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Review article

A literature review of children's and youth's conceptions of the internet

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ABSTRACT

The Internet has become an important environment in everyday life of children and youth. Consequently, understanding basic Internet concepts has been listed as a target competence in many school curricula. However, any constructive approach to teaching concepts of the Internet should take into account learners' initial conceptions, shaped by daily experiences, that they bring into the classroom. Based on a systematic literature review of research published between January 2000 and March 2022, we synthesized more than 400 descriptions reported by children and youth and classified them into five categories: (1) the structure of the Internet, (2) responsibility for the operation of the Internet, (3) web search engines and their function, (4) transmission techniques and (5) services of the Internet, as well as into subcategories that encompass commonly found kinds of conceptions within these categories. In addition, we classified all conceptions into three types: (1) intuitive, (2) elaborate and (3) misconception. The results show that children and youth hold more intuitive than elaborate conceptions. They also hold many misconceptions in all five categories. Although it has been suggested that age or user's online experiences may be important factors for shaping elaborate conceptions about the Internet, we observed that many intuitive conceptions and misconceptions seem to be persistent across different age groups. This indicates that these factors, although necessary, but may not be sufficient for developing adequate conceptions. Instead, we argue that an elaborate conception of the structure of the Internet requires explicit learning and instruction. Finally, we explain implications of our findings for education and for future research.

Contents

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1. Introduction

The Internet has become an important environment in everyday life also for children and youth. According to a study in Canada, already in the 2000s about 50% of Grade 4 children accessed the Internet for homework and this percentage rose with age (Spears et al., 2005). The results of a more recent study showed that most children in Switzerland grow up in media-rich households and media experiences shape their everyday lives (Genner et al., 2017). Other studies in Switzerland and Germany confirm that mobile phones and the Internet use is a major part of the everyday life of youth (Suter et al., 2018). In addition, the organization for Economic Co-operation and Development (OECD) with 37 member countries reported that 55% of 15-year-old students connect to the Internet or search the Web for schoolwork at least once a week (OECD, 2015). Finally, according to a report from the Pew Research Center, in the 2010s nearly all U.S. teens aged 13 to 17 reported using the Internet on a daily basis (Lenhart, 2015).

Although children and youth are increasingly using the Internet, results of several empirical studies revealed that most of them do not have a proper understanding of the Internet and its basic concepts (Edwards et al., 2018; Eskela-Haapanen & Kiili, 2019; Mertala, 2019). Policy makers have recognized the importance of basic knowledge about Internet concepts for using services of the Internet efficiently and, therefore, have started to integrate them in school curricula. Many countries across the world have formulated explicit targets for the development of basic understanding of Internet concepts and for effective use of services of the Internet from an early age (Anderson et al., 2002; Brinda et al., 2008; D-EDK, 2016; Department for Education, 2013; National Research Council, 1999; Skolverket, 2018). For example, national school curricula aim at fostering a general understanding of computer networks such as the Internet (Department for Education, 2013), or understanding of the Internet as a place for obtaining and evaluating information (D-EDK, 2016; Skolverket, 2018). The UNESCO curriculum (2002) states that at the end of secondary school, students should: (1) be able to demonstrate an understanding of the local network in use in relation to the external network (typically the Internet) and the use of email [on p. 67], (2) be aware of the connectivity of computers in a local and an external network and be familiar with the appropriate functions of such networks [on p. 68], (3) understand the various means of electronic communication such as electronic mail, chatting and mailing list, use of the Internet and the World Wide Web [on p. 79], (4) be able to retrieve information by navigating, searching and selecting information from the Internet and the World Wide Web [on p. 79], (5) be critical about the quality of all information, and acknowledge the ownership and privacy aspects of information [on p. 79].

Several empirical studies have investigated how children and youth understand the Internet's structure. For example, Papastergiou (2005) investigated the mental models of high school students (aged 12 to 16) about the structure of the Internet. More than half of the participants held the misconception that the Internet is a big central computer and that a single authority controls the operation of the Internet. More recently, Kodama et al. (2017) investigated fifth to eighth graders' mental models of the Google search engine. More than half of all drawings (65%) represented Google like a person or people working to find information on behalf of the user. Diethelm, Wilken, and Zumbrägel (2012) showed that, in the context of electronic communication, such as email or messaging, many students hold the misconception that there is a direct connection between two computers, whereas in reality, the communication is done over many servers and routers. Other studies also have stressed students' challenges with evaluating Internet resources. For example, children and youth tend to believe that the Internet is the most credible source of information, and that everything on the Internet is valid and reliable (Eskela-Haapanen & Kiili, 2019; Rowlands et al., 2008).

The results of these empirical studies clearly show that children and adolescents do not arrive in their computer sciences classes as blank slates. In contrast, they have already started to develop various naive conceptions and misconceptions about the structure of the Internet early on. Constructivist learning and teaching approaches stress the importance of gaining an overview and understanding of such early conceptions, because they form the starting point for teachers to instruct their students. In order to support learners to gradually build up more scientific conceptions, the conceptual change-literature also emphasizes taking their initial conceptions into account (Carey, 2000). Building on similar ideas, the model of *Educational Reconstruction*, proposed by Kattmann et al. (1997) as a framework for research and development in science education, postulates that when designing their learning environments, teachers should bring together two elements, namely (1) the student' perspectives regarding the chosen subject and (2) the clarification analysis of the science content. Later, Duit (2007) elaborated the educational reconstruction framework by adding teacher processes and conceptions to the student perspectives element and by further specifying the analysis of content structure, most notably by adding the analysis of educational significance to this element. Based on the framework of Kattmann et al. (1997) and Duit (2007), Diethelm, Hubwieser, and Klaus (2012) presented an adaption for computer science education, adding three elements to the Kattmann

model, namely (1) the selection of computer science phenomena, (2) the investigation of teachers' perspectives, and (3) the analysis of social demands, which is the same as the educational significance of the learning content, as also presented by Duit (2007).

Diethelm, Hubwieser, and Klaus (2012) stress the importance of respecting all types of students' perspective as a separate element in this framework. By students' perspective, they do mean not only misconceptions, but also other conceptions that students bring into the classroom. Taking this into account, this systematic review focuses on the concept of the Internet and the investigation of students' perspectives, namely various conceptions that students have shaped about the Internet. Rücker and Pinkwart (2016) have already conducted a systematic review children's conceptions about computers. However, apart from a brief overview given by Mertala (2019), such a systematic investigation is still missing for Internet conceptions. Over the last 20 years, many qualitative studies have been conducted in this domain. It is now time to bring together the results of these separate studies, summarizing across different methodologies, countries and age groups, to draw conclusions about their variety and frequencies. The aim of this systematic review is to answer the question what particular conceptions and misconceptions children and youth have about the Internet. To this aim, we conducted a systematic literature search, located relevant studies and, from these, collected the descriptions of children and youth. Next, we categorized these descriptions into five main concept categories: (1) the structure of the Internet, (2) responsibility for the operation of the Internet, (3) web search engines and their function, (4) transmission techniques, and (5) services of the Internet. Within the five main categories, we inductively defined subcategories and sub-subcategories. Subsequently, we assigned the descriptions to three types of conceptions: (1) intuitive conception, (2) elaborate conception and (3) misconception. Finally, we indicated if children used an analogy in their descriptions, as analogies are often used by teachers to explain concepts and ideas.

The remainder of this article is outlined as follows. In Section 2, we present the terminologies that we used throughout this review. In Section 3, we provide a reference definition for a complete scientific conception of the Internet and its various aspects considered in this review. Then, in Section 4 we discuss in depth the systematic search method. In Section 5, we review the distinct conceptions that we were able to identify in the literature to address our research question. In Section 6, we summarize and discuss the results. Moreover, based on our observation from the literature, we discuss whether technology's progression may change children's and youth's conceptions over time, and whether age and experience may have a role on developing adequate conceptions about the Internet. We provide potential avenues for future research and address limitations of our review. Finally, in Section 7 we present our conclusion.

2. Related work and terminologies

Before elaborating on the working definitions and terminologies that we use in this review, we start by giving an overview of the various terms used in the literature to describe and label ideas and beliefs about a specific concept.

Two frequently used terms are mental model and conceptual model. Although mental models and conceptual models differ from one another, they have often been used interchangeably in the literature. According to Norman (1987), a conceptual model is a scientifically appropriate representation of the concept, invented by the scientist, educator or system designer to help the learner form a correct internal representation of the underlying concept. For mental models, on the other hand, one cannot provide a general definition, as this term is used differently in different contexts (see Jones et al., 2011). In all the relevant literature for this review, mental models are defined as internal representations that learners form about the concepts that evolve through their experience. According to the constructivist perspective, learners actively and recursively construct their knowledge on the basis of their prior knowledge (Ben-Ari, 1998), that is, learners constantly build different mental models through their experiences.

Other relevant terms are concept and conception, which are sometimes used in the literature synonymously and stand for mental representations of what something really is (see Sawyer, 2019; Weiskopf, 2008 for discussions on this distinction). In this review, we consider a *concept* as a general notion or an abstract principle, and a *conception* as the sum of one's understanding, ideas, imaginations and beliefs concerning a concept.

Over the years researchers have differently categorized children's and youth's statements about the Internet. For instance, Papastergiou (2005) used these four categories: (1) simplistic, naive or vague responses, (2) responses that comprise elements of scientific thought, but are erroneous, (3) responses that comprise elements of scientific thought, but are incomplete, and (4) scientifically correct and elaborate responses. To provide another example, Yan (2005) and Yan (2006) used the following categories: (1) minimal, (2) partial, (3) sophisticated, and (4) scientific level. For this study we avoided using the terms *simplistic*, *naive*, *vague*, *minimal* or *partial*, since we believe that children's and youth's conceptions deserve to be considered as valuable source of information, and as Mertala (2019) also emphasizes, these labels seem disrespectful. We also avoided using the terms *incomplete*, *sophisticated* or *scientifically correct* conceptions, since from what we observed in the literature, it barely happened that participants' responses would cover all aspects of the subject in response to a question being asked. Moreover, based on the results of the studies that we reviewed, it could never be determined with certainty how the participants of these studies would have been able to explain the whole subject or further aspects of the subject in response, had they been asked further targeted follow up questions. Therefore, for this study, we used three kinds of conception types: (1) intuitive, (2) elaborate and (3) misconception. We developed our definitions based on the conceptual change-literature, as this is probably the most important strand of research concerned with conceptual development from an educational perspective (for an overview, see Carey, 2000).

Throughout this review, we use the term *Intuitive conceptions* for conceptions that children build through their daily experiences and social interactions. The term intuitive conception stems from the conceptual change-literature, and is used to describe conceptions that individuals start by developing rather simple generalizations to help explain everyday phenomena (Linn & Songer, 1991). For example, when seeing that heavy objects such as stones sink in water, children can develop the idea that heaviness must be the decisive characteristic that makes objects float (Edelsbrunner et al., 2018). In the context of children's conceptions of the Internet, intuitive conceptions are either beliefs, ideas, general facts and descriptions attributing some general function to the Internet and its services (e.g., what purpose it serves or what can be done online, what advantages or disadvantages the Internet has) or they are mixed, partially correct, ideas, which cannot be linked together correctly (e.g., "Google worker gets any information that he can find, so it can be true, false, anything"). In some cases, intuitive conceptions are imprecise descriptions, in which the scientific vocabularies and terms to express these thoughts and ideas are missing (e.g., some participants argued that for addressing data, the use of a number

is required). In the literature on conceptual change, intuitive conceptions are commonly linked to misconceptions (Edelsbrunner et al., 2018). Note, however, that in our review intuitive conceptions do not indicate incorrect conceptions of the Internet.

We use the term *Elaborate conceptions* for conceptions that comprise elements of scientific thought and indicate an elaborate understanding of the subject (see Section 3 for our reference definition of the Internet). Some descriptions in this conception category consist of scientific terms and are expressed elaborately (e.g., the Internet consists of local and wide area networks connected among them). However, others comprise several ideas linked together without any use of scientific terms but still indicating an elaborate understanding of the subject (e.g., not everything on the Internet is true, because anyone can put a site on the Internet). In some cases, elaborate descriptions are simply correct facts indicating a reasonable awareness of the discussed subject, for which a further scientific explanation is not expected (e.g., search engines are tools to search or to navigate the Web). The latter example shows that the term scientific conception that has often been used in the conceptual change-literature (e.g., Carey, 2000; Edelsbrunner et al., 2018) is not adequate for describing the children's conceptions of the Internet that are typically reported in the literature. We therefore avoided using the term scientific conception and instead settled on "elaborate conception".

Finally, we use the term *Misconceptions* for scientifically incorrect conceptions (e.g., the Internet is managed by one big central computer). Misconceptions are those conceptions that deviate from the expert view and are formed when learners try to make sense of the world around them with limited and erroneous understanding of scientific concepts (Edelsbrunner et al., 2018; Ohlsson, 2009).

For every conception, we also indicated if it involved a metaphorical or analogical description. We are aware that metaphors and analogies differ from one another and have been used and defined in various ways in education literature (see Aubusson et al., 2006 for a discussion on the distinction between analogy and metaphor). For the purpose of this paper we use *analogy* to indicate that the learner tried to find another simpler way to explain abstract ideas in familiar terms. Sometimes they did this with a metaphor when they had no prior knowledge or particular thoughts of the concept (e.g., the Internet is magical) and sometimes they provided an analogy either showing misconceptions (Google is something like a lobby of the Internet) or showing awareness of the similarities and differences between the Internet concept and the object to which they compare it (e.g., describing the Internet like streets with many junctions: At these junctions there are signs to show the way. On the streets there are houses with addresses. And so it is possible to send a message to a certain house). In our classification, metaphors were typically linked to intuitive conceptions whereas analogies could reflect both intuitive or elaborate conceptions or even misconceptions.

3. Our reference definition of the Internet

Even for adults and many expert users of the Internet, giving explicit and broadly accepted answers to the question "*What is the Internet and how does it function?*" is not straightforward. Similar to the question "*What is a human being?*", providing an appropriate answer depends on the context, aims and audience. For example, human beings can be described from biological or anatomical but also from psychological, social, or spiritual perspectives. However, in order to classify children's and youth's conceptions, we needed a reference for a complete scientific conception of the Internet and the aspects we considered for this research. The working definition we present here could be interpreted as part of "the clarification of science content structure" element of the educational reconstruction framework for computer science education from Diethelm, Hubwieser, and Klaus (2012).

The Internet can be described from economic, technical, and social perspectives. In addition, the transmission of data on the Internet is comprised of several layers (OSI model), which are coordinated in a vertical hierarchy (Day & Zimmermann, 1983). When we talk about the information being communicated via the Internet, it is important to know through which layer. For example, when data is transmitted via the Internet, in the transport layer it is broken into packets, in the physical layer it is transmitted as a series of 0s and 1s between network nodes via physical cables or wireless connections, raw data is transmitted as a series of 0s and 1s, while taking care of the transmission rate. On the contrary, in the application layer, data is transmitted and presented as whole and meaningful to the user. For the purpose of this review, we define the Internet and its functions as follows:

The Internet is a distributed system that connects millions of computers all over the globe by connecting smaller computer networks to one global network. The connection consists of routers mostly connected by copper wires, glass fibres and radio waves. Due to its redundant network structure, some devices can also fail without affecting the overall system.

The Internet is used for many different services, such as sending emails, instant messaging (IM) or streaming media. The exchange of data between computers that belong to a network is done over many servers and routers, while maintaining the set of Internet communication protocols (TCP/IP). In this layer, data is not sent or received as a whole, but is broken down into units called packets and they find their path through the Internet by using the unique address of each device connected to the Internet. The role of routers is to sort the data packets and pass them on to the next router to ensure that they end up on the right device on the network.

The World Wide Web, or the Web, is the most frequently used service of the Internet, containing websites, webpages and other files and transferring them with a standardized protocol (HTTP). Using computer programs called web browsers, people view, interact, and contribute to websites. Webpages use hypertext markup language (HTML) to describe the page content for the browser software. A server either generates HTML dynamically or serves static files or chunks of media files to the requesting client.

Millions of people use the Web via web search engines — websites that help users to search and find information on other websites. When the keyword(s) are entered into the search box of a specific search engine, such as Google, the system looks for matches between the entered keyword(s) and its database of webpages (the index), previously crawled and indexed at regular intervals. Using algorithms, the list of webpages that contain matches to keywords that were searched are ranked and enriched with advertisements and recommendations based on various criteria.

From a social and economic perspective, there are many parties involved, including Internet Service Providers (ISP), universities, companies and individuals, which are responsible for the exchange of data on the Internet and the content of the World Wide Web. The operation of the Internet is thus depending on the shared agreement and responsibility of all these parties worldwide. Therefore, no single organization or authority owns or controls the Internet. Some countries regulate the access to the Internet, for example restrict users from accessing specific sites on the World Wide Web. Also, a considerable proportion of all humans on earth still do not have access to the Internet at all.

4. Method

In this section, we describe the systematic search method that we used to answer our research question. To locate relevant literature in English, we followed the PRISMA-S description procedure (Rethlefsen et al., 2021). A PRISMA-S checklist is provided in Table A.2 in the online Appendix [LINK]. Items 3, 6 and 11 of the PRISMA-S checklist are not applicable for our search. Furthermore, we conducted a hand search of papers in German. The procedure we followed for this part of the search will also be described in the section below.

4.1. Literature search and selection of relevant papers

Before starting our systematic search, we conducted a preliminary search to gain a first understanding of the different search terms and their combinations, and to identify key publications in this area. On Google Scholar, we combined search terms like *conception*, *mental model*, and *perception* with terms such as *children*, *students*, *Internet*, *search engines* and *Web*. This approach led to an initial set of 10 relevant publications and a pool of keywords.

Next, we searched a comprehensive selection of search platforms and databases to avoid missing any relevant literature. Via the search platform ProQuest we searched two databases: ERIC and APA PsycArticles, and via the platform Web of Science (WoS), we searched the Web of Science Core Collections. Finally, the three databases Scopus, ACM and IEEE Xplore Digital Libraries were searched. We selected ERIC and APA PsycArticles as they are two of the largest databases with core collections in the area of social and behavioral sciences, learning and education, developmental psychology, and psychology of education. WoS Core Collections and Scopus are both comprehensive interdisciplinary databases encompassing articles from workshops and conference proceedings, journals and other sources. Since in the field of computer science, workshop and conference proceedings are considered to be the main source for publishing, these two data bases were of special relevance for our literature search. Finally, we selected the ACM and IEEE Xplore digital libraries as they are considered to be the most comprehensive databases for computer science and information technology literature.

The Internet has become an integral part of children's and youth's everyday lives in the last twenty years (Genner et al., 2017; Spears et al., 2005; Suter et al., 2018). Therefore, we started our search from January 2000 to November 2021. Auto Alerts were set up to provide weekly updates of new literature until March 31, 2022.

Before executing the final search, the search strategies were checked by the third and the last authors to identify errors, missing keywords and other possible issues within our search strategies. For the reproducible searches for all databases we refer the reader to Table A.3 in online Appendix [LINK].

We used the following keywords for our final search: *Internet*, *Web*, *search engine* and *Google*. Since the focus of this review is on research investigating children's and youth's conceptions of the Internet and search engines, these keywords were first crossed with *concept**, *conception**, *mental model*, *conceptual model*, *beliefs*, *perception**, *understand**, *think**, *misconception*, *conceptual understanding*, *cognition*, *model* and then crossed with *child**, *student**, *youth*, *young users*. Moreover, we filtered studies that focused on *graduate*, *undergraduate*, *college*, *university* or *postgraduate* students. For every database various restrictions were added to further tailor the selection to the subject of this review.

This approach led to an initial sample of $n = 220$ publications in ProQuest, $n = 258$ publications in WoS, $n = 288$ publications in Scopus, $n = 81$ publications in ACM and $n = 35$ publications in IEEE Xplore. All the retrieved articles were exported into a reference manager software (Zotero, 2006) for further selection and analysis. Merging the results of this approach and eliminating the duplicates led to an initial literature database of $n = 479$ publications.

As this review aims at synthesizing children's and youth's understanding of the concepts related to the Internet, publications were only included if they met all of the following four criteria: The studies were (1) based on empirical data, (2) related to concepts of the Internet, World Wide Web or search engines, (3) situated at the school level, namely, in kindergarten, primary, lower or upper secondary level, and (4) published as peer-reviewed journal article, workshop or conference proceedings paper, or review. Using these four criteria, we first scanned the titles of the selected publications, which resulted in the elimination of $n = 431$ items. Second, we read the abstracts and, when still in doubt, the full texts. From the $n = 26$ articles that were fully screened, finally, we selected a total collection of $n = 19$ relevant publications (see Table 1). At this final step, seven articles were excluded because they were focusing on *Internet search skills*, *perceptions about advantage and disadvantage of the Internet*, *cyber-safety awareness* and *Internet beliefs and online help seeking*. Besides, one article from Scopus was originally in German, which has already appeared in our German paper search, and one article was a review on understanding of and use of Internet-based devices.

In addition to the search in the databases described above, we conducted a hand search of proceedings of well-known workshops and conferences held in German-speaking countries. We chose the proceedings of three workshops and conferences: *proceedings of Informatik und Schule (INFOS)*, *proceedings of Workshops der GI-Fachgruppe "Didaktik der Informatik"* and *proceedings of Fachtagung zur Hochschuldidaktik Informatik (HDI)*. We undertook a title screening of tables of contents of these proceedings, further examining studies whose titles indicated a relation to the topics of this review. This approach led to $n = 12$ additional articles for further analysis, from which $n = 4$ were considered as relevant. The 8 excluded publications were those focusing on teachers' mental models, Internet in computer science classes and didactic approaches to explain the structure and function of the Internet or they were non-related intervention studies.

Lastly, the reference lists of all $n = 19$ selected sources were manually scanned to identify additional possible relevant sources that were still missing in our database. This led to another $n = 7$ relevant publications. Merging the $n = 4$ relevant German literature and the results of the last two steps led to a final literature database of $N = 30$ relevant publications. A PRISMA flow chart summarizing the article selection process is presented in Fig. 1.

Because subscription-based platforms like ProQuest and Web of Science may deliver slightly different results depending on the institution through which one accesses them (Gusenbauer & Haddaway, 2020), the first and the fourth authors conducted the same search method separately via two different institutional login accounts and saved the publications in two separate Zotero reference managers (Zotero, 2006). Whilst ACM and IEEE Xplore digital libraries and Scopus provided the same search results, we found some differences between the search results of the first and fourth author for Web of Science (WoS) and ProQuest. First, on WoS the first author found $m = 258$ publications whereas the fourth author found only $n = 154$ publications and as a result missed 2 relevant articles (Gecer & Topal, 2013; Kamishlian, 2010). Second, in the ProQuest database, the fourth author found 3 more publications than the first author, but missed another relevant article.

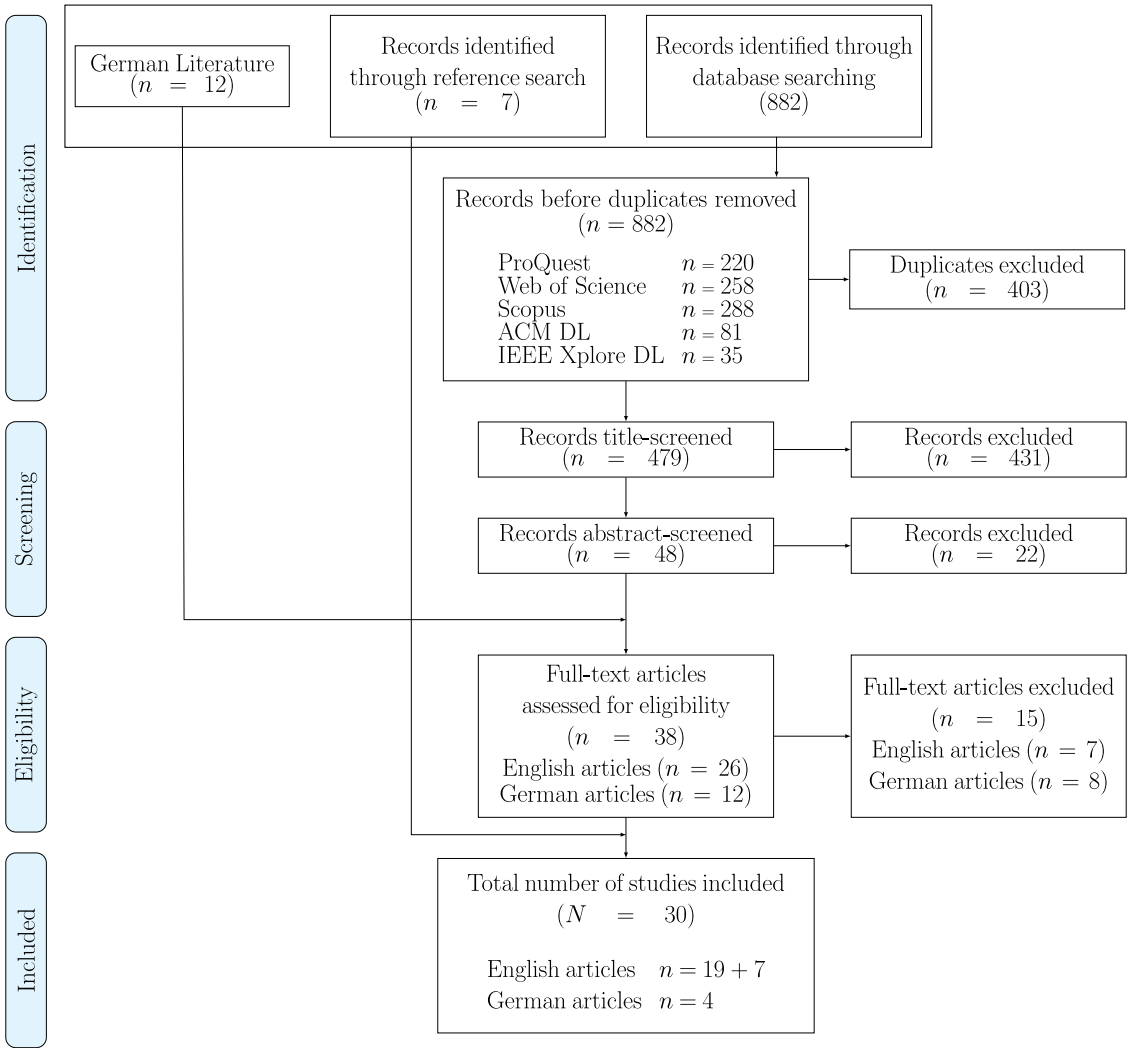

Fig. 1. Schematic representation of the literature search and selection process.

4.2. Characteristics of included studies

The first author extracted information about the selected publications, such as year of publication, sample characteristics, geographical location and applied methods (e.g., interviews, instruments and data analysis) (see Table 1 for an overview). The fourth author then checked these details for the first five studies in the Table and retrieved the same information. All studies contained children's descriptions of the Internet, which were obtained by standard methods of research like interviews, questionnaires and/or drawing tasks. We did not see any reasons to exclude one of the studies based on lack of research quality. The age of the participants in the selected studies ranged from kindergarteners to high-school students and the participants came from diverse cultural backgrounds and different countries, such as Australia (2 articles), England (1 article), Finland (3 articles), France (1 article), Germany (4 articles), Greece (2 articles), Jordan (1 article), Sweden (1 article), Switzerland (1 article), Taiwan (3 articles), Turkey (3 article) and USA (8 articles) (see Table 1 for an overview). In all, this set of 30 papers seems representative enough to draw conclusions about Internet conceptions of children and youth. However, as the number of studies per country was small, it did not seem appropriate to analyze effects of specific factors and conditions like culture or country on these conceptions.

4.3. Extracting the descriptions from the papers

To clarify what kind of statements or descriptions to extract from the relevant publications, the first and the fourth authors first read 2 randomly selected articles. The main purpose of this was to discuss and clarify the process of extracting descriptions according to the established criteria in Section 4.1. At this step, not only misconceptions, but also all other descriptions representing any ideas from participants (some almost correct and some just representing some associations to everyday life experiences), were collected. Some descriptions were the exact words from the participants and some had been reformulated by the authors of the studies. Some authors' descriptions were also related to products of drawing tasks. This approach for collecting the relevant descriptions gave us the chance to get a larger overview of children's and youths' conceptions of the Internet.

After establishing a consistent approach for collecting relevant descriptions, authors one and four continued independently reading 4 other selected publications to extract and collect all children's and youth's descriptions. This step was explicitly meant for finding the inter-rater agreement percentage in extracting description from the reviewed articles. Following this approach, both authors extracted in total 53 descriptions: author one extracted 50 descriptions, whereas author four extracted 51 descriptions, with an overlap of 48 descriptions corresponding to

Table 1
Overview of the sources found in the literature.

No.	Source	Publication type	Method	Sample size	Participants age or grades	Location
1.	Slone (2002)	Journal	Interviews	31	< 13 yo	North Carolina, USA
2.	Enochsson (2004)	Journal	Interviews	30	9–12 yo	Sweden
3.	Tsai (2004)	Journal	Interviews	40	Gr. 10–11	Taiwan
4.	Papastergiou (2005)	Journal	Questionnaire survey & Drawing task	340	12–16 yo	Greece
5.	Yan (2005)	Journal	Questionnaire survey, Interviews & Drawing task	83	5–12 yo	USA
6.	Tsai (2006)	Journal	Questionnaire survey	83	Gr. 7–8 & 10–11	Taiwan
7.	Yan (2006)	Journal	Questionnaire survey & Drawing task	332	Gr. 4–8	New England, USA
8.	Hammond and Rogers (2007)	Journal	Individual & Grouped interviews	9	9-12 yo	England
9.	Tsai (2007)	Journal	Questionnaire survey	322	17 yo	Taiwan
10.	Ersoy and Türkkan (2009)	Journal	Interviews & Drawing task	23	Gr. 4	Turkey
11.	Koufou et al. (2009)	Journal	Questionnaire survey	6	Gr. 6	Greece
12.	Yan (2009)	Journal	Questionnaire survey & Drawing task	681	9–17 yo	USA
13.	Diethelm and Zumbrägel (2010)	Proceedings	Interviews	23	13–14 yo	Germany
14.	Kamishlian (2010)	Proceedings	Interviews, Drawing task & Think-Aloud-Method tasks	5	11–12 yo	Cambridge, USA
15.	Esgi and Cevik (2010)	Journal	Drawing task	65	Gr. 5–7	Turkey
16.	Dinet and Kitajima (2011)	Proceedings	Drawing task	51	10–14 yo	France
17.	Dodge et al. (2011)	Journal	Interviews & Drawing	37	KG-Gr. 2	USA
18.	Diethelm, Wilken, and Zumbrägel (2012)	Proceedings	Interviews	23	13-14 yo	Germany
19.	Gecer and Topal (2013)	Journal	Questionnaire survey	524	Gr. 6–8	Turkey
20.	Seifert et al. (2013)	Proceedings	Interviews	5	13–15 yo	Germany
21.	Brinda and Braun (2017)	Proceedings	Interviews	12	9–11 yo	Ruhrgebiet, Germany
22.	Kodama et al. (2017)	Journal	Drawing followed by recorded verbal descriptions	26	10–14 yo	Washington D.C, USA
23.	Edwards et al. (2018)	Journal	Interviews	48	4–5 yo	Australia
24.	Murray and Buchanan (2018)	Journal	Grouped interviews & Drawing task	33	10–12 yo	NSW, Australia
25.	Oliemat et al. (2018)	Journal	Interviews	40	KG-Gr. 2	Jordan
26.	Bilal and Zhang (2019)	Proceedings	Questionnaire survey	38	10–18 yo	USA
27.	Eskela-Haapanen and Kiili (2019)	Journal	Interviews	30	7–9 yo	Finland
28.	Mertala (2019)	Journal	Interviews & Drawing task	65	5–7 yo	Finland
29.	Waldvogel (2019)	Proceedings	Drawing task	42	< Gr. 6	Switzerland
30.	Mertala (2020)	Journal	Interviews	33	3–6 yo	Finland

90.56% inter-rater agreement. The high percentage agreement at this step showed a reliable and consistent approach for extracting the relevant descriptions with the established criteria. Therefore, the first author continued alone to extract the relevant descriptions for the remaining 24 papers. Eventually, she selected a total of 420 descriptions.

4.4. Categorizing the descriptions

After the descriptions were collected, they were sorted into two predefined categories:

1. Structure of the Internet, including descriptions reflecting conceptions of what the Internet as a physical entity is,

conceptions of the distributed storage of information and how the Web can be distinguished from the Internet.
2. Web search engines and their function, covering descriptions reflecting conceptions of how search engines work and rank the results and how they can be distinguished from other services of the Internet as well as conceptions of evaluating the quality of information found on the Internet.

During the coding process, three more categories were added:

3. Responsibility for the operation of the Internet, including conceptions of the existence of a distributed and shared responsibility for the operation of the Internet worldwide.
4. Transmission techniques, encompassing descriptions reflecting conceptions of various means of transmission of data between devices belonging to a network.
5. Services of the Internet, covering the functioning of two widely used services electronic communications (e.g., E-mail and chat) and video streaming.

The first, second and final author then proceeded to sort the descriptions into the five main categories. Next they constructed subcategories and classified some of the subcategories further into sub-subcategories. In the category *structure of the Internet*, 3 subcategories were constructed: (1) the Internet as an entity with no conception of structural components, (2) the Internet has a structure: components, devices, technologies enabling connection and networks, and (3) network storage structure: Information storage and its origin on the Internet. The second category *responsibility for the operation of the Internet* does not include further subcategories. Within the third category *Web search engines and their function* 4 subcategories were constructed: (1) distinguishing between a search engine (mainly Google), a web browser, the Web and the Internet, (2) search engines' functional aspects, (3) search engines users' data privacy and their business model, and (4) search results evaluation and trustworthiness of online information. The fourth category *transmission techniques* covers two subcategories: (1) physical transmission, packeting, speed and (2) addressing. Finally, the category *services of the Internet* included 2 subcategories: (1) electronic communication and (2) streaming. See Table 2 for an overview of all categories and constructed subcategories.

Next, the first and second author together classified the descriptions based on two further characteristics. First, according to type of conception: intuitive, elaborate or misconceptions, and second on whether or not the description included an analogy.

To inspect inter-rater reliability, author 4 underwent a training process in which she was instructed about all the working definitions and terminologies. Then, she classified a random selection of 50 descriptions independently into the predefined categories, subcategories, and sub-subcategories as well as three types of conceptions and whether or not the description included an analogy. To determine the degree of agreement with the first authors' coding for the different kinds of categories, Cohen's k was calculated. We also intended to compute Gwet's AC1 (Gwet, 2014), which was not possible due to sparse data in some categories. The estimated inter-rater reliabilities for this sample of descriptions were $k = 0.80$, CI90[.68; .92] for categories, $k = 0.84$, CI90[.74; .94] for subcategories, $k = 0.63$, CI90[.48; .78] for kinds of conceptions, and $k = 0.36$, CI90[.21; .50] for analogies. As we intended to reach inter-rater reliability of well-above 0.60 for each kind of category, the two raters discussed inconsistencies and refined definitions and rules for border cases. Discussions showed that the sufficient yet not excellent average agreement for conceptions was mainly due to the difficulty to define a clear border between intuitive and elaborate conceptions. For instance, some descriptions were a mixture of correct and incorrect thoughts (e.g., *Google worker gets any information that he can find, so it can be true, false, anything.*) and some descriptions, although arising from scientific thoughts, were imprecise and the scientific terms and vocabularies were missing (e.g., *Not everything on the Internet is true, because anyone can put a site on the Internet*). In order to deal with such descriptions, we extended and clarified our definitions of the three kinds of conceptions (see Section 2 for the finalized definitions). The minor disagreements for codings of categories, subcategories, and sub-subcategories arose from the fact that some descriptions could be sorted into more than one category, subcategory and/or sub-subcategory. For instance, the description *videos are pushed through the cables as whole* can be sorted into both categories 4 and 5, in subcategories "physical transmission, packeting, speed and bandwidth" and "streaming", respectively. Therefore, we set the rule to sort such descriptions into more than one category, subcategory and/or sub-subcategory. After refining the category definitions and rules, author four repeated classifying another list of 75 randomly selected descriptions with the new rules. This time, the estimated inter-rater reliabilities were $k = 0.96$, CI90[.91 ; .94] for categories, $k = 0.93$, CI90[.87; .99] for subcategories, $k = 0.83$, CI90[.74; .93] for sub-subcategories, $k = 0.84$, CI90[.75; .93] for kinds of conceptions, and $k = 0.81$, CI90[.67; .96] for analogies. The high Cohen's k in this step showed a reliable and consistent approach. The remaining discrepancies and disagreements could be easily resolved through discussions. Author 1 adjusted the codings of all remaining descriptions based on the revised definitions and rules.

5. Children's and youth's conceptions of the Internet

In this section, we summarize the main results of the literature review per concept category 5.1–5.5 and discuss in depth the outcomes that answer our research question. For each category, we present an overview of children's and youth's descriptions and describe a few key examples from the papers (see Table 2). For the complete list of children's and youth's descriptions, we refer the reader to Table A.1 in the online Appendix [LINK].

5.1. Structure of the Internet

For the first concept category "Structure of the Internet" we synthesized three Sections 5.1.1–5.1.3. With 319 descriptions, this category is the largest in this review.

5.1.1. The internet as an entity with no conception of structural components

Most of the descriptions and drawings in this subcategory seemed to indicate that the interviewed children and youth had not had the opportunity to think or learn about the infrastructure of the Internet yet. All the statements were intuitive, reflecting a lack of any awareness or knowledge about the technical or structural components of the Internet.

Metaphorical descriptions of the internet. In a few studies, children and youth explained their ideas about the Internet by focusing on comparisons or made analogies between the Internet and objects or experiences from their everyday lives, such as books or libraries (Enochsson, 2004), a key, a sun or even a person who knows everything (Gecer & Topal, 2013), a big brain, electronic dictionary or the world (Murray & Buchanan, 2018), toys or magic (Slone, 2002), or as guiding a tour (Tsai, 2006). All 23 descriptions in this sub-subcategory are intuitive conceptions and indicate a lack of knowledge about the technical aspects or the physical structure of the Internet.

Table 2
Numbers of different kinds of conceptions per concept category and subcategory, including examples of children's and youth's descriptions within each subcategory.

(Sub-) Category label and example description	Number of conceptions per (Sub-) Category			
	Intuitive	Elaborate	Misconception	Analogy
Category 1. Structure of the Internet				
Subcategory 1.1. The Internet as an entity with no conception of structural components	173	–	–	76
The Internet is like a big brain.	✓			
Subcategory 1.2. The Internet as a network with conceptions of structural components	60	21	45	1
Well, it [the Internet] is in all computers.			✓	
Subcategory 1.3. Network storage structure: Information storage and its origin on the Internet	5	2	13	–
Webpages are stored in the modem.			✓	
Category 2. Responsibility for the operation of the Internet	3	5	7	–
The Internet is a device operated by man.			✓	
Category 3. Web search engines and their function				
Subcategory 3.1. Search engines as tools to carry out web searches	–	3	12	–
Search engines are tools to access the Internet.		✓		
Subcategory 3.2. Search engines' functional aspects	16	5	17	1
Google works when people research stuff and send it to Google for them to post online.			✓	
Subcategory 3.3. Search engines users' data privacy and their business model	3	5	2	–
Google collects data about everything and everyone.	✓			
Subcategory 3.4. Search results evaluation and trustworthiness of online information	7	5	4	–
Everything on the Net has to be true.			✓	
Category 4. Transmission techniques				
Subcategory 4.1. Physical transmission, packeting, speed and bandwidth	5	1	5	2
Signals are used by Smartphones as medium of transmission.	✓			
Subcategory 4.2. Addressing	2	3	1	3
In addressing of data a number is used.	✓			
Category 5. Services of the Internet				
Subcategory 5.1. Electronic communication	–	1	6	1
Communication by chat or IM is done by direct connections between devices.			✓	
Subcategory 5.2. Streaming	3	2	7	6
I think the central computer reads the video and sends the parts to us.			✓	
Total	**277**	**53**	**119**	**141**

Descriptions of the internet (often) limited to an opinion or fact, possibly with pros or cons. When asked about the Internet, instead of describing its structure as a technology, children and youth displayed their opinions about the Internet sometimes combined with the advantages or disadvantages that the Internet brought or might bring to their everyday life. Some children reported very common and general facts about the Internet, not implying any further knowledge about the structure of the Internet. They described the Internet as helpful, accessible or cool (Bilal & Zhang, 2019), an invention (Murray & Buchanan, 2018), informative or convenient (Slone, 2002), a useful tool or technology (Tsai, 2006). In Gecer and Topal (2013), participants used various interesting metaphors and described the Internet as addictive things such as chocolate, alcoholic drinks or a cigarette. We identified 46 descriptions for this sub-subcategory, which are all intuitive with no indication of knowledge about the technical aspects or the physical structure of the Internet.

The Internet as a place for online everyday life activities. When asked about the (nature of) the Internet, many children and youth replied with descriptions of activities that can be done online. Such conceptions originate in learners' daily experiences and do not seem to imply any particular misconceptions, but rather the absence of knowledge to describe the structure of the Internet. We identified 104 descriptions which were all intuitive conceptions representing the most widely reported conceptions in the searched literature. This ranged from kindergarteners, who typically mention specific activities one can do online, to as high-school students, who describe such activities in more abstract terms.

Mertala (2019) reported that 5-to −7-year-old children described the Internet based on specific functionalities, such as "Daddy has ordered ski boots for me" or "I go to YouTube". In another study from Mertala (2020), also 3-to −6-year-old indicated a similar pattern and used descriptions, such as "You can order pizza" or "You cannot watch YouTube if you do not have Internet". Eskela-Haapanen and Kiili (2019) reported that the majority of 7-to −9 year-old children described the Internet with general activities such as gaming, watching movies or paying bills, or as an information environment where one can find for example, pictures, texts and comments. Murray and Buchanan (2018) summarized that many 10-to −12 year-old children described or illustrated the Internet in terms of the activities that the participants engaged with online. They also saw it as a place

(e.g., to search on Google) or talked about the many benefits of being able to communicate with others on the Internet. Finally, Papastergiou (2005) reported similar findings with 12-to −16 year-old high school students, who gave more abstract and advanced descriptions of Internet functions, such as "information source" and "communication and entertainment medium".

5.1.2. The Internet as a network with conceptions of structural components

In this subcategory, children's and youth's descriptions reflected some intuitive conceptions about the technical aspects or the physical structure of the Internet. When asked about the Internet, many interviewed children and youth described components, devices and technologies (such as cables, modems, routers and telephone lines, or satellites) which enable Internet access. Although these descriptions showed awareness about the universality of the Internet and its existence as an entity, an adequate understanding about the underlying physical infrastructure of the Internet was still missing. However, we also observed that a few children and youth did mentally represent the Internet in terms of connections among computers or even among networks, which reflect elaborate conceptions.

The Internet and wireless network connection. At the moment, wireless connection is the most common type of broadband connection worldwide in everyday life. We found several indications, that the wireless connection influences and confuses children's and youth's conceptions of the Internet. We identified 13 descriptions from more recent studies, all indicating intuitive conceptions.

For example, Mertala (2019) reported that, as a result of this experience with the Internet as a wireless connection, many 5-to −7 year-old children imagined that the Internet was located in a specific place, such as at home, and therefore, the quality of the connection differed depending on how far or close they were to this location. For instance, one child commented "the Internet works if you are not too far away from the Internet". A few children also drew or described mobile routers as Internet and for example said "when this [router] is shut down nothing works except phone and televisions". Also in response to the question of "how does the Internet work", many children described occasions in which they had experienced Internet problems and what was done to fix them (e.g., when connection breaks, one has to go to the settings. Then it [Internet connection] works). Similar descriptions indicating conceptions about wireless connection were reported in other studies, as well (Brinda & Braun, 2017; Esgi & Cevik, 2010; Oliemat et al., 2018).

Distinguishing between online and offline mode. Because of the instant automatic wireless Internet connections many children, youth and even adults do not realize if and when they are online or offline. For example, in studies from Brinda and Braun (2017) and Mertala (2019), a few students believed that for communication purposes an Internet connection is required. On the contrary, 20% of the participants in the study from Mertala (2019) also commented that computers could be used for communication purposes and other services (i.e., E-mail, to pay bills or buy and sell stuff), without connecting these activities to the Internet use. The descriptions in this sub-subcategory indicate misconceptions and a lack of understanding about the difference between online and offline services.

The Internet described with its visible components and technologies that enable online access. Descriptions in this sub-subcategory reflected conceptions of the Internet as a composition of various devices such as user's computer, servers, routers, telephones, cables and other devices and technologies, which enable online access or are involved in connecting computers and users to the Internet. We identified 25 descriptions in this sub-subcategory, and classified them all as intuitive.

For example, in a few studies, the Internet was only seen in relation with electricity or described with wires and cables. Enochsson (2004) reported on children who, although they had not thought so much about the Internet as a network, assumed that there are wires connecting the Internet. In the study from Eskela-Haapanen and Kiili (2019) a few children thought that the Internet has something to do with electricity. Participants in Papastergiou (2005) explained the Internet consisted of, for instance, "cord", "many microchips", "many cables and devices", "telephone" or "modems".

The Internet and its relation to personal devices and their contents. In this sub-subcategory, we classified 5 descriptions as intuitive, reflecting seeing the Internet as something that is connected to devices. These included descriptions picturing the Internet as something connected to the back of a user's PC (Kamishlian, 2010), and to computers or other devices such as iPad and its content (Eskela-Haapanen & Kiili, 2019).

However, the other 14 descriptions reflected the misconception that the Internet is located inside devices. They included, for instance, conceptions of the Internet as a book in the computer (Enochsson, 2004), or as something located in users' devices (Edwards et al., 2018; Eskela-Haapanen & Kiili, 2019; Mertala, 2019; Murray & Buchanan, 2018; Papastergiou, 2005; Yan, 2005).

The Internet function described with satellites. This concept subcategory includes 5 descriptions that relate the function of the Internet, or even the storage and retrieval of information from the Internet to satellites, indicating misconceptions about the structure of the Internet. Although, new satellite Internet services, such as Starlink, provide satellite Internet access to a few countries, in the cited studies in this review satellite Internet Service was not meant. For instance, Enochsson (2004) reported on a fourth grader, who described the Internet consisting of computers all over the world, connected to each other through satellites (e.g., "I think it's a satellite thing or something . . . "). Interestingly, also Brinda and Braun (2017) reported on a few students who, although being aware that smartphones are connected to an extensive network, still thought that this connection takes place via a satellite. A few drawings in Papastergiou (2005) also involved elements like satellites and microwaves.

Descriptions about what servers are, where they are located and what they do. This sub-subcategory including 9 descriptions, consists of intuitive, elaborate conceptions and misconceptions, which reflect youth's conceptions about servers and their roles in the distributed system of the Internet.

As Papastergiou (2005) reported, when being asked "what do you think a server is and does", 55 students described the server "as a tool that helps users in certain tasks", reflecting intuitive conceptions. About 50 students also provided correct answers containing correct references to types of servers and their function as web-server software, describing them, for example, "as something (e.g. a program) that helps users in accessing information through the Internet". In the same study, servers were also described as the single central computer of the Internet that contains all the information or directs all the other computers on the Internet, or as a person that surfs the Internet, as a technician or an engineer, reflecting misconceptions. Seifert et al. (2013) also reported on some students, who talked about server rooms and the importance of keeping servers constantly cool and to avoid risks of excessive heat on servers, representing an elaborate conception of characteristics of servers.

The Internet in relation with the web and its content. Our literature review also showed that many children and youth falsely restricted their descriptions of the Internet to the Web, for instance drawing or describing the Internet as a collection of websites. We found only one elaborate conception in this subcategory, showing awareness of the distinction between the Web and the Internet (Papastergiou, 2005).

We classified the other 12 descriptions as misconception about the functions of the Web and its distinction from the Internet. For instance, the analysis of students' descriptions in Papastergiou (2005) confirmed that websites and web pages are often seen as main components of the Internet (68.5% of the responses). Also Kamishlian (2010) reported on a child who drew and then described the Internet as a collection of Websites accessed by search engines. Finally, Bilal and Zhang (2019) also reported that approximately 30% of their participants perceived the Internet as databases, web pages or information.

The Internet as a centralized system vs. a network of computer networks system. In this sub-subcategory, we collected 38 descriptions which seem to imply that children and youth understand the Internet as a centralized system, on the one hand, and as a distributed system, on the other hand. The descriptions varied from intuitive to elaborate conceptions as well as misconceptions.

Viewing the Internet as a centralized system, such as representing it as one big central computer or program is a broad misconception (Diethelm, Wilken, & Zumbrägel, 2012; Diethelm & Zumbrägel, 2010; Enochsson, 2004; Kamishlian, 2010; Papastergiou, 2005; Yan, 2005). Until 2012, such descriptions were widely reported in various studies. However, after that, they seem to have diminished. For example, Diethelm, Wilken, and Zumbrägel (2012) interviewed 23 13-to −14-year-old students. 40% of participants believed that there was one central computer somewhere, called "the Internet". However, the authors also reported on a few students who contradicted themselves during the interview. When they realized that their model of the Internet with one computer did not work, they changed their mind and talked about several central computers.

Many studies reported descriptions from children and youth indicating that they viewed the Internet as a distributed system. That is, they saw the Internet as a network, or even more elaborate, as a network of computer networks. Examples of intuitive conceptions are descriptions of the Internet as a network all over the world with certain functions, such as communicating with others (Enochsson, 2004) or a global-wide connection between information, people, computers, mobile phones, and webpages (Dinet & Kitajima, 2011). However, a few participants showed elaborate conceptions and described the Internet consisting of computers all over the world connected through bases or networks (Enochsson, 2004). In a few studies, participants draw the Internet as a network, a computer network or many computers connected to each other in some topology (Kamishlian, 2010; Papastergiou, 2005; Yan, 2005).

5.1.3. Network storage structure: Information storage and its origin on the internet

This subcategory consists of 20 descriptions indicating intuitive, elaborate conceptions and misconceptions from several studies. These descriptions reflect children's and youth's conceptions about webpage and information storage on the Internet.

In several studies, participants did not relate the origin of information to human activities in different networks. For instance, they claimed that "information is stored in some other secret or remote location" (Papastergiou, 2005), indicating intuitive conceptions. Papastergiou (2005) reported also on other participants, who talked about the existence of many central places, servers or computers, reflecting elaborate conceptions of the distributed storage of Information.

The misconception that the Internet is a centralized system also appeared among participants from Papastergiou (2005), when being asked about webpage or information storage on the Internet. "Information is in a huge computer, in the USA, so that incorrect information is checked and rejected", is an example of this misconception. A few participants, on the contrary, thought webpages or information are stored in users' computers (e.g. in its "hard disk", "CPU", "modem"). This misconception was also presence among children, for instance in the study from Eskela-Haapanen and Kiili (2019), where students thought that "information comes from a firm".

5.2. Responsibility for the operation of the Internet

All 15 descriptions in this concept category came from Papastergiou (2005), who asked participants if there could be a single responsible person for the operation of the Internet worldwide. Although a few 12-to −16-year-old students (36.5%) held intuitive or elaborate conceptions about how the responsibility of the Internet is managed, most students (63.5%) held various misconceptions.

Intuitive conceptions included imprecise descriptions such as: "if there would be a single responsible person, users' actions would be controlled and restricted". Elaborate conceptions included descriptions reflecting understanding of the existence of a distributed and shared responsibility for the operation of the Internet worldwide, for instance among users, many persons, companies or organization.

Descriptions reflecting misconceptions were those that viewed the Internet as a centralized system with a single responsible person for the operation of the Internet. The single person was described as "the owner", "inventor", or "director" of the Internet, "information manager" or "technician". In some descriptions, the Internet was described as "self operating", "independent" or "a device" or "a machine" operated by man.

5.3. Web search engines and their function

For this concept category, we synthesized four Sections 5.3.1–5.3.4, including 79 descriptions. Here we present an overview of the results of these subcategories.

5.3.1. Search engines as tools to carry out web searches

We found 15 descriptions from seven studies about how children and youth viewed a search engine as a tool (a software system) to carry out web searches. Whilst only a few students from Bilal and Zhang (2019) described the search engines as tools to search, find, and access information, to access the Internet or to search or to navigate the Web, descriptions from the other six studies revealed that children and youth do not distinguish between web search engines and the Internet. Instead, they often held the misconception that search engines are the central aspect of the Internet and thought that all information comes directly from the search engine. For example, children depicted the Internet as a search engine, such as the Google Homepage (Dinet & Kitajima, 2011). When specifically asked about the Internet, they answered "The Internet is the Google search engine" (Kamishlian, 2010) or "The Internet is a big search engine" (Murray & Buchanan, 2018). In a study by Seifert et al. (2013) all five students believed that Google was representing the entire Internet or determined at least the Internet's main structure. Google was referred to as the starting point of the Internet, like a lobby. Similarly, Eskela-Haapanen and Kiili (2019) reported on a child, who explained that the Internet has a front page and from there one can search information.

5.3.2. Search engines' functional aspects

We only retrieved three studies that explicitly investigated children's and youth's conceptions about search engines and their function. Their results indicated that the majority of children and youth held intuitive conceptions and several misconceptions about search engines and the way they work. Only a few of them appeared to have formed more elaborated conceptions.

Search engines described as a physical space, as a search engine interface or as specific instances of search engines. We collected 5 descriptions in this sub-subcategory from Kodama et al. (2017) and Bilal and Zhang (2019).

Kodama et al. (2017) asked their participants to draw and then explain how they thought Google works behind the scenes to find websites for people. Drawings that we classified as intuitive were those that either presented Google as a physical space, such as a Google building, an office building, or an office space or depicted Google as an interface, like the Google logo, the Google Homepage, a search results page or the Google search bar. Also in the study from Bilal and Zhang (2019), when being asked to describe search engines, a few participants mentioned specific search engine brands such as Google, Yahoo, and Bing without mentioning anything about their function. These representations seem to indicate that children conceptualized Google or any other search engine with what they heard from adults or other sources and what they saw on the screen while using the search engines themselves.

Search engines or companies deliver information to users via physical connections, people or helpers. We classified 11 descriptions in this sub-subcategory, reported by Kodama et al. (2017), only one as an intuitive conception and the rest as misconceptions.

The intuitive conception was related to a drawing, in which the child drew a computer screen with a conversation between the user and Google and explained "I think Google is created by like conversation-wise. I mean everybody has to have a conversation with something". Kodama et al. (2017) reported several misconceptions. For example, children explained that search results are produced by humans working at Google, or believed in some sort of connection or signals between users and Google via an antenna or a satellite. In some drawings, people that work for Google were represented as intelligent and in possession of a lot of information.

Search engines perform the search on the computer and its local components. We identified 4 descriptions in this sub-subcategory, 1 description indicated an intuitive conception and 3 descriptions indicated misconceptions. In general, these descriptions seemed to show that many children and youth saw the Google search engine as an integrated part of the computer and thought that the search is performed on the local computer hardware (Kodama et al., 2017; Seifert et al., 2013).

Search engines' criteria for ranking search results. This sub-subcategory included 15 descriptions, encompassing intuitive and elaborate conceptions as well as misconceptions. Seifert et al. (2013) and Bilal and Zhang (2019) focused on conceptions of how search engines rank their search results. In both studies, participants mentioned several criteria by which search engines rank results, like ranking only based on popularity of search engine results, referring to how many people have "clicked", "chosen", or "used that result", indicating intuitive conceptions of how search engines rank the search results. However, none of them related ranking to algorithms combining several criteria. Some descriptions revealed intuitive conceptions such as search results rankings being based on Google's interest or on payments received by website owners. Although it is correct that businesses can pay to get links to their products as commercial links high up the search page, this does not mean that they can pay for better ranking of their website in the regular search results. Based on the results of the current study, however, we do not know if the children could not distinguish between commercial and regular search links or that they really thought that one can also pay to get a higher ranked by the search engine. Therefore, we classified these descriptions as intuitive conceptions.

Where and how search engines store data. We only selected three descriptions in this sub-subcategory, exclusively from Seifert et al. (2013), indicating elaborate conceptions about where Google stores data. In this study, when being asked about where and how Google stores data, participants had elaborate conceptions that there is a lot of data on the Internet stored in hard disks, servers and databases, all networked together and that servers are in large server rooms.

5.3.3. Search engines users' data privacy and their business model

This subcategory includes 10 descriptions about data privacy of search engines' users and the business model of companies such as Google. These topics were only covered in the study of Seifert et al. (2013). We also found one description in the study from Bilal and Zhang (2019), which touches user's data privacy when using search engines.

Although the participants of these two studies did not seem to have generally conceptualized how search engines function, they seemed to have intuitive or even elaborate conceptions users' data privacy and their online behavior. For instance, Seifert et al. (2013) reported that 13-to −15 year-old interviewed students in their study explained that "Google collects data about everything and everyone", or that "via its search function Google can trace the online behavior of users and knows always who is visiting which webpage", indicating intuitive conceptions.

When being asked about how Google company earns money, participants mainly mentioned advertisements (e.g., advertising in front of videos on YouTube). Two students in the same study also said "Google gets 1 cent for every click on a webpage link", which indicates a misconception.

5.3.4. Search results evaluation and trustworthiness of online information

This subcategory covers descriptions about the quality of online information and evaluation of search engine results. Twelve descriptions reflect children's and youth's expressions of doubts towards the trustworthiness of online information, indicating intuitive or elaborate conceptions, 4 descriptions point to the misconception that everything on the Internet can be trusted.

Intuitive expressions of doubt were descriptions such as "Everything is not true. Well ... I don't really know why" or explicit wondering about the truth of specific types of content (e.g., jokes, horror stories) (Eskela-Haapanen & Kiili, 2019). In the study by Eskela-Haapanen and Kiili (2019) 80% of the children expressed their doubts about the trustworthiness of the online information in various ways and 10% even expressed their doubts accompanied with elaborate justifications explaining the possibility of spreading false information on the Internet or possibility of finding wrong information in Wikipedia.

However, other studies indicated that many children and youth seemed to have no doubt about the trustworthiness of information online (Enochsson, 2004; Eskela-Haapanen & Kiili, 2019; Papastergiou, 2005). For example, Rowlands et al. (2008)(as cited in Kamishlian (2010)) reported that teens thought that if information was found using the Yahoo! search engine, it must have been true. Moreover, Papastergiou (2005) reported on students who even provided false explanations as to why the data can be trusted. According to them "the information is in a huge computer, in the USA, so that incorrect information can be checked and rejected".

5.4. Transmission techniques

This concept category includes descriptions related to the concepts of transmission techniques on the bit layer, such as physical transmission, packeting, speed and bandwidth and addressing. All descriptions were drawn from three studies (Brinda & Braun, 2017; Diethelm, Wilken, & Zumbrägel, 2012; Diethelm & Zumbrägel, 2010). As the results from Diethelm and Zumbrägel (2010) and Diethelm, Wilken, and Zumbrägel (2012) came from the same study with the same participants (23 13-to −14-year-old students), we only present and discuss the results from the most recent paper. The summary of the results appear in Sections 5.4.1 and 5.4.2.

5.4.1. Physical transmission, packeting, speed and bandwidth

This subcategory includes 11 descriptions, with 4 intuitive and 1 elaborate conceptions as well as 6 misconceptions. While many children and youth held misconceptions about transmission of data, assuming that a thick cable can transfer more data than a thin one, files and media are always transferred in one piece or routing on the Internet is performed by humans, few descriptions indicated intuitive and elaborate conceptions. For example, 3 out of 23 students in Diethelm, Wilken, and Zumbrägel (2012) talked imprecisely about converting text into some kind of code for transmission. In the same study, one child explained that "Videos are transmitted in fragments, and then at some point there is one fragment missing. And then it must go back and collect the next fragment", indicating intuitive conceptions.

5.4.2. Addressing

For this subcategory, we found 6 descriptions, indicating intuitive and even elaborate conceptions about the need for a unique address for governing the transmission of data via the Internet. For example, in Diethelm, Wilken, and Zumbrägel (2012), even if they did not seem to have the scientific vocabulary to explicitly mention it, many participants showed awareness about the fact that addressing works by using a unique name, the email address or the home address used for registering for an email address, indicating an intuitive conception about an Internet Protocol (IP) address. Several elaborate descriptions also emerged, which came quite close to the scientific view. For instance, one student tried to use an analogy and described "This is like a huge mail box for many people and with many smaller boxes, like in school where everyone has his own locker and can access it only with a key, like a password".

In another study, Brinda and Braun (2017) investigated conceptions of 9-to −11-year-olds about the addressing and transmission medium used by smartphones. Whilst 5 out of 8 participants showed awareness that for addressing a number is used, one participant mentioned explicitly that the number needs to be unique (like a telephone number that needs to be unique), indicating an elaborate conception.

5.5. Services of the Internet

Similar to Section 5.4, all the descriptions were drawn only from Diethelm, Wilken, and Zumbrägel (2012) and Brinda and Braun (2017). They are related to two services of the Internet that children and youth use commonly in their everyday life activities: electronic communication 5.5.1 and streaming 5.5.2.

5.5.1. Electronic communication

This subcategory includes 7 descriptions taken from the study of Diethelm, Wilken, and Zumbrägel (2012) and one description from the study of Enochsson (2004). The descriptions mainly pointed to misconceptions about electronic communication on the Internet.

Only a few students in the study of Diethelm, Wilken, and Zumbrägel (2012) seemed to understand that for chat or Instant Messaging (IM) data is going via a server (elaborate conception). The other 6 descriptions in this subcategory indicated several misconceptions. For example, about 35% of students talked about being in a private area of the Internet while using chat or IM. The same number of students held the misconception that chat or IM occurs via a direct connection between devices. A few students even talked about people in the Internet sorting out E-mails. In the study from Enochsson (2004), one participant described that E-mail communication takes place via satellites.

5.5.2. Streaming

This subcategory contains 12 descriptions, covering conceptions, mainly misconceptions, about streaming. They all came from the Diethelm, Wilken, and Zumbrägel (2012) study.

A few descriptions of video streaming reflected intuitive conceptions combined with a couple of interesting analogies. One frequently used analogy was reading out a book or a letter to someone: "The fact that you can repeat the story only as far as you have heard it, can be compared with the fact that you have to wait if the video has not yet been loaded sufficiently". Two elaborate descriptions with interesting analogies were also used to explain streaming and loading. For example, one participant explained "Data, especially videos, moving like snakes through the cable. If there is a bottleneck and too many snakes want to pass through transmission slows down at once. If one snake is too big for the bottleneck the snake is altered so that it becomes thinner and therefore longer".

The other descriptions indicated misconceptions. About 35% of participants thought that a YouTube video is played on their own computer, whereas 26% thought that the video is played on the Internet (e.g., "streaming is like looking at the server through the Internet like at a cinema screen"). One student also talked about a central computer reading the video and sending the parts to him. These results imply that, although streaming is one of the most common online activities among youth, they do not have an adequate conception of how it actually works.

6. Discussion

This study aimed to find out which particular types of conceptions and misconceptions children and youth have about the Internet (RQ 1). In addition, we wanted to find out if conceptions change over time and technology's progression and/or age has a role on conceptions' about the Internet (RQs 2 & 3).

Before discussing the answers to our specific research question, a few observations regarding the literature on children's conceptions of the Internet and how it relates to prior literature on conceptual development in childhood are warranted. Many of the statements that we extracted from the literature indicated that children's conceptions of the Internet are often on an intuitive nature that cannot be equated to misconceptions that are commonly found in science areas (e.g., Carey, 2000; Edelsbrunner et al., 2018; Vosniadou & Brewer, 1992). It appears that many children have just been starting to think about Internet-related concepts, and sometimes even in terms of analogies to other concepts or associations from everyday life. Since such conceptions do not indicate yet clear misconceptions, we differentiated between intuitive conceptions and more fully established misconceptions. Similarly, many of the more elaborate conceptions

within our review could not be described with the common label of scientific concepts (Carey, 2000; Edelsbrunner et al., 2018), as they lacked important elements of scientifically accepted views that we would expect even from children. As we will discuss in the limitations, we cannot be sure whether this was because of children's lack of conceptual knowledge or for methodological reasons. Still, we suggest future researchers to take into account that misconceptions and scientific conceptions might need to be interpreted and labeled slightly different in conceptual change models about the Internet than has typically been done before in the science education-literature focusing on, for instance, physics and chemistry.

To answer our research question, we synthesized conceptions of the Internet held by children and youth in five different concept categories: (1) structure of the Internet, (2) responsibility for the operation of the Internet, (3) web search engines and their function, (4) transmission techniques and (5) services of the Internet. For the first two categories we found descriptions from many different studies, whilst the findings of the third category, and particularly the two final categories, are based on the results from only a few studies.

For all five categories, we found that children and youth hold more intuitive than elaborate conceptions. In addition, they displayed consistent misconceptions about the nature and functioning of the Internet. For the concept category "structure of the Internet", we found that children and youth often described the Internet as a non-digital entity, indicating that they do not have any knowledge about the physical infrastructure of the Internet yet. They described the Internet based on its functions in everyday life. They often did not distinguish between the Internet and its most widespread and used service, the World Wide Web and its contents. In the recent studies, they confused the Internet with wireless connection. They described the Internet with its visible components and technologies that enable online access, or they saw it as something either connected to a device or located inside devices, which also gives a potential explanation as to why they believed that information from the Internet is permanently stored in users' devices. A few children and youth thought that the Internet has something to do with satellites. As also seen in the descriptions in the "responsibility for the operation of the Internet" category, they often described the structure of the Internet as a centralized computer system, with all information stored in one central system managed by a single person. Only a few children and youth conceptualized the Internet as a distributed system with distributed storage of information and described it in terms of connections between computers or between computer networks.

For the concept category "web search engines and their function", we found many indications that children and youth were not aware of the nature of search engines, how they function and how algorithms are designed to find and rank search results for specific queries based on several criteria. We found that often children and youth do not distinguish the Internet from web search engines, and that they believe that web search engines are basically the entire Internet. A possible explanation for the origin of this misconception could be the default setting of the search engine in browsers, which gives direct access to search on the Internet. Moreover, they described the Google search engine as a physical space like a data center. They thought that users and search engines communicate via satellites, wires or antenna and that search results are delivered to users by people working at Google. They thought that search engines perform the search on the local computer hardware. Above all, many believed that everything found by search engines, or, online information, is true and can be trusted. Interestingly, however, they had more intuitive and elaborate conceptions about search engines' data storage medium, users' data privacy and their business model than the underlying technique and functions of the Internet.

For the concept category "transmission techniques", only a few children and youth seemed to have some knowledge about aspects of information networks, including packets, switching, routing, addressing, protocols, network services, etc. They think files and media are transferred in one piece and that there are people working in or for the Internet who are responsible for sorting out data and routing them through the Internet. Although a few children seem to understand that there must be a unique address being involved in transmitting data, most of them do not relate this address to IP addresses. Most likely, they are not familiar with terms like "IP address" and "packeting" yet.

Finally, for the concept category "services of the Internet", they think that communication on the Internet works with direct connections between devices, whilst the communication is done over many servers and routers. Although video streaming is one of the widely used services of the Internet, specially among youth, they are not aware that by streaming they are not saving the content to their own device, but viewing it only online.

One of the advantages of a comprehensive systematic review about Internet is that it allows drawing conclusions that go beyond the single focuses of separate empirical studies. Whereas single studies might only focus on conceptions of one or two of our five categories, this systematic review allows for gaining insight into the conceptions from different categories and for observing how they interact with each other. An important observation we made was that there seems to be a hierarchical structure with an understanding of the Internet's structure (Category 1) as a requirement for understanding of the lack of central control on the Internet (Category 2), the functioning of search engines (Category 3) and transmission techniques (Categories 4) and the functioning of the services of the Internet (Category 5). This explains, for example, that misconceptions about the distributed nature of the Internet do often go hand in hand with misconceptions about search engines (e.g., conceptions of search engines as starting point or the center of the Internet) and transmission techniques (e.g., thinking that this happens via a direct link between the devices). It implies that only when children and youth have conceptualized the structure of the Internet rather elaborately, they might be able to start grasping other aspects of information networks. Theoretical models of children's conceptions of the Internet could incorporate this finding by conceptualizing children's conceptions as a hierarchically structured model in which ontological categories are added or shifted over time (Chi, 2009).

In addition to answering the question about how conceptions from different categories might be linked and related to each other, our systematic review also allows for preliminary answers to whether children's and youth's conceptions change over time, due to technology's progression. Indeed our review, spanning twenty years of literature on children's and youth's conceptions of the Internet, seems to indicate that some conceptions have been consistently present, whereas others seemed to have disappeared. For instance, we observed that while the activity-based conceptions of the Internet or identifying the Internet with the Web and its content have been persisting for twenty years, the conception of the Internet as a centralized system has not been reported for nearly a decade. The last evidence for this misconception was reported by Diethelm, Wilken, and Zumbrägel (2012). One reason for such changes in conceptions could be that, over the last two decades, the physical appearance of computers has changed. Nowadays, instead of desktop computers, children and youth use portable devices. This switch could have made it more difficult for children to understand that the Internet is a separate entity from the devices that are used to connect to it, which probably led

to the misconception that the Internet is residing inside devices. Other interesting misconceptions that have been persisting for twenty years are related to the function of the Internet and its various services to satellites. Considering that the concept of satellite Internet services is relatively new and limited to a few countries, further investigation is required to find out the potential origin of this misconception. With the Starlink Project or with smartphone supporting emergency SOS communication via satellite, the structure of the Internet becomes even more ambiguous and we might well see an increase of misconceptions about the importance and exclusive role of satellites. Interestingly, a recent study by Mertala (2019) showed that children's and youth's understanding of the Internet appears to mainly involve conceptions that have to do with wireless connections, reflecting the current technology of connecting to the Internet. At the same time, these instant wireless Internet connections have made it more difficult for children and youth to realize what being online or offline means. In other words, due to less active engagement (or effort) involved to connect a device to the Internet, children and youth might develop fewer spontaneous conceptions about the nature and functioning of the Internet. We predict therefore that future studies will find less conceptions about the Internet overall, while activity-based conceptions of the Internet will most likely remain to exist. An advantage of developing less spontaneous conceptions could be that children also develop fewer misconceptions that need to be corrected. With the Internet becoming more and more of an always present, hard to grasp phenomenon, it will be especially important to provide targeted and explicit instruction to make sure that children and youth acquire a proper understanding about the Internet, its structure and how it functions.

Furthermore, the findings of three studies from the thirty studies included in this review addressed the question if age and experience are crucial factors in building appropriate conceptions about the Internet. Overall, the results of these studies (Yan, 2005, 2006, 2009) suggested that age rather than the user's online experience is a better predictor of users' conceptions of the technical and social complexity of the Internet. Older empirical studies (not included in this review) have also examined factors influencing adults' conceptions of the Internet, for example, university students' and staff members' frequency of using the Internet (Thatcher & Greyling, 1998), and university students' one-semester exposure to the Internet (Levin et al., 1999). Their results suggest that there are differences in conceptions of the Internet based on users' experience. However, they also argued that, while frequent use of the Internet may be a necessary condition for having conceptions about the Internet, it is not sufficient to have complete scientific conceptions about this complex system. Wrapping this together, it seems there are inconsistencies in the literature about factors having a positive effect on Internet users' conceptions across different age groups. Looking across the studies in our systematic review, encompassing data spanning from 5 to 18-year-old participants, we did not observe a general trend for youth to have less misconceptions or more elaborate conceptions than younger children. In contrast, the conceptions of children and youth seemed to be very similar, despite the fact that youth typically have had more online experiences than children, too. As discussed, children's and youth's conceptions of the Internet seem to be rooted in the lack of understanding about the structure of the Internet as a large network of networks. Based on this observations, age or online experience may not be sufficient conditions for understanding the Internet and its many aspects. Therefore, further research and investigations need to be considered to be able to talk with more certainty about the various possible factors, including age and users' online experience, which may affect users' understanding of the Internet and its aspect.

6.1. Suggestions for future research

Given that Internet technologies and the ways we interact with them in everyday life are still evolving, it is difficult to predict to which extent the results of this review remain representative of children's and youth's conceptions. Furthermore, an individual might hold several conceptions simultaneously across the five categories discussed here that might be consistent or even inconsistent with each other. Research on conceptual change in other fields has shown that such mutually inconsistent conceptions can co-exist (e.g., Edelsbrunner et al., 2018) and may be activated depending on the situation and context the child is in Ohlsson (2009), Shtulman and Valcarcel (2012). Such internally consistent or inconsistent conceptions may or may not have been manifested within the reviewed studies, as targeting such aspects strongly depends on the specific questions about the Internet that are asked. We suggest conducting studies that do not just prompt children and youth to provide one statement regarding their beliefs of a particular aspect of the Internet, but that try to collect more comprehensive data about the many beliefs that they might hold about different categories that we discussed here.

To answer such research questions, it would be very helpful to have an assessment tool that can be used to comprehensively assess children's and youth's conceptions of the Internet on a large scale, instead of having to rely on guided interviews and/or drawing tasks. As a first step in this direction, the organized collection of conceptions presented in this paper could be used as a basis to formulate a developmental model of Internet conceptions. Such a model could describe how children develop from holding intuitive conceptions (e.g., the Internet is for shopping) to more substantial conceptions of the Internet as an (infra)structure, combined with potential misconceptions (e.g., the Internet resides in my computer or the Internet is a big computer) and finally to elaborate conceptions (e.g., the Internet is a network of computer networks). Such a developmental model could then, as a second step, form the basis for an assessment to examine whether children are predominantly holding intuitive conceptions about different aspects of the Internet, whether they have acquired specific misconceptions, and whether they already posses more elaborate conceptions. Ideally, such a tool should be easily adaptable to cover new categories that have not been detected in studies yet or might evolve in children's and youth's minds in the time to come. Our research indicates that, whilst the assessment of such conceptions might be difficult for much younger children, it might work well for children starting around age ten, which is also the time when current curricula start focusing more on the Internet (D-EDK, 2016; Department for Education, 2013; Skolverket, 2018) and valid assessment via questionnaires might be possible with most children.

As soon as we are able to systematically assess children's and youth's conceptions of the Internet, this will open up further opportunities to link this to other behaviors and skills. For instance, we suggest investigating how conceptions of the Internet relate to reasoning and information-seeking behavior across different topics and school subjects. For example, it might be investigated whether children and youth with intuitive and perhaps misconceptions about information on the Internet simply trust what they find and thus do not manage to critically evaluate information from the Internet (Thomm & Bromme, 2012; Vaupotič et al., 2021). Such beliefs might also be related to children's and youth's more general tendencies to trust different epistemic authorities that might publish information on the Internet (Wintterlin et al., 2022). Furthermore, going beyond correlational designs, assessing the conceptions that we have identified here before and after interventions might show how such conceptions interact with participants' reasoning and information-seeking behavior during

working with the Internet, and how their conceptions and behaviors are affected by instructions. This might show for example whether and how children's conceptions of the Internet interact with their sense-making when facing information from multiple online-sources (McGrew, 2020).

6.2. Limitations

This review has several limitations. The first limitation concerns the time period: only articles published since 2000 were included. The second limitation is related to the reporting choices in the included studies. Most of conceptions we collected, were derived from citations of statements that children had made. However, the authors of the studies did not always systematically cite the exact statements of the children. Therefore some of the conceptions are based on statements that were summarized or reformulated by the authors or were the authors' descriptions of the outputs of the participants' drawing tasks. Although this approach made it possible to get a larger overview of children's and youths' conceptions, it does mean that the descriptions could have been biased by subjective interpretations. The third limitation is formed by the selection of keywords for the literature search. Starting from a preliminary search in Google scholar, the first step was to gain a first impression of the possible relevant publications and define our search terms and their combinations. We sought to find the majority of important contributions to this field of research. Nevertheless, including different or further keywords, such as "view" or "pupils", might have led to further relevant publications. The fourth limitation is that we decided not to include forward citation search, that is investigating the publications that cited the relevant included publications in this review. However, we did examined the bibliographies of included publications and identified seven further relevant articles. In addition, we set up auto alerts for all the databases and search platforms to receive weekly updates of new literature. The fifth limitation, which more generally applies to examining conceptions in children, is that there was a large variety to what extend the participants of the separate studies were asked follow-up questions or what kind of follow up questions were asked. Only a few studies, such as those by Diethelm, Wilken, and Zumbrägel (2012), Ersoy and Türkkan (2009), used slightly more extensive interview methods in which children could reveal more details of their conceptual understanding than just a single short answer or one drawing. As a result, it is very likely that the participants of most of the other studies held more elaborate or a larger variety of conceptions about the Internet that remained uncovered in the context of the studies. We suggest using more in-depth approaches such as semi-structured interviews (e.g., Vosniadou & Brewer, 1992) and concept mapping (e.g., Thurn et al., 2020) in future research to help better understand children's more detailed conceptions of the Internet. The last limitation to emphasize concerns the distribution of geographical location of the participants in included publications. Differences in the curricula between countries might have led to different conceptions. Since the sample size per country was too small, we cannot make any meaningful comparisons between countries.

7. Conclusion

This review provides an extensive list of Internet conceptions, including misconceptions, of children and youth. It provides a basis for a detailed insight into the nature of these conceptions, their potential (hierarchical) relation to each other, their dependence on technological development and the age and experience of the person who hold them. Previous research has shown that knowledge about misconceptions held by children and students in other domains, like physics (Edelsbrunner et al., 2018) and statistics (Iten et al., 2014) will improve teaching quality. We hope that Computer Science teachers can use this list to accordingly adapt their lessons to the preexisting conceptions and misconceptions that their students bring to the classroom as per the "Investigation of Students' Perspectives" element of the Educational Reconstruction Framework (Diethelm, Hubwieser, & Klaus, 2012). More specifically, the conceptions identified here might support educators in constructing teaching materials for developing elaborate conceptions of the Internet among children and youth. Furthermore, the findings can be used as a stepping stone for further research into the consistency of conceptions across categories and the development of assessments of conceptions about the Internet.

8. Selection and participation

This paper is a literature review from existing studies. Therefore, there were no participants involved directly in this work.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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