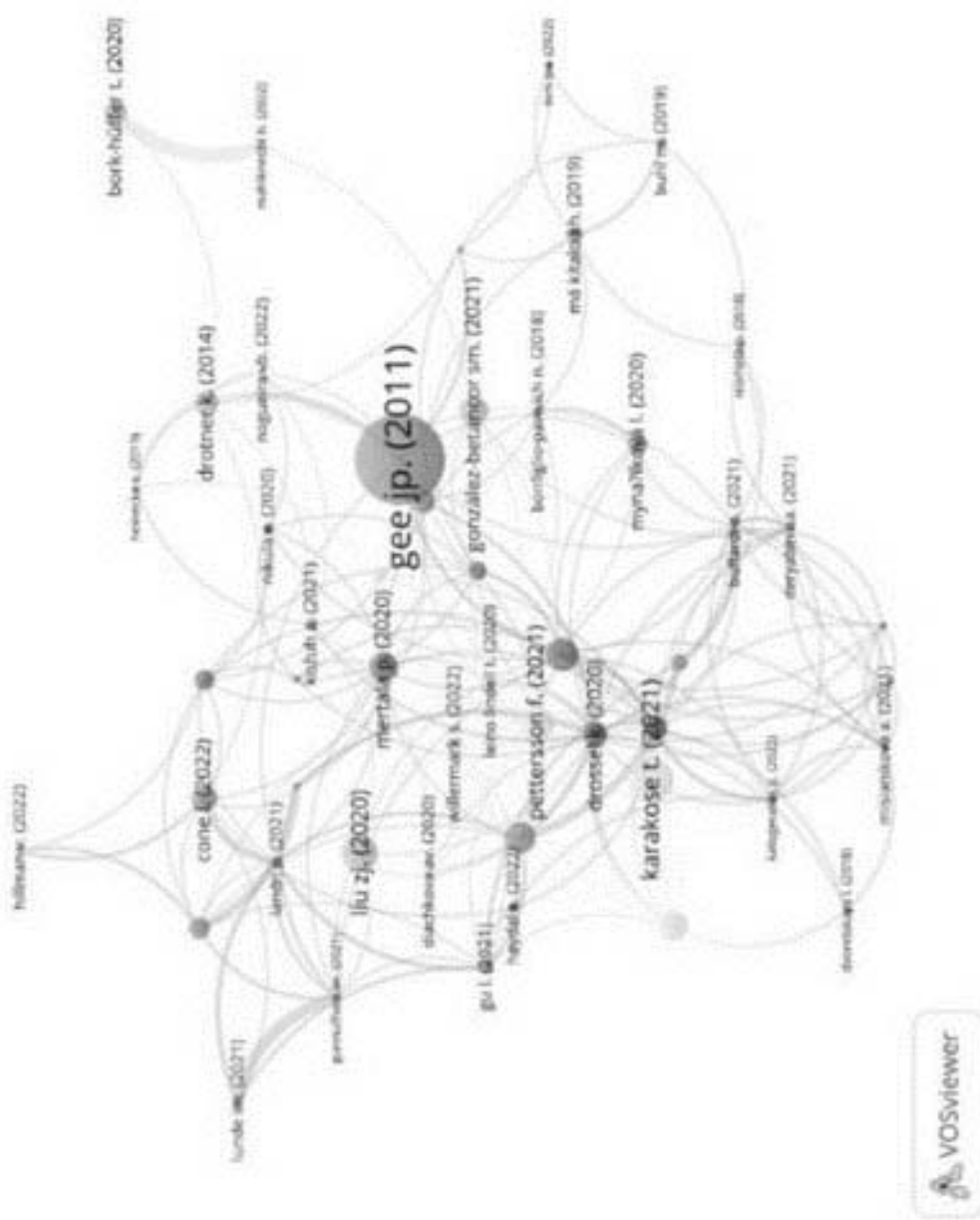


Fig. 4. Science mapping of 50 documents in DTS based on the bibliographic coupling analysis (each document has at least two citations)  
Source: Authors

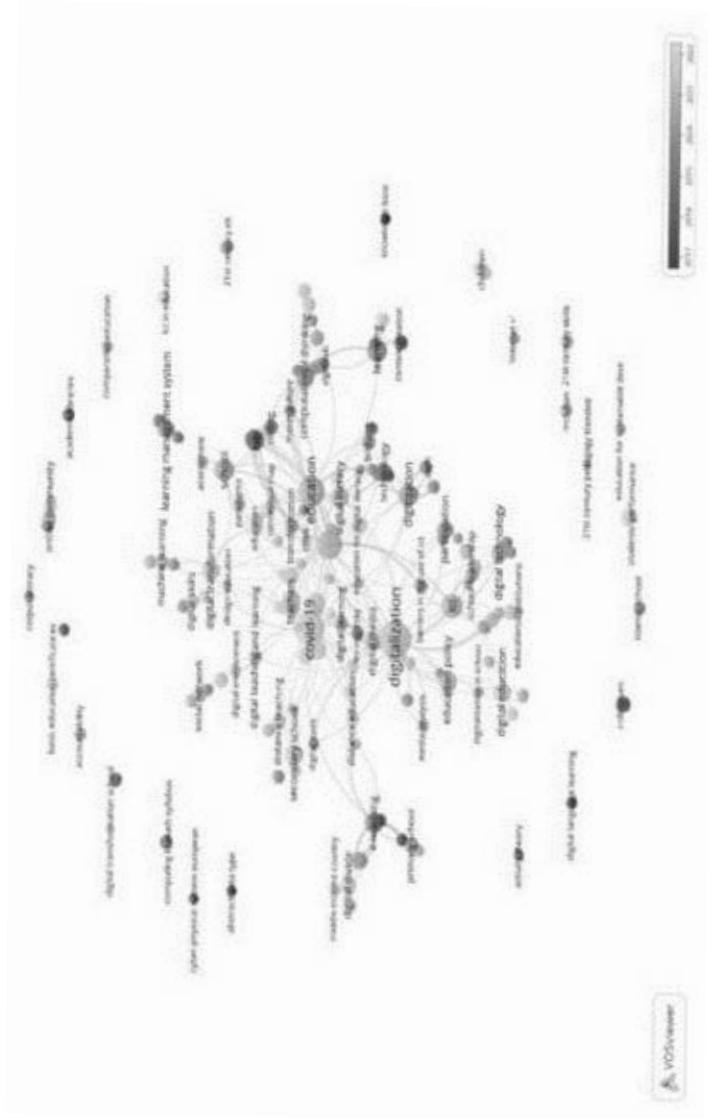


Fig. 5. Science mapping of 477 keywords in DTS based on the co-occurrence analysis  
Source: Authors

**Table 4: Top 10 documents in DTS based on the number of citations**

<i>ID</i>	<i>Document</i>	<i>Type</i>	<i>Theme</i>	<i>Citations</i>
1	Gee and Hayes (2011)	Book	Learning in the digital age	273
2	Karakose, Polat and Papadakis (2021)	Article	School leadership	56
3	Liu et al. (2020) (*)	Article	Digital literacy	31
4	Pettersson (2021)	Article	School leadership	30
5	Tuomi et al. (2018)	Article	NA	26
6	Godhe (2019)	Article	Future school	26
7	Saari and Sääntti (2018)	Article	Educational polycies and school gornverence	25
8	Mertala (2020)	Article	Future school	20
9	Greenhow, Sonnevend and Agur (2016)	Book	NA	19
10	Håkansson, Lindqvist and Pettersson (2019)	Article	School leadership	19

*Note:* \* funded document, NA: not available

*Source:* Authors

keywords are education for digital competence, curriculum research, curriculum analysis, post-digital philosophy, Germany, Twitter, social network analysis, natural language processing, distance education, electronic culture environment, behaviour, parents, and COVID-19.

Finally, digital transformation, with 19 related keywords, traditional keywords are digital skills, media literacy, machine learning, and digital competence. On the other hand, related new keywords are digital shift, learning organisation, parents, and COVID-19.

In Figure 5, keywords play an important role in linking all three keywords of digitisation, digitalisation, and digital transformation. Topics related to these keywords include digital skills/digital competence, distance education issues (distance learning, distance teaching, distance education, online learning, e-learning), learning organisation (digital leadership digital shift, social values, boundary spanning, learning space, electronic culture environment), and policy issues (policy change, education policy).

In addition, some topics are not directly related to digitisation, digitalisation, or digital transformation. Main keywords are curriculum, education policy, digitalisation in school, technological learning, game-based learning, libraries, digital divide, academic performance, digitalisation of the classroom, digital teaching and learning, digital environment, social network, 21<sup>st</sup>-century skills, LMS and learning platforms, accessibility, digital safety, educational quality.

From another perspective, topics related to DTS-related actors are also interesting. The key-

words related to students are digitalisation, digital transformation, digital competence, curriculum, and digital space, and the keywords related to teachers are digital competence, digital teaching and learning, curriculum, digital leadership, and COVID-19. As for schools, related keywords are digital maturity, challenge, digitalisation, digital transformation, digital competence, COVID-19, ICT, digital tools, and barriers. The keywords related to students' families are digitalisation, digital transformation, digital competence, parental involvement, and parent-teacher-school.

## DISCUSSION

The rise of applied science and technology in education, in general, and of digital transformation in schools, specifically, is an unavoidable process. Over the past 20 years, digital transformation has occurred at all levels and across all challenges. It can take both passive and active forms. To explore the field of DTS, the bibliometric method was applied to a dataset of 142 documents collected from Scopus from 2001 to 2022. From the new results presented above, the detailed contents are discussed below.

In the trend of rapid growth of the DTS field in recent years, there were some specific research topics in some periods. In the period 2001-2017, the documents are interested in digitisation literacy, barriers to teaching e-learning in primary schools, and exploring the application of information technology in teaching. The topics, educational policy, digital literacy, digital competence, and digital educational environ-

ment, were initially interesting in 2018 and 2019. From 2020 to 2022 (as of January 08, 2023), the issues of the previous period have been continued and extended. The explosion of technology, digital communication platforms, open-source content, and social networking is considered a new approach to Digital Learning Environments (Veletsianos 2016). In addition, with the impact of COVID-19, educational activities have shifted from traditional to online learning urgently (Bond 2021) and without prior preparation (Daniel 2020). This leads to many practical issues that need to be studied and attracted the research community's attention.

The research community has grown strongly in recent years, along with annual publication growth. In general, the community is mainly researchers or small research groups. In addition, the number of publications by leading scientists is still small, leading to limited research cooperation in the community. When looking at cooperation by country, the situation was similar, cooperation between countries was fragmented. It is interesting to note that two clusters of countries have collaborated on research. With a group of countries in Europe and America, DTS studies started in the USA and gradually connected with other countries in Europe, and now Germany, Sweden, Italy, and Spain are active countries in the research on DTS. Next is the cluster of countries in Asia, which has appeared in recent times, with China, India, and Russia centred. The clustering between the two groups can be considered between various aspects, for example, economics (Park et al. 2021), education policy and practice (Veletsianos 2016), and the- orising teaching and learning (Lee 2017).

According to Google, education transformation is a research field that includes many elements of vision, learning, culture, technology, professional development, funding and sustainability, and community engagement (Alenezi 2021). Therefore, it is possible to consider different approaches to DTS by different subjects in the research field. Six themes of DTS were evaluated, including school digitalisation, educational policies, learning in the digital age, digital literacy, future school, and school leadership. Based on authors' affiliations, authors came in from diverse disciplines, for example, education, pedagogy, science, information technolo-

gy, humanity and social sciences, and social policies. Based on the scopes sources, they are interested in ICT in education, governance, educational technology, e-learning, educational research, and communication. Regardless of the different approaches, information and communication technology is the foundation for the digital transformation process (Hanna 2016).

In the steps of DTS, digitisation is independent of both digitalisation and digital transformation. This can be considered between two different approaches. Digitisation in DTS is related to digitised technology, digitised literacy, digitised resources and digital education governance, and these topics are often spatially limited. While digitalisation and digital transformation take a broader approach, ICT enabled transformation (Hanna 2016). The application of ICT helps schools form an open learning environment with the support of digital learning platforms. At the same time, it requires not only the adjustment of programs, policies, learning methods and forms of learning but also the adjustment of the roles of the stakeholders. During the DTS process, based on the frequency of keywords appearing, the research community focuses on the digitisation phase. The studies of this stage also show very clearly how simple the problem of digitisation is, that the level of problems related to it is mainly components of infrastructure or basic conditions, besides the remarkable point of this stage when there are many problems of digitisation that need to be established, not only about the components of digitisation themselves but also the relevance to which the components carry social elements.

As in other areas of research, the COVID-19 pandemic also affects DTS (Jimenez-Pitre et al. 2022). On the one hand, it disrupts the learning process, while on the other hand, it promotes the DTS process, even though it is only seen as an emergency remote education and related issues (Bond 2021). This is not enough to guide the whole field of research. Because during the COVID-19 pandemic, many other research documents have been still published, for example, curriculum, school leadership, school development, digital communication, digital skills, and involvement of parents and students. The fluctuation of the epidemic has accelerated extremely quickly, even exploding the need to digitise

and forcing many aspects of the socio-economic system to digitise. This leads to complexity due to the participation of components and fields that are not very technical or not technical at all but are forced to digitise to adapt to the new normal.

In the field of DTS research in the period from 2001 to 2022, apart from the research topics, if we analyze the contents of the research authors, we can see that digitization has become a national education policy issue (Salmieri 2019), the future of the whole national education system (Høydal and Haldar 2022), tablets will likely be every student's learning tool (Salmerón et al. 2021), modes of school innovation will depend on numbers (Pât et al. 2022), or be useful for education in remote areas (Nogueria 2022), and measuring progress in education (Dvoretzkaya et al. 2022), many topics that appeared do not directly link with the keyword digitisation, digitalisation and digital transformation. This case suggests future research directions. The first is the relationship between the parties involved in the DTS process. Besides, students' digital competence has a direct relationship with digitalisation and digital transformation, while other research topics have not been explored. The second is to develop a program suitable for the digital learning environment, although there is a link between curriculum requirements, curriculum analysis and digitalisation. The third is digital education in DTS in general and digital education in digitalisation and/or digital transformation. Four is the role of the school library in the DTS process, for example, space, services, safety, and sanitisation, as followed by Dobreva and Anghelescu (2022). In addition, learning management systems are not yet considered a component of DTS. Some other topics that can be studied in the near future include digital safety, well-being, educational quality, educational equity, 21<sup>st</sup>-century skills, and online community in DTS. Digital transformation has marked a fairly complete level of development, which is not only reflected in the responsiveness of digital transformation in all aspects of society, promoting rapid development in fields, but more importantly, creating a driving force for labour productivity. Besides, there are national education systems that, as studies have shown, are

already contributing to digital transformation education, and participatory education will be the foundation for other sectors to participate.

Finally, this study has some limitations. The first is that the analytical data are collected from a single source, resulting in the analysis results not fully reflecting the field of DTS research. Next is the limitation in analytical methods, statistical descriptive and science mapping analysis, so the content of the studies has not been described in detail. To address these limitations, further studies may add data collection sources, for example, Web of Sciences, Lens, Google Scholar, and/or combine them with content analysis or systematic review.

## CONCLUSION

In an effort to clarify the field of DTS research, the authors applied bibliometric analysis to review 142 Scopus-indexed documents. The content of this document is related to digital transformation in schools. The results of the analysis of documents in the period 2001-2022 show that the annual publication growth trend has increased rapidly in recent years. This led to an expanded research community and limited research collaboration among scientists during this period. Germany, Sweden, USA, Italy and Russia have the most publications. Sustainability is the most relevant source. Six themes in DTS were evaluated, that is, school digitalisation, educational policies, learning in the digital age, digital literacy, future school, and school leadership. Among the three phases of digital transformation, digitalisation is attracting much attention from the research community. Although COVID-19 contributes to the promotion of DTS, it is not an important factor in the research field. Some suggested research directions include stakeholder roles, program development, digital education, and school library role.

The stages of digital transformation also reflect the process of changing socio-economic fields on which digital transformation is becoming the foundation, and more meaningfully, this process has raised human awareness of ways of interaction, working methods, and tools and contribute to redefining the value of work and the contributions of individuals and organisations, including school organisations, in many aspects.

The most important thing is that no matter how much digital transformation in general and digital transformation in schools develops, the role of people and the mechanisms and systems that ensure the school's operation need to be compatible. Human activities and operations still play a decisive role. This not only shows the aspects of humanity and human development, but at the same time, the human role also ensures digital safety and digital security, related to the risks that digital transformation can bring. On the other hand, because the data system on the one hand brings convenience to time, quality, and efficiency in school operation, if there is no regulation to ensure safety, the data can become a target or information for malicious purposes.

Although this study has some limitations, it provides an overview of the research area. Therefore, this can be a reference source to support the research community in identifying research topics while supporting educational policymakers in planning digital transformation strategies in high schools.

### RECOMMENDATIONS

Despite the fact that this tendency has been growing recently, investigations that examine the in-depth information contained in these studies as well as the factors influencing them are still required for both sponsored and unfunded research. Because digital transformation in schools should be viewed as a global issue, it is also vital to determine the causes of and strategies for fostering collaboration across nations with various levels of development.

There is a need for studies on aspects of digital transformation in the current school environment, that is, studies in the direction of detail and in-depth study of infrastructure issues and accompanying conditions of digitalisation and transformation (software, equipment, tools, facilities, etc.). In addition, there should also be studies in the direction of determining the change in relationships between people, the internal organisation of the school, and the school organisation with related organisations when applying digital transformation. It is more urgent to conduct studies on both the positive and negative impacts of digital transformation on all aspects of school operations. In addition

to the above research directions, it is also necessary to have multidisciplinary, interdisciplinary, and comparative studies between countries or regions to address the current number of school transformation issues.

### CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

### REFERENCES

- Abad-Segura E, González-Zamar MD, Infante-Moro JC, Ruipérez García G 2020. Sustainable management of digital transformation in higher education. *Global Research Trends- Sustainability*, 12(5): 2107. <https://doi.org/10.3390/su12052107>
- Ahn J 2020. Unequal loneliness in the digitalized classroom: Two loneliness effects of school computers and lessons for sustainable education in the e-learning era. *Sustainability*, 12(19): 7889. <https://doi.org/10.3390/su12197889>
- Alenezi M 2021. Deep dive into digital transformation in higher education institutions. *Education Sciences*. <https://doi.org/10.3390/educsci11120770>
- Barlovits S, Jablonski S, Lázaro C, Ludwig M, Recio T 2021. Teaching from a distance-Math lessons during COVID-19 in Germany and Spain. *Education Sciences*, 11(8): 406. <https://doi.org/10.3390/educsci11080406>
- Behrooz R, Nader N, Rasuli B, Naghshineh N 2014. Digital library education in Iran: Perspectives of Library and Information Science educators and academic librarians. *Malaysian Journal of Library and Information Science*, 19(3): 51-65.
- Bennett N, Sandore B 2001. The IMLS digital cultural heritage community project: A case study of tools for effective project management and collaboration. *First Monday*. <https://doi.org/10.5210/fm.v6i7.872>
- Bond M 2021. Schools and emergency remote education during the COVID-19 pandemic: A living rapid systematic review. *Asian Journal of Distance Education*, 15(2): 191-247.
- Buffardi A, Taddeo G, Calzone S, Mazza C 2021. What do Italian students and teachers ask about digital? Data and reflections from schools participating in national operational programs. *Italian Journal of Sociology of Education*, 13(1): 95-133. <https://doi.org/10.14658/PUPJ-IJSE-2021-1-5>
- Burrell MD 2007. Gulf Coast Community College'Memory Project. *Community and Junior College Libraries*, 13(4): 41-47. [https://doi.org/10.1300/J107v13n04\\_07](https://doi.org/10.1300/J107v13n04_07)
- Cone L, Brøgger K, Berghmans M, Decuypere M et al. 2022. Pandemic Acceleration: Covid-19 and the emergency digitalization of European education. *European Educational Research Journal*, 21(5): 845-868. <https://doi.org/10.1177/1474904121104179>
- Cruz-Cárdenas J, Ramos-Galarza C, Guadalupe-Lanas J, Palacio-Fierro A, Galarraga-Daniel SJ 2020. Education

- and the COVID-19 pandemic. *Prospects*, 49(1): 91-96. <https://doi.org/10.1007/s11125-020-09464-3>
- Daniela L, Rüdolf A 2019. Learning platforms: How to make the right choice. Didactics of smart pedagogy. *Smart Pedagogy for Technology Enhanced Learning*, 191-209. [https://doi.org/10.1007/978-3-030-01551-0\\_10](https://doi.org/10.1007/978-3-030-01551-0_10)
- Deryabin A, Boytsov I, Popov A, Rabinovich P, Zavedensky K 2021. Russian school principals' beliefs about digital competences of educational process' participants. *Voprosy obrazovaniya/Educational Studies Moscow*, (3): 212-236. <https://doi.org/10.17323/1814-9545-2021-3-212-236>
- Diaz-García V, Montero-Navarro A, Rodríguez-Sánchez JL, Gallego-Losada R 2022. Digitalization and digital transformation in higher education: A bibliometric analysis. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.1081595>
- Dobrev M, Anghelescu H 2022. Libraries and COVID-19: Opportunities for innovation. *IFLA Journal*, 48(1): 3-8. <https://doi.org/10.1177/03400352221077748>
- Donthu N, Kumar S, Pattnaik D 2020. Forty-five years of journal of business research: A bibliometric analysis. *Journal of Business Research*, 109: 1-14. <https://doi.org/10.1016/j.jbusres.2019.10.039>
- Drossel K, Eickelmann B, Vennemann M 2020. Schools overcoming the digital divide: In depth analyses towards organizational resilience in the computer and information literacy domain. *Large-Scale Assessments in Education*, 8(1): 1-19. <https://doi.org/10.1186/s40536-020-00087-w>
- Drotner K, Kobbernagel C 2014. Toppling hierarchies? Media and information literacies, ethnicity, and performative media practices. *Learning, Media and Technology*, 39(4): 409-428. <https://doi.org/10.1080/17439884.2014.964255>
- Dvoretzkaya I, Uvarov A, Kochak E 2022. The Smart Education Progress Measurement: Can field experts' opinions help? In: *Resilience and Future of Smart Learning: Proceedings of 2022 International Conference on Smart Learning Environments*. Singapore: Springer Nature Singapore, pp. 223-232. [https://doi.org/10.1007/978-981-19-5967-7\\_24](https://doi.org/10.1007/978-981-19-5967-7_24)
- Evans G, Savard R 2008. Canadian libraries on the agenda: Their accomplishments and directions. *IFLA Journal*, 34(2): 127-159. <https://doi.org/10.1177/0340035208092173>
- Fitzgerald M, Kruschwitz N, Bonnet D, Welch M 2014. Embracing digital technology: A new strategic imperative. *MIT Sloan Management Review*, 55(2): 1.
- Gama JAP 2018. Intelligent educational dual architecture for University digital transformation. In: *2018 IEEE Frontiers in Education Conference (FIE)*, IEEE, pp. 1-9. <https://doi.org/10.1109/FIE.2018.8658844>
- Gu L, Lindberg OJ 2021. Understanding Swedish Educational Policy Developments in the Field of Digital Education. In: JB Krejsler, L Moos (Eds.): *What Works in Nordic School Policies? Educational Governance Research*. Vol 15. Springer, Cham, pp. 213-233. [https://doi.org/10.1007/978-3-030-66629-3\\_11](https://doi.org/10.1007/978-3-030-66629-3_11)
- Häkansson Lindqvist M, Pettersson F 2019. Digitalization and school leadership: on the complexity of leading for digitalization in school. *The International Journal of Information and Learning Technology*, 36(3): 218-230. <https://doi.org/10.1108/IJILT-11-2018-0126>
- Hanna NK 2016. *Mastering Digital Transformation-Innovation, Technology, and Education for Growth*. Bingley, UK: Emerald Publishing.
- Hartong S 2019. The transformation of state monitoring systems in Germany and the US: Relating the datafication and digitalization of education to the Global Education Industry. In: M Parreira do Amaral, G Steiner-Khamsi, C Thompson (Eds.): *Researching the Global Education Industry: Commodification, the Market and Business Involvement*. Cham: Springer International Publishing, pp. 157-180. [https://doi.org/10.1007/978-3-030-04236-3\\_8](https://doi.org/10.1007/978-3-030-04236-3_8)
- Hinings B, Gegenhuber T, Greenwood R 2018. Digital innovation and transformation: An institutional perspective. *Information and Organization*, 28(1): 52-61. <https://doi.org/10.1016/j.infoandorg.2018.02.004>
- Høydal ØS, Haldar M 2022. A tale of the digital future: Analyzing the digitalization of the Norwegian education system. *Critical Policy Studies*, 16(4): 460-477. <https://doi.org/10.1080/19460171.2021.1982397>
- Jimenez-Pitre I, Molina-Bolivar G, Pitre RG 2022. Digital transformation in the education sector due to the impact of Covid-19. *Journal of Language and Linguistic Studies*, 18(3): 75-87.
- Kalogeratos G, Pierrakeas C 2022. Knowledge and skills of the digital transformation of the Greek public school in the post covid era. In: *2022 13th International Conference on Information, Intelligence, Systems and Applications (IISA)*, IEEE, pp. 1-7. <https://doi.org/10.1109/IISA56318.2022.9904416>
- Kaminskyi OY, Yereshko YO, Kyrchenko SO 2018. Digital transformation of university education in Ukraine: trajectories of development in the conditions of new technological and economic order. *²ôîðîäö³éí³ ðàôîñëâ³ç³ çàñîðèð èàà-àñü*, [Information Technologies and Learning Tools], 64(2): 128-137. <https://doi.org/10.33407/itlt.v64i2.2083>
- Karakose T, Polat H, Papadakis S 2021. Examining teachers' perspectives on school principals' digital leadership roles and technology capabilities during the COVID-19 pandemic. *Sustainability*, 13(23): 13448. <https://doi.org/10.3390/su132313448>
- Kiron D, Unruh G 2017. Digital Transformation on Purpose. Cambridge MA: Massachusetts Institute of Technology. From <<https://sloanreview.mit.edu/article/digital-transformation-on-purpose>> (Retrieved on 18 August 2023).
- Ko•uh A, Maksimovic J, Osmanovic Zajic J 2021. Fourth Industrial Revolution and digital competences of teachers. *World Journal on Educational Technology: Current Issues*, 13(2): 160-177. <https://doi.org/10.18844/wjet.v13i2.5651>
- Lee JCK 2017. Theorizing teaching and learning in Asia and Europe. In: John Chi-Kin Lee, Kerry J. Kennedy (Ed.): *Theorizing Teaching and Learning in Asia and Europe: A Conversation between Chinese Curriculum and European Didactics*. 1st Edition. Oxon and New York, NY: Routledge, pp. 1-9. <https://doi.org/10.4324/9781315751900>
- Leino Lindell T 2020. Teachers calling for organizational support to digitalize teaching. *The International Journal of Information and Learning Technology*, 36(3): 218-230. <https://doi.org/10.1108/IJILT-11-2018-0126>



- nal of Information and Learning Technology*, 37(5): 323-339. <https://doi.org/10.1108/IJILT-02-2020-0017>
- Li F, Nucciarelli A, Roden S, Graham G 2016. How smart cities transform operations models: A new research agenda for operations management in the digital economy. *Production Planning and Control*, 27(6): 514-528. <https://doi.org/10.1080/09537287.2016.1147096>
- Liu ZJ, Tretyakova N, Fedorov V, Kharakhordina M 2020. Digital literacy and digital didactics as the basis for new learning models development. *International Journal of Emerging Technologies in Learning (iJET)*, 15(14): 4-18. <https://doi.org/10.3991/ijet.v15i14.14669>
- Loebbecke C, Picot A 2015. Reflections on societal and business model transformation arising from digitization and big data analytics: A research agenda. *Journal of Strategic Information Systems*, 24(3): 149-157. <https://doi.org/10.1016/j.jsis.2015.08.002>
- Lunde IM, Gunnulfson AE 2021. Governance through digital formations—The case of ‘what works’ in a Norwegian education context. In: John Benedicto Krejler, Leif Moos (Eds.): *What Works in Nordic School Policies? Mapping Approaches to Evidence, Social Technologies and Transnational Influences*. Springer, pp.195-212. [https://doi.org/10.1007/978-3-030-66629-3\\_10](https://doi.org/10.1007/978-3-030-66629-3_10)
- Matter P, Gees T, Peskova MB, Adriaensen B, Riedl R, Koumpis A 2020. Enhancing the digital learning experience: The case of the digital lab of the Berner Fachhochschule. In: Chad Lane, Susan Zvacek, James Uhomobhi (Eds.): *Proceedings of the 12<sup>th</sup> International Conference on Computer Supported Education - Volume 1: CSEU*, 171-177. <https://doi.org/10.5220/0009427901710177>
- McMullen AJ 2007. Electronic reserves on a budget: A case study of a homegrown system built with open source and free software solutions. *Journal of Interlibrary Loan, Document Delivery and Electronic Reserve*, 17(1-2): 137-150. [https://doi.org/10.1300/J474v17n01\\_13](https://doi.org/10.1300/J474v17n01_13)
- Menna F, Nocerino E, Morabito D, Farella EM, Perini M, Remondino F 2017. An open source low-cost automatic system for image-based 3D digitization. The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 42: 155. <https://doi.org/10.5194/isprs-archives-XLII-2-W8-155-2017>
- Mertala P 2020. Paradoxes of participation in the digitalization of education: A narrative account. *Learning, Media and Technology*, 45(2): 179-192. <https://doi.org/10.1080/17439884.2020.1696362>
- Moher D, Liberati A, Tetzlaff J, Altman DG 2009. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7): e1000097. <https://doi.org/10.1371/journal.pmed.1000097>
- Motschnig R, Pfeiffer D, Gawin A, Gawin P, Steiner M 2017. When kids are challenged to solve real problems—Case study on transforming learning with interpersonal presence and digital technologies. *IxDanda*, 34: 88-111. <https://doi.org/10.55612/s-5002-034-005>
- Mynaříková L, Novotný L 2020. Knowledge society failure? Barriers in the use of ICTs and further teacher education in the Czech Republic. *Sustainability*, 12(17): 6933. <https://doi.org/10.3390/su12176933>
- Nikula E, Järvinen T, Laiho A 2020. The contradictory role of technology in Finnish young people’s images of future schools. *Young*, 28(5): 465-484. <https://doi.org/10.1177/1103308819894806>
- Nogueira VB, Teixeira DG, de Lima IACN, Moreira MVC et al. 2022. Towards an inclusive digital literacy: An experimental intervention study in a rural area of Brazil. *Education and Information Technologies*, 27(2): 2807-2834. <https://doi.org/10.1007/s10639-021-10711-z>
- Park SC, Kim CJ, Taghizadeh-Hesary F, Sirivunnabod P 2021. *Economic Integration in Asia and Europe: Lessons and Policies*. Tokyo, Japan: Asian Development Bank Institute.
- Pata K, Tammets K, Väljataga T, Kori K, Laanpere M, Rõbtsenkov R 2022. The patterns of school improvement in digitally innovative schools. *Technology, Knowledge and Learning*, 27(3): 823-841. <https://doi.org/10.1007/s10758-021-09514-5>
- Pham HH, Dong TKT, Vuong QH, Luong DH, Nguyen TT, Dinh VH, Ho MT 2021. A bibliometric review of research on international student mobilities in Asia with Scopus dataset between 1984 and 2019. *Scientometrics*, 126(6): 5201-5224. <https://doi.org/10.1007/s11192-021-03965-4>
- Rodrigues LS 2017. Challenges of digital transformation in higher education institutions: A brief discussion. In: *Proceedings of 30<sup>th</sup> IBIMA Conference*. <http://hdl.handle.net/10400.22/15234>
- Saari A, Säänti J 2018. The rhetoric of the ‘digital leap’ in Finnish educational policy documents. *European Educational Research Journal*, 17(3): 442-457. <https://doi.org/10.1177/1474904117721373>
- Salmerón L, Delgado P, Vargas C, Gil L 2021. Tablets for all? Testing the screen inferiority effect with upper primary school students. *Learning and Individual Differences*, 86: 101975. <https://doi.org/10.1016/j.lindif.2021.101975>
- Salmieri L 2019. The rhetoric of digitalization in Italian educational policies: Situating reception among digitally skilled teachers. *Italian Journal of Sociology of Education*, 11(1): 162-183. <https://doi.org/10.14658/PUPJ-IJSE-2019-1-8>
- Trevisan LV, Eustachio JHPP, Dias BG, Filho W, Pedrozo EÁ 2023. Digital transformation towards sustainability in higher education: State-of-the-art and future research insights. *Environment, Development and Sustainability*, 1-22. <https://doi.org/10.1007/s10668-022-02874-7>
- Tuomi P, Multisilta J, Saarikoski P, Suominen J 2018. Coding skills as a success factor for a society. *Education and Information Technologies*, 23(1): 419-434. <https://doi.org/10.1007/s10639-017-9611-4>
- UNESCO (n.d.). Digital Learning and Transformation of Education: Open Digital Learning Opportunities For All. From <https://www.unesco.org/en/digital-education> (Retrieved on 18 August 2023).
- Veletsianos G 2016. Digital learning environments. In: Nick Rushby, Daniel W Surry (Eds.): *The Wiley Handbook Of Learning Technology*. John Wiley & Sons, Ltd, pp. 242-260. <https://doi.org/10.1002/9781118736494.ch14>
- Verhoef PC, Broekhuizen T, Bart Y, Bhattacharya A, Dong JQ, Fabian N, Haenlein M 2019. Digital transformation: A multidisciplinary reflection and research agenda. *Journal*

- of Business Research*, 122: 889-901. <https://doi.org/10.1016/j.jbusres.2019.09.022>
- Westerman G, Calm ejane C, Bonnet D, Ferraris P, McAfee A 2011. *Digital Transformation: A Roadmap for Billion-Dollar Organizations*. Cambridge, United States: MIT Sloan Management, MIT Center for Digital Business and Capgemini Consulting, pp. 1-68.
- Zain S 2021. Digital transformation trends in education. In: David Baker, Lucy Ellis (Eds.): *Future Directions in Digital Information*. East Riding of Yorkshire, England: Chandos Publishing, pp. 223-234. <https://doi.org/10.1016/B978-0-12-822144-0.00036-7>

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