


Multidimensionality of Digital Research in Educational Science

Valeria Frolovičeva, University of Latvia, Latvia*

 <https://orcid.org/0009-0006-0564-5686>

ABSTRACT

The aim of this article is to review the concept of e-research and provide insight into the multidimensionality of technology-based research in educational science. First, existing theories that reflect different aspects of digital transformation in academic work were reviewed. Secondly, additional elements were proposed for writing the research methodology when conducting technology-based research in the educational sciences. Finally, a criteria tool was created to illustrate the idea of how some additional technological aspects could be included in technology-based research and/or e-research methodology. To illustrate the reviewed concepts in the context of educational sciences, each section is supplemented with examples of empirical studies, particularly paying attention to research methodology (i.e., research instruments, research procedure, data collection, etc.). In addition, the article touches upon aspects of researchers' digital literacy.

KEYWORDS

Digital Transformation, E-Research, E-Research Design, E-Researcher's Identity, Research Skills, Researcher's Digital Literacy, Methodology, Technology-Driven Research, Technology-Enhanced Research

INTRODUCTION

Technology-based research in such branches of science as physics, biological science, and computer science has become a typical routine. However, technologies have given impetus to the application of technological solutions in other areas of science as well (Fry & Schroeder, 2009), such as offering new opportunities for researchers in the social sciences and humanities (Rogers, 2013; Markauskaite & Reimann, 2014).

It has been observed that the amount of research conducted using the internet is increasing daily (Kiliņč & Firat, 2017). The large amount of data in the digital environment provides endless opportunities for researchers, educators, and students to raise new questions in new ways (Anderson & Kanuka, 2003; Jankowski, 2009). The variety of computer software and online tools available facilitate and speed up many stages of the research process, such as communication with respondents,

DOI: 10.4018/IJDLDC.335853

*Corresponding Author

This article published as an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>) which permits unrestricted use, distribution, and production in any medium, provided the author of the original work and original publication source are properly credited.

data collection, data analysis, publication of results, and so forth (Genoni et al., 2009; Jankowski, 2009; O'Donnell & O'Donnell, 2019).

When it comes to technology in education science, it most often means research on technology-enhanced learning, such as interactive learning materials, gamification, and the use of advanced technologies (e.g., VR, AR) and their impact on self-directed learning, student motivation, learning achievements, and so forth. However, with the development of technology-enhanced learning, technology-enhanced research in the context of educational science has also received much attention (Hwang & Tsai, 2011). The aspect of e-research, and technology-based research in general, in the context of educational research methodology is the main research object of this article, which highlights the experience of educational scholars in implementing technological solutions to achieve their research goals. Therefore, this paper aims to review the concept of e-research and provide insight into how different technology-based methods are implemented in education science. To achieve this goal, the study mainly addresses the following research questions:

- RQ 1. What kind of educational research can be classified as e-research?
- RQ 2. What is the variety of technology-based research designs in educational studies?
- RQ 3. How can one achieve a more comprehensive description of technology-based research methodology?

To answer the research questions, the theories of Anderson and Kanuka (2003), Kozinets (2010), Shepherd and Watters (2002), Hughes (2000), and in *Developing New Products and Services* (2012) are reviewed, and their concepts rethought in the context of educational science. As a result of the analysis of theoretical sources, additional aspects are identified, as well as several useful definitions proposed to describe the technology-based research methodology. In order to demonstrate the findings in a more illustrative way, a criteria tool has been created that provides insight into concrete examples of how education researchers are using the internet and other technology solutions to improve their research methodology in educational science.

The Significance of the Study

Anderson and Kanuka's (2003) quote about 21st-century scholars stating, "It is too easy . . . to become seduced by the technology itself" (p. 31) is still as relevant today as it was two decades ago. Without a doubt, technologies suggest more practical solutions to existing approaches, such as providing the ability to collect data from "any part of the world, twenty-four hours a day and seven days a week" (Kiliç & Firat, 2017, p. 1465). However, the new possibilities of digital media also require new additional conditions and raise new questions about how to succeed in effective, high-quality, and safe research. For example, questions about data quality and reliability, as well as additional ethical risks, become particularly relevant (Kiliç & Firat, 2017). Moreover, such an "easy way to go" solution, in some cases, can lead to ineffective use of information and communication technology (ICT) in science by producing results that have little relevance or significance (Anderson & Kanuka, 2003). For example, widely used online surveys can give better results by providing a much larger sample for analysis and the opportunity for respondents to express their opinions more openly than via in-person communication. On the other hand, there is a risk of receiving invalid or misleading responses or responses without the possibility of the subject to clarify and explain the answers, which may result in the data being invalid (Kiliç & Firat, 2017). In addition, reflecting the personal observations of the tendencies of academic work in recent years, it seems important to highlight the following aspect. Currently, anonymous online surveys that are distributed remotely, for example, through social media, have become very popular in educational science, as well as in social sciences in general. Such technological solution provides an opportunity to obtain more data in a faster time period. However, in this case, it would be the responsibility of the researcher to mention it in the methodology section, since face-to-face and remote surveys have different levels of reliability. If the

survey is distributed remotely, a researcher cannot claim with a 100% guarantee that the data collected is valid. For example, how can a researcher be assured that an anonymous online survey of teachers, distributed via social media, was not completed by a person who may not be involved in the work of education at all? Consequently, more studies on researchers' digital literacy are required to examine how researchers conceptualize their literacy when using digital research tools (Tsatsou, 2017), as it can affect further scientific findings in quite a broader sense.

Scholars must be certain, that by conducting technology-based research, all software and hardware components are "working exactly as he expects, no surprises!" (Appelbe & Bannon, 2007, p. 84). Therefore, the ability to choose the appropriate research method and tools from a wide range of technological solutions becomes an essential competence to conduct effective and meaningful research (Anderson & Kanuka, 2003; Kiliç & Firat, 2017).

The necessity of acquiring technology-enhanced research skills and e-research literacy nowadays can be evidenced by most current study programs (for the year 2024) offered by some universities. For example, Lancaster University's Ph.D. in E-Research and Technology Enhanced Learning and SOAS University of London's module for Ph.D. students, Common Core II: Technology-Enhanced Research. In the description of the study courses, the following are mentioned as the main learning objectives and learning outcomes:

- a) understanding the impact of digital technologies on research
- b) evaluation of the strengths and weaknesses of digital tools, understanding which of them are most suitable for the research purposes
- c) a critical review of digital methods used by other researchers, etc.

METHODOLOGY

An integrative literature review (Snyder, 2019), conducted to accomplish the research objective, gives an overview of the existing theories and provides insight into the reconceptualization of e-research in the context of educational science.

Firstly, to explore existing theories of the concept of e-research, the selected sources provide a framework and structure, as well as comprehensive guidance, on how to conduct research via the internet. The following works selected to accomplish this include Anderson and Kanuka (2003), Kozinets (2010), Shepard and Watters (1998), and Hughes (2000). To ensure the relevance of sources in contemporary scientific discourse, the citations were checked through the Semantic Scholar search engine by setting a time period of the last 10 years (2013-2023).

The results show that the publication, "The Evolution of Cybergenres" by Shepherd and Watters (2002), since 2013, has garnered 64 citations (out of 184 since its publication date). The source generally is cited in the context of website organization, navigation, design, and user experience. The doctoral dissertation, *Teaching English with Technology: Exploring Teacher Learning and Practice* by Hughes (2000), is cited 13 times (having 25 citations overall since its publication year). This source is cited particularly in the context of integration strategies of different technologies in the learning process. The book, *e-Research: Methods, Strategies, and Issues* by Anderson and Kanuka (2003), has garnered 84 citations (out of 207 since its publication), primarily referenced when researchers describe the research strategy in the methodology section. Finally, the book, *Netnography: Doing Ethnographic Research Online* by Kozinets (2010), is cited 604 times during the sample period (out of 680 since its publication). The source generally is cited in the context of novel methodological approaches in research via social media opportunities. Thus, it is concluded that the findings and insights of these theories are still relevant and applicable in contemporary scientific discussions.

Secondly, several empirical studies were selected to demonstrate the findings in a more illustrative way. The empirical research review includes articles from the *ScienceDirect* database collection. The search conducted in the *ELSEVIER* journal, *Computers in Human Behavior*, by the

keyword “Classroom” from 2020 to 2023, shows 39 publications (July 2023), seven of which were selected for review. Additionally, three publications from other scientific journals cited in *Computers in Human Behavior* are included, resulting in a total of 10 empirical studies being analyzed. It is important to note that the main emphasis of this review lies in recognizing the variety of e-research methodologies in educational science rather than providing a comprehensive literature review on the use of technologies in education in general.

Finally, a criteria tool was created to provide insight and serve as an example of the additional description of the technology-based and/or e-research methodology.

Defining the Concept of E-Research

E-research can be considered a subtype of technology-based research, which focuses on research in network environment, (i.e., the internet) (Anderson & Kanuka, 2003).

E-Researcher's Identity

Along with the growing role and presence of technology in research and science in general, discussions about the transformation of research methodology became relevant amid the research. For example, such points of interest were raised as, “Whether [digital] humanists are actually doing anything different or just extending the activities that have always been their core concerns, enabled by advantages of network digital technology?” (Drucker, 2012, p. 85) or “Should the current methods of study change, slightly or wholesale, given a focus on objects as well as the contents that are ‘of the medium?’” (Rogers, 2013, p. 19).

Interestingly, the digital transformation affects science not only in terms of methodology, but it also defines a new type of researcher's identity. For example, such new definitions are introduced as “cyberscientist” (Nentwich, 2003), “net-enhanced researcher” (Anderson & Kanuka, 2003), “e-researcher” (Anderson & Kanuka, 2003; Pop, 2011), “e-research literate” (Genoni et al., 2009), and “remote researcher” (Martin, 2001). Anderson and Kanuka (2003) give the following description of a net-enhanced researcher: “A net-enhanced researcher acquires an attitude of curiosity, a critical but accepting attitude towards technological tools, and a willingness to look at the world through new technological and communication lenses” (Anderson & Kanuka, 2003, p. 1). Nentwich (2003) contrasted cyberscientists with classic ones who still prefer traditional non-digital research methods, whereas Pop (2011) called e-researchers “a new breed” of researchers and “explorers of the future.”

Nowadays traditional or non-digital researchers are not so distinctly separated from e-researchers, especially after the lockdown during the COVID-19 pandemic when all scholars had to become e-researchers or remote researchers if they wanted to remain active. Therefore, these terms and definitions in contemporary science are not so widely used and discussed as they were at the beginning of the 21st century.

Conceptualization of E-Research

After reviewing publications on online research, it can be concluded that until now, there has been no definite agreement on the term which defines research conducted in the digital and online environment. Anderson and Kanuka (2003) applied two synonyms, “e-research” (i.e., electronic research) and “net-based research” (i.e., networked research), both meaning a type of research that is carried out on the internet. The term “e-research” is also used by Jankowski (2009), Markauskaite et al. (2012), and Markauskaite and Reimann (2014), as well as “eResearch” by Appelbe and Bannon (2007) and “e-Research” by Salmons (2016). Concepts such as “online research” (Salmons, 2016), “internet research” (Kaufmann & Tzanetakis 2020), and “internet-enabled research” (Walther, 2002) basically mean the same as e-research, where the World Wide Web is considered a tool for resolving research questions (Albuquerque-Pai et al., 2023). On some occasions, the term “e-science” is used alongside the term e-research. However, several researchers believe that it is more appropriate to use the term e-research in the field of social sciences and humanities because e-science implies the use of high

technology and data-oriented methodology, which does not correspond to the research practice of humanities (Beaulieu & Wouters, 2009; Genoni et al., 2009).

Table 1 presents a summary of the concept of e-Research, enriched with citations from the publications mentioned above and provides a better overview and understanding of the concept of e-research.

The Scope of e-Research Towards Research Activities

There is no well-defined scope for the concept of e-research (Anderson & Kanuka, 2003; Appelbe & Bannon, 2007), and it is a highly disciplined dependent (Appelbe & Bannon, 2007). Some scholars use the term e-research mainly in a methodological sense, focusing on the development of methodological approaches enhanced by the internet (i.e., research design and process of data collection) (Anderson & Kanuka, 2003; Salmons, 2016), while others see e-research as a shift of a form of scholarly work in general (Appelbe & Bannon, 2007; Jankowski, 2009; Markauskaite et al., 2012). E-research, in a broad sense, refers not only to methodological aspects, scientific equipment, and software tools but also includes the set of knowledge-based resources such as digital libraries, collections, archives, and human (scholarly) activity in communication networks, such as collaboration, communication, publishing, etc. (Appelbe & Bannon, 2007; Jankowski, 2009; Markauskaite et al., 2012). All these elements create a digital research infrastructure. Nentwich (2003) has proposed the term “cyberspace” (i.e., virtual environment) to define all scientific and scholarly research activities on the internet. However, Anderson and Kanuka (2003) believe that cyberspace and some other definitions with the prefix “cyber-“ are not quite suitable for the context of network-based education development and instead propose using the abbreviation “net,” meaning networked.

Table 1. Summary of the concept of e-research

Term	Quotations	Source
e-Research	“Generally, the <i>e</i> prefix means that the activity . . . takes place on a high-speed, digital network that is available ‘anytime/anywhere.’ Today that network is the internet.”	(Anderson & Kanuka, 2003, p. 4)
Net-Based Research	“ <i>Net</i> seems to reflect the technical nature of the environment, but also carries with it the context of human interconnectedness.”	(Anderson & Kanuka, 2003, p. 13)
Cyberscience	“All scholarly and scientific research activities in the virtual space generated by the networked computers and by advanced information and communication technologies, in general.”	(Nentwich, 2003, p. 22)
eResearch	“eResearch strictly means research conducted relying on supporting infrastructure that should properly be called either eResearch Infrastructure or Cyberinfrastructure.” “eResearch infrastructure is a large system that is made up of . . . software and hardware and organizational components, where each researcher should be able to readily find the components they want and need.”	(Appelbe & Bannon, 2007, p. 84)
e-Research	“... a form of scholarship conducted in a network environment utilizing internet-based tools and involving collaboration among scholars separated by distance, often on a global scale.”	(Jankowski, 2009, p. 7)
e-Research	“... a set of research activities that use advanced information and communication technologies, including computer networks, large shared databases, remote research instruments, and computational power.”	(Markauskaite et al., 2012, p. 34)
e-Research	“... methodological traditions of using information and communication to study perceptions, experiences, and behaviors through their verbal or visual expressions, actions or writing.”	(Salmons, 2016, p. 6)
Digital Research	“Digital research involves the employment of digital technologies in research practices.”	(Tsatsou, 2017, p. 1241)

The Scope of E-Research Towards the Environment

Anderson and Kanuka (2003) propose e-research as an opportunity to observe and collect data on events that occur both on and off the network. Thus, expanding the understanding of the use of e-research in scientific activities. Firstly, two research environments have been defined: cyberspace (i.e., research on the network) and the real world (i.e., off the network). Further, four possible ways were identified to conduct research, depending on the environment:

- Both the research subject and the data collection are in cyberspace, for example, an online questionnaire about the experience of searching on the internet.
- The research subject is in cyberspace, while the data is collected in the real world, for example, an in-person interview about student's experience of online learning.
- The research subject is in the real world, while the data is collected in cyberspace, for example, an online questionnaire about group work experiences in a classroom.
- Both the research subject and the data collection are in the real world environment, for example, face-to-face interview about group work experiences in a classroom.

A similar classification of research methodology is proposed by Robert Kozinets (2010) in his book *Netnography: Doing Ethnographic Research Online*. Kozinets introduced the new term "netnography" in 1995, which means a specialized form of ethnographic research conducted on social networks. Kozinets (2010) identifies three categories of ethnographic research:

- "Pure" netnography when all research procedures are conducted online.
- "Blended" netnography/ethnography when research procedures are conducted both online and offline.
- "Pure" ethnography when all research procedures are carried out offline.

Table 2 provides an overview of the concepts mentioned above. In addition, the overview is supplemented with concrete examples of educational studies to acknowledge the reflection of the concepts in educational science.

In this study, the settings of "blended" and "pure" (Table 2) will be applied not only on research on the internet but on digital environment in general. Thus, defining a hybrid setting that combines physical places and digital spaces as a blended type, while research conducted only in a digital environment as a pure type.

E-RESEARCH DESIGN

E-research design largely replicates research methods used in non-digital environments (Anderson & Kanuka, 2003) by replacing non-digital tradition with online tool; however, scholars have identified aspects in which traditional or non-digital research and technology-based research cannot be considered as the same, even if the methodology is based on the same traditional research design, such as interviews, surveys, observations, etc. For example, the original Delphi method has evolved into E-Delphi (i.e., the electronic Delphi method), where E-Delphi means a modern rendering of the original Delphi method carried out via the internet. E-Delphi is different in speeding up the process, overcoming geographic barriers, and ensuring the anonymity of the experts involved (Walker, 2023). Similarly, the traditional focus group method evolved into the online focus group, which is considered "analogous" to the traditional focus group method with the difference that it is conducted in an online environment using synchronous web conferencing platforms (e.g., Zoom, Microsoft Teams), thus expanding the research geographically (Morrison, 2023).

Table 2. Summary of e-research concept towards the environment (i.e., digital vs. non-digital)

Concept	Non-Digital	Blended	Digital
E-Research (Anderson & Kanuka, 2003)	Real world	Real world [combined] with cyberspace	Cyberspace
<i>An example of a concept in education science*</i>	A case study via face-to-face interviews to evaluate the communication model applied in primary school classrooms towards immigrant students (Mersin et al., 2022).	Investigating students' online academic help-seeking and internet self-efficacy via self-reporting questionnaire (on paper) in the classroom (Fan & Lin, 2023).	Investigating students' achievement emotions in online learning environments by self-reporting via online questionnaire (Cheng et al., 2023).
Netnography (Kozinets, 2010)	"Pure" ethnography	"Blended" netnography/ethnography	"Pure" netnography
<i>An example of a concept in education science*</i>	A student collaboration in the classroom was observed when creating a poster in a physics lesson on an interactive tabletop. Data collection was conducted via video and audio recording of the classroom session (Zabolotna et al., 2023).	Students' drawings (on paper) and narratives were used to explore middle-school students' attitudes and perceptions of the nature of the internet (Brodsky et al., 2021).	To investigate peer-organized social-media communities, analysis of posts, comments, and reactions in a Facebook group was conducted. Exploring teachers' interaction, that focused on pedagogical use of ICT (Nelmarkka et al., 2021).

*The examples of studies are suggestive rather than conclusive.

Several empirical studies are available with innovative data collection methods via different software programs or technological solutions. In this regard, Rogers (2013) suggests to distinguish between those methods that "migrated" to the new media and the natively digital methods that are "born" and developed in the new medium. The methodologically innovative studies make it possible to obtain new data, gain a deeper insight into various aspects of learning phenomena, and find new research directions, which previously would not have been possible with traditional multiple-choice tests, self-assessment measurement scales, and interviews (Markauskaite & Reimann, 2014).

The Conceptualization of Technology-Based Research Designs

In recognizing the diverse use of technology in research, the need to define two different technology-based research designs emerged in order to characterize the researcher's attitude towards the role of technology within the research, whether it is primary (i.e., becomes the subject of the study) or secondary (i.e., is a supporting tool for conducting the study). The definition of these designs is based on the concepts presented by Hwang and Tsai (2011), O'Donnell and O'Donnell (2019) and in *Developing New Products and Services* (2012).

Hwang and Tsai (2011) and O'Donnell and O'Donnell (2019) suggest to use the term technology-enhanced research by analogy with the term technology-enhanced learning when the learning process is supported through technology by improving the quality (O'Donnell & O'Donnell, 2019), thus referring to the use of a wide variety of technologies (i.e., software and devices) to support different stages and types of research activities. Therefore, in this study, the technology-enhanced research design reflects the secondary role of technologies as a supporting tool for conducting the study.

Whereas, conceptualizing the primary role of technologies in research methodology is based on the theory of product design in *Developing New Products and Services* (2012). Even though the theory relates to market research, it can be applied to research methods in educational research as well. *Developing New Products and Services* (2012) represents the concept of technology-driven design that focuses on applying new technologies to develop products and services. Thus, technology is the subject of research.

Therefore, the suggestion would be to use the following division of technology-based research (Figure 1).

- 1) Technology-driven research explores the use of technology as one the main aspects of the investigation, for example, in the case of testing new software for data collection while conducting an observation study of students' collaboration skills during group work in classroom sessions. Thus, the description of the methodology includes the technology specification, presents a detailed description of the research procedure, and provides an analysis of the advantages and limitations of a particular technology in the context of specific research tasks.
- 2) Technology-enhanced research integrates technology as a supporting tool to investigate the main subject (e.g., an online questionnaire about the students' collaboration skills during the group work in classroom session). In this case, research methodology provides a very brief description of the technology used.

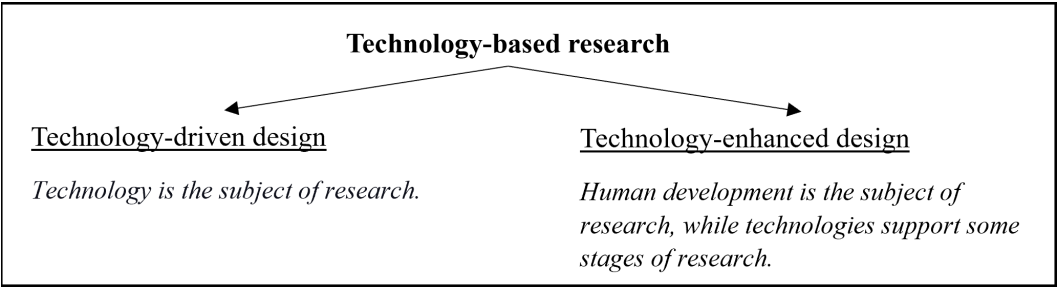
Digital Transformation of the Research Methods

Published in 2002, Michael Shepherd and Carolyn Waters' article, "The Evolution of Cybergenres," introduces the new term *cybergenre* to refer to digital textual materials, such as digital dictionaries, distinguishing them from non-digital dictionaries. Shepherd and Watters (2002) used the term *genre* as a synonym for *kind* and *type*. The following division of textual materials is offered, depending on the changes in their structure and functionality facilitated by digital media (Shepherd & Watters, 2002):

- *Extant cybergenres*: text materials that previously have existed in non-digital form, namely, are digitized reproductions of printed materials, mainly without changing their structure, design, and functionality. Two types of *extant cybergenres* were distinguished:
 - a) *Replicated cybergenre*: reproduction of non-digital documents without any interactivity, except the only option to scroll the text up and down.
 - b) *Variant cybergenre*: reproduction of non-digital documents with low interactivity, for example, text document supplemented with hyperlinks.
- *Novel cybergenres*: content developed in the digital environment, that provides features with a high level of functionality and interactivity, that makes the existence of the content completely dependent on the digital environment. For example, supplementing the traditional text by interactivity, such as creating content, drawing, manipulating images and graphics, and so forth.

A similar categorization is proposed by Joan Elizabeth Hughes (2000) in the dissertation Teaching English with Technology: Exploring Teacher Learning and Practice in the Context of Instructional

Figure 1. Technology-based research designs



Methods in K-12 Education. Hughes (2000) proposes a taxonomy of how teachers integrate technology into the classroom:

- *Technology as replacement*: learning activity represents the same instructional practice as in the non-technology version. For example, students highlight words in a *Word* text file that essentially repeats the action when students underline words with a pencil on a worksheet.
- *Technology as amplification*: the teaching methods are the same as in the non-technological version, except that technology makes learning more “powerful,” for example, when students search for information on the internet.
- *Technology as transformation*: technology changes teaching methods and student learning by enabling activities that are not possible in a non-technological version, for example, writing a hypertext narrative instead of writing a linear text on paper by hand.

For an overview of the main concepts and terms mentioned above, a summary table (Table 3) is provided below. Both theories (i.e., Shepherd and Watters, 2002 and Hughes, 2000) suggest dividing digital transformation into levels: small-scale, intermediate, and extensive. This classification can also be extended to technology-based research methods.

Based on the theories by Shepherd and Watters (2002) and Hughes (2000), the following classification for technology-based research methods can be advised in relation to the level of digital transformation, namely the level of novelty of the method performed in the digital environment:

- Replicated methods represent small-scale digital transformation. At this level, the same methods are used as in the non-digital version, replacing the “paper tradition” with online tools. For example, a questionnaire conducted using digital media (e.g., Google Forms, SurveyMonkey, etc.) or an interview conducted using online conferencing platforms (e.g., Zoom, Microsoft Teams, etc.).
- Variant methods reflect the intermedium digital transformation. At this level, existing research procedures are maintained, but with some integrated digital media extensions with low interactivity, for example, embedding hyperlinks or audiovisual material in an online survey or structuring the survey using pop-up selection boxes.

Table 3. Summary of concepts and terms. digital transformation of research methods in the context of technology-enhanced research

Concept	Level of Transformation		
	Small-Scale	Intermediate	Extensive
Cybergenre¹ (Shepherd & Waters, 2002)	Extant cybergenres		Novel cybergenres
	Replicated cybergenres	Variant cybergenres	
Technology Use Taxonomy (Hughes, 2000)	Replacement	Amplification	Transformation
<i>An example of a concept in education science*</i>	The study investigates achievement emotions in online learning environments by students' self-report via online questionnaire (Cheng et al., 2023).	The study investigates the impact of social media advertising on product choice among young people. An online questionnaire with integrated TikTok videos was created. Students worked in classroom settings (van der Bend et al., 2023).	Log files were used to study participants' online behavior and explore interactions with peers and teachers in the virtual classroom learning space (Serradell-Lopez et al., 2023).

*The examples of studies are suggestive rather than conclusive.

- Novel or innovative methods indicate an extensive level of digital transformation. They are based on technological solutions that make the existence of the research method completely dependent on the digital environment. For example, netnographic studies of teachers' interactions in virtual space via social media or learning behaviors research by trace data analysis, such as log files or constructing a technology-based multimodal methodology by combining different types of environments, tools, and devices in one study methodology.

Criteria Tool for e-Research and Technology-Based Research in Educational Science

Nowadays, it is impossible to imagine any scientific research without the support of technology, for example, the use of software for quantitative data analysis or transcription of the interview on a computer. Therefore, it is important to emphasize that the study is not focused on the use of technology in general, but only on technological solutions in relation to research methods. Thus, the purpose of the empirical research review is to provide the idea of how some additional technological aspects can be included in the description of the research methodology in educational science.

By rethinking the concepts mentioned in the previous sections, the following criteria tool of technology-based research, including e-research, in education science can be suggested (see Table 4). The criteria tool provides specific additional elements in order to “construct” and obtain a more comprehensive description of the technology-based research methodology, recommending that the following additional aspects be included (the terms are taken from already existing theories but are rethought and interpreted in the context of educational research):

In Relation to the Framework of Research

- **Technology-enhanced research** (O'Donnell & O'Donnell, 2019): the use of technologies to support research activities, while the main research object are some human development aspects, such as collaboration skills, learning self-regulation, internet self-efficacy, student motivation, and so forth.
- **Technology-driven research** (*Developing New Products and Services*, 2012): a scholar is exploring the use of technology as the main aspect of the investigation, for example:
 - (a) by testing new software for data collection or data analysis,
 - (b) by investigating the possibilities of a concrete technology in the context of technology-enhanced learning (i.e., the user experience).

In Relation to the Research Environment

- in relation to the global network (Anderson & Kanuka, 2003):
 - (a) Net-based research or e-research: type of research that is conducted on the internet (i.e., global network).
 - (b) non-Net-based research: type of research that is supported by electronic devices and software but is conducted outside the internet (i.e., global network).
- in relation to the physical and digital environment (Anderson & Kanuka, 2003; Kozinets, 2010):
 - (a) Pure digital: the research subject and process of data collection are located in digital environment.
 - (b) Blended: includes a combination of physical and digital environments within the same study.

In Relation to the Data Type

- **Monomodal:** data collected from one source only, for example, self-report via an online questionnaire.
- **Multimodal:** data collected from different mediums, such as video, audio recording, written transcripts, eye tracking, log data, and physiological data (Järvelä et al., 2023). For example, data collection based on the concept of the Internet of Things (IoT) system (i.e., in a network of physical devices).

In Relation to the Research Method Transformation (i.e., Novelty of Technology-Enhanced Research Methods) (Shepherd & Watters, 2002; Hughes, 2000)

- **Replicated:** same methodological practices are used as in the non-digital version, replacing the “paper tradition” with online tools.
- **Variant:** existing research procedures are maintained, but with some integrated digital media extensions with low interactivity.
- **Novel:** innovative methodology indicates an extensive level of digital transformation. It is based on technological solutions that make the existence of the research method completely dependent on the digital environment.

In Relation to the Research Tools and Devices

The following additions are proposed that even in cases where the replicated method is used, a mentioning of digital tools (e.g., *Google Forms*, *SurveyMonkey*, etc.) would be necessary and valuable. For now, in many cases, when writing the methodology part, it is only mentioned that the survey was conducted online, but it does not mention which digital tool was used. Furthermore, only a few studies mention the type of device, such as a smartphone, tablet or laptop and whether the device used by participants during the research activity is private, classroom device or a computer lab was provided. Therefore, the suggestion would be to include a more detailed description of the devices and digital tools used during the research in any case, whether it is technology-enhanced or technology-driven research.

Implementation of the Criteria Tool

A few recent empirical studies have been selected from the journal *Computers in Human Behavior* in the *ScienceDirect* collection. The search was performed on the keyword “Classroom” in the topic (title, abstract, and keywords) with the publication year 2023. Next, the studies that reflect the learning process (e.g., learning outcomes, collaboration skills, etc.) and conducted within the classroom settings were selected. These search settings were chosen because it was expected that the search result would reveal more diverse studies on the use of technology in the research procedure of the study, as it involves the combination of two environments, both digital and non-digital. Six publications were chosen to illustrate different combinations of proposed criteria.

The criteria tool created is based on the theories of Anderson and Kanuka (2003), Kozinets (2010), Shepherd and Watters (2002), Hughes (2000), and in *Developing New Products and Services* (2012). The additional elements (represented as criteria) for writing technology-based research methodology are proposed and described in this section. The first column of Table 4 provides a brief description of the studies, including information relevant to the analysis of technology use such as the research object, type of activity, and procedure of data collection. Secondly, the analysis of the research methods is given by marking the relevant option of the criteria with a tick. Finally, the last column of the row provides a summary that can serve as an example of an additional description of the technology-based methodology.

Table 4. Criteria Tool: Additional Elements for e-Research and Technology-Based Research Methodology

	Brief Description of the Study (Research Object, Activity, and Data Collection)	The Framework of Research Methods (i.e., Research Design)	Environment		Type of Data	Novelty of Methods	Additional Description of the Research Methodology
			Digital Environment	Global Network (i.e., the Internet)			
(Lim et al., 2023)	The study investigates the effects of personalized scaffolds, facilitated by artificial intelligence system on students' learning processes and outcomes. Students wrote essays with the help of an online learning environment. The following data was collected: think aloud, trace data with navigational logs, peripheral data such as keystrokes and mouse movement data, eye-tracking data, knowledge tests, questionnaire	<input checked="" type="checkbox"/> technology-enhanced <input type="checkbox"/> technology-driven	<input type="checkbox"/> "pure" <input checked="" type="checkbox"/> blended	<input checked="" type="checkbox"/> e-research <input type="checkbox"/> non-Net-based	<input type="checkbox"/> monomodal <input checked="" type="checkbox"/> multimodal	<input type="checkbox"/> replicated <input type="checkbox"/> variant <input checked="" type="checkbox"/> novel	Blended e-research with variant technology-enhanced research design based on multimodal data analysis.
(Järvelä et al., 2023)	The study contributes to developing AI-enabled support for collaborative learning. Students worked in groups in authentic school settings. Data collection was conducted by skin sensor, video cameras, and microphones. AI machine deep-learning approach was used for pattern prediction, during data analysis.	<input type="checkbox"/> technology-enhanced <input checked="" type="checkbox"/> technology-driven	<input type="checkbox"/> "pure" <input checked="" type="checkbox"/> blended	<input type="checkbox"/> e-research <input checked="" type="checkbox"/> non-Net-based	<input type="checkbox"/> monomodal <input checked="" type="checkbox"/> multimodal	<input type="checkbox"/> replicated <input type="checkbox"/> variant <input checked="" type="checkbox"/> novel	Blended technology-based research with novel technology-driven research design based on multimodal data analysis.
(Webster & Paquette, 2023)	The study is about the impact of smartphones on students' lives and the support of teachers in decision-making related to the presence of smartphones in the learning process. The data collection was conducted via an online survey and interview (in person or via Zoom).	<input checked="" type="checkbox"/> technology-enhanced <input type="checkbox"/> technology-driven	<input type="checkbox"/> "pure" <input checked="" type="checkbox"/> blended	<input checked="" type="checkbox"/> e-research <input type="checkbox"/> non-Net-based	<input type="checkbox"/> monomodal <input checked="" type="checkbox"/> multimodal	<input checked="" type="checkbox"/> replicated <input type="checkbox"/> variant <input type="checkbox"/> novel	Blended e-research with replicated technology-enhanced research design based on multimodal data analysis.
(Serradell-Lopez et al., 2023)	The study is about the students' interactions with peers and teachers in the virtual classroom (board, forum, and virtual debate space). The data collection was conducted via log files.	<input checked="" type="checkbox"/> technology-enhanced <input type="checkbox"/> technology-driven	<input checked="" type="checkbox"/> "pure" <input type="checkbox"/> blended	<input checked="" type="checkbox"/> e-research <input type="checkbox"/> non-Net-based	<input checked="" type="checkbox"/> monomodal <input type="checkbox"/> multimodal	<input type="checkbox"/> replicated <input type="checkbox"/> variant <input checked="" type="checkbox"/> novel	Pure e-research with novel technology-enhanced research design based on monomodal data analysis.
(Cheng et al., 2023)	The study investigates achievement emotions in online learning environments by students' self-report via online questionnaire.	<input checked="" type="checkbox"/> technology-enhanced <input type="checkbox"/> technology-driven	<input checked="" type="checkbox"/> "pure" <input type="checkbox"/> blended	<input checked="" type="checkbox"/> e-research <input type="checkbox"/> non-Net-based	<input checked="" type="checkbox"/> monomodal <input type="checkbox"/> multimodal	<input checked="" type="checkbox"/> replicated <input type="checkbox"/> variant <input type="checkbox"/> novel	Pure e-research with replicated technology-enhanced research design based on monomodal data analysis.
(van der Bend et al., 2023)	The study investigates the impact of social media advertising on product choice among young people. An online questionnaire with integrated TikTok videos was created. Students worked in classroom settings.	<input checked="" type="checkbox"/> technology-enhanced <input type="checkbox"/> technology-driven	<input type="checkbox"/> "pure" <input checked="" type="checkbox"/> blended	<input checked="" type="checkbox"/> e-research <input type="checkbox"/> non-Net-based	<input checked="" type="checkbox"/> monomodal <input type="checkbox"/> multimodal	<input type="checkbox"/> replicated <input checked="" type="checkbox"/> variant <input type="checkbox"/> novel	Blended e-research with variant technology-enhanced research design based on monomodal data analysis.

* The analysis of research examples is more suggestive than definitive.

CONCLUSION

The outcomes of this research provides an overview of the concept of e-research and gives insight into the multidimensionality of technology-based research in educational science. The significance of the study is justified by the fact that technology-enhanced research skills and e-research literacy nowadays are required in academia.

Even though the role of technology-based solutions in educational research is now a common practice, there is no complete and comprehensive agreement on how technological aspects should be described in the methodology section. Furthermore, there is evidence that face-to-face and remote research methods, especially self-report surveys, have different levels of validity and reliability, making it the responsibility of the researcher to include a description of which technologies and to what extent they are used in their research. Therefore, additional guidance and definitions are needed for writing a comprehensive research methodology in case of conducting technology-based research and/or e-research.

Three main research questions were addressed within the framework of this study:

- RQ 1. What kind of educational research can be classified as e-research?
- RQ 2. What is the variety of technology-based research designs in educational studies?
- RQ 3. How can a more comprehensive description of technology-based research methodology be achieved?

To address RQ 1, a review of several theoretical studies on online research has been conducted. The theoretical works of Anderson and Kanuka (2003), Nentwisch (2003), Jankowski (2009), and Kozinets (2010) can serve as more comprehensive sources for investigating the concept of e-research. The results have shown that there is no definite agreement on how to define research conducted in the online environment. Therefore, the term e-research by Anderson and Kanuka (2003) is considered a more appropriate way to define the type of research, which focuses on research in network environment (i.e., the internet). The concept of e-research can be considered as a subtype of technology-based research that implies the presence of the internet in research in various appearances. The internet can be both an object of study and a research tool to study, both online and non-digital processes. For example, if (a) is an online questionnaire about the experience of searching on the internet, (b) is an in-person interview about student's experience of online learning, and (c) is an online questionnaire about group work experiences in a classroom, (a), (b), and (c) are all classified as e-research.

During the research, no scientific source was found that would provide a definite answer to RQ 2. Therefore, several theoretical works on different aspects of digital transformation of academic work were rethought and interpreted in the context of research methodology. The following publications have been considered constructive and suitable to define technology-based research in educational science: (a) "The Classification of Digital Dictionaries" by Shepherd and Watters (2002), (b) "The Taxonomy of Instructional Methods" by Hughes (2000), and (c) "Smart Product Prototyping Strategies" from *Developing New Products and Services* (2012). First, two types of technology-based research designs have been defined in the context of educational science: technology-enhanced research and technology-driven research. Second, the three types of research methods were defined in relation to digital transformation (i.e., the novelty): replicated, variant, and novel.

To address RQ 3, additional methodological aspects have been summarized and criteria tool have been created to provide insight and an example of the additional description of the technology-based and/or e-research methodology. In addition, recent empirical studies from the *ScienceDirect* collection in educational science were selected and examined in accordance with proposed criteria, particularly paying attention to the research methodology (i.e., research instruments, study procedure, data collection, etc.). Although, in some cases, the current approach to the analysis of research

methodology can be considered subjective, it represents a step towards revisiting technology-based methodology in education science.

This article can be helpful for scholars of different branches of social sciences in writing the methodology section for empirical studies, in cases of conducting technology-based research and/or e-research. In addition, an overview of the concepts and various aspects of technological solutions in research design can provide new ideas to create new innovative research projects in educational science.

LIMITATIONS AND FUTURE STUDIES

The purpose of the paper is to provide an insight into variety of technology-based methods in the education science. Therefore, the study provides the review of six empirical studies; however, a more comprehensive systematic literature review would be valuable to acquire the current tendencies of technology-enhanced research methods in educational science.

REFERENCES

- Albuquerque-Pai, A., Dsouza, M. P., Jothikaran, T. A. J., Sebastin, K. V., & Ashok, L. (2023). Defining e-research in social work: A review of strategies and challenges. *China Journal of Social Work*, 16(2), 137–165. doi:10.1080/17525098.2023.2232821
- Anderson, T., & Kanuka, H. (2003). *E-research: Methods, strategies, and issues*. Allyn & Bacon.
- Appelbe, B., & Bannon, D. (2007). eResearch – Paradigm shift or propaganda? *Journal of Research and Practice in Information Technology*, 39(2), 83–89. https://www.researchgate.net/publication/290975961_eResearch_-_Paradigm_shift_or_propaganda
- Beaulieu, A., & Wouters, P. (2009). E-research as Intervention. In N. W. Jankowski (Ed.), *E-research: Transformation in Scholarly Practice* (pp. 54–69). Routledge.
- Brodsky, J. E., Lodhi, A. K., Powers, K. L., Blumberg, F. C., & Brooks, P. J. (2021). “It’s just everywhere now”: Middle-school and college students’ mental models of the Internet. *Human Behavior and Emerging Technologies*, 3(4), 495–511. doi:10.1002/hbe2.281
- Cheng, S., Huang, J. C., & Hebert, W. (2023). Profiles of vocational college students’ achievement emotions in online learning environments: Antecedents and outcomes. *Computers in Human Behavior*, 138, 107452. doi:10.1016/j.chb.2022.107452
- Developing New Products and Services*. (2012). Saylor Academy. https://saylordotorg.github.io/text_developing-new-products-and-services/
- Drucke’r, J. (2012). Humanistic Theory and Digital Scholarship. In M. K. Gold (Ed.), *Debates in the Digital Humanities* (NED-New edition, pp. 85–95). University of Minnesota Press. <https://www.jstor.org/stable/10.5749/j.cttv8hq.9>
- Fan, Y. H., & Lin, T. J. (2023). Identifying university students’ online academic help-seeking patterns and their role in Internet self-efficacy. *The Internet and Higher Education*, 56, 100893. doi:10.1016/j.iheduc.2022.100893
- Fry, J., & Schroeder, R. (2009). Towards a Sociology of e-Research. In N. W. Jankowski (Ed.), *e-Research: Transformation in Scholarly Practice* (pp. 35–53). Routledge.
- Genoni, P., Merrick, H., & Willson, M. (2009). E-research and Scholarly Community in the Humanities. In N. W. Jankowski (Ed.), *E-research: Transformation in Scholarly Practice* (pp. 91–108). Routledge.
- Hughes, J. (2000). *Teaching English with technology: Exploring teacher learning and practice* [Doctoral dissertation, Michigan State University]. ProQuest Dissertations & Theses Global. http://techedges.org/wp-content/uploads/2015/11/Hughes_Full_Dissertation.pdf
- Hwang, G.-J., & Tsai, C.-C. (2011). Research trends in mobile and ubiquitous learning: A review of publications in selected journals from 2001 to 2010. *British Journal of Educational Technology*, 42(4), E65–E70. doi:10.1111/j.1467-8535.2011.01183.x
- Jankowski, N. W. (2009). The Contours and Challenges of e-Research. In N. W. Jankowski (Ed.), *e-Research: Transformation in Scholarly Practice* (pp. 3–31). Routledge.
- Järvelä, S., Nguyen, A., Vuorenmaa, E., Malmberg, J., & Järvenoja, H. (2023). Predicting regulatory activities for socially shared regulation to optimize collaborative learning. *Computers in Human Behavior*, 144, 107737. doi:10.1016/j.chb.2023.107737
- Kaufmann, M., & Tzanetakis, M. (2020). Doing internet research with hard-to-reach communities: Methodological reflections on gaining meaningful access. *Qualitative Research*, 20(6), 927–944. doi:10.1177/1468794120904898 PMID:33281502
- Kiling, H., & Firat, M. (2017). Opinions of expert academicians on online data collection and voluntary participation in social sciences research. *Educational Sciences: Theory & Practice*, 17(5), 1461–1486. https://www.researchgate.net/publication/317401567_Opinions_of_Expert_Academicians_on_Online_Data_Collection_and_Voluntary_Participation_in_Social_Sciences_Research
- Kozinets, R. V. (2010). *Netnography: Doing Ethnographic Research Online*. SAGE. https://www.researchgate.net/publication/267922181_Netnography_Doing_Ethnographic_Research_Online

- Lim, L., Bannert, M., van der Graaf, J., Singh, S., Fan, Y., Surendrannair, S., Rakovic, M., Molenaar, I., Moore, J., & Gašević, D. (2023). Effects of real-time analytics-based personalized scaffolds on students' Self-Regulated Learning. *Computers in Human Behavior*, 139, 107547. doi:10.1016/j.chb.2022.107547
- Markauskaite, L., Kennan, M. A., Richardson, J., Aditomo, A., & Hellmers, L. (2012). Investigating eResearch: Collaboration Practices and Future Challenges. In A. Juan, T. Daradoumis, M. Roca, S. Grasman, & J. Faulin (Eds.), *Collaborative and Distributed E-Research: Innovations in Technologies, Strategies and Applications* (pp. 1–33). IGI Global. doi:10.4018/978-1-4666-0125-3.ch001
- Markauskaite, L., & Reimann, P. (2014). Editorial: e-Research for education: Applied, methodological and critical perspectives. *British Journal of Educational Technology*, 45(3), 385–391. doi:10.1111/bjet.12154
- Martin, K. (2001). Analysis of remote reference correspondence at a large academic manuscripts collection. *The American Archivist*, 64(1), 17–42. doi:10.17723/aarc.64.1.g224234uv117734p
- Mersin, G., Köprülü, F., & Öznacar, B. (2022). Viewpoints of teachers and Syrian immigrant students about the impact of the communication model on academic success in primary schools. *Pegem Journal of Education and Instruction*, 13(1), 319–325. doi:10.47750/pegegog.13.01.35
- Morrison, D. (2023). Online focus groups. In J. M. Okoko, S. Tunison, & K. D. Walker (Eds.), *Varieties of qualitative research methods* (pp. 359–364). Springer. doi:10.1007/978-3-031-04394-9_55
- Nelimarkka, M., Leinonen, T., Durall, E., & Dean, P. (2021). Facebook is not a silver bullet for teachers' professional development: Anatomy of an eight-year-old social-media community. *Computers & Education*, 173, 104269. doi:10.1016/j.compedu.2021.104269
- Nentwich, M. (2003). *Cyberscience*. Australian Academy of Science.
- O'Donnell, E., & O'Donnell, L. (2019). Towards Supporting Academic Authors, Researchers, and PhD Students in Higher Education. In V. Wang (Ed.), *Scholarly Publishing and Research Methods Across Disciplines* (pp. 110–134). IGI Global. doi:10.4018/978-1-5225-7730-0.ch006
- Pop, C. V. (2011). The E-researcher. *Caietele Echinox*, 20, 131–136. <https://www.cceol.com/search/article-detail?id=157778>
- Rogers, R. (2013). *Digital Methods*. The MIT Press. doi:10.7551/mitpress/8718.001.0001
- Salmons, J. (2016). *Doing Qualitative Research Online*. SAGE Publications Ltd., doi:10.4135/9781473921955
- Serradell-Lopez, E., Lara-Navarra, P., & Martínez, S. (2023). The Pareto Principle in virtual communities of learning. *Computers in Human Behavior*, 138, 107444. doi:10.1016/j.chb.2022.107444
- Shepherd, M., & Watters, C. (2002). The evolution of cybergenres. *Proceedings of the Thirty-First Hawaii International Conference on System Sciences 1998*, 2, 97–109. doi:10.1109/HICSS.1998.651688
- Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, 104, 333–339. doi:10.1016/j.jbusres.2019.07.039
- Tsatsou, P. (2017). Literacy and training in digital research: Researchers' views in five social science and humanities disciplines. *New Media & Society*, 20(3), 1240–1259. doi:10.1177/1461444816688274
- van der Bend, D. L. M., Gijsman, N., Bucher, T., Shrewsbury, V. A., van Trijp, H., & van Kleef, E. (2023). Can I @handle it? The effects of sponsorship disclosure in TikTok influencer marketing videos with different product integration levels on adolescents' persuasion knowledge and brand outcomes. *Computers in Human Behavior*, 144, 107723. doi:10.1016/j.chb.2023.107723
- Walker, K. D. (2023). Electronic Delphi method. In J. M. Okoko, S. Tunison, & K. D. Walker (Eds.), *Varieties of Qualitative Research Methods* (pp. 155–160). Springer Texts in Education. doi:10.1007/978-3-031-04394-9_25
- Walther, J. B. (2002). Research ethics in internet-enabled research: Human subjects issues and methodological myopia. *Ethics and Information Technology*, 4(3), 205–216. doi:10.1023/A:1021368426115 PMID:15977362
- Webster, E., & Paquette, J. (2023). “My other hand”: The central role of smartphones and SNSs in Korean students' lives and studies. *Computers in Human Behavior*, 138, 107447. doi:10.1016/j.chb.2022.107447

Zabolotna, K., Malmberg, J., & Jarvenoja, H. (2023). Examining the interplay of knowledge construction and group-level regulation in a computer-supported collaborative learning physics task. *Computers in Human Behavior*, 138, 107494. doi:10.1016/j.chb.2022.107494

ENDNOTE

- ¹ The term *cybergenre* in Shepherd and Waters (2002) is a combination of the words *cyber* and *genre*, where *genre* is used as a synonym for *type*. Thus, the term *cybergenre* could be used in a wider context, for example, in relation to research methods, not only textual materials, as it was in Shepherd and Waters (2002).