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Re-defining Characteristics of a Design Protagonist – Elements of Children's Design Capital

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The importance of child empowerment in and through design and making has been acknowledged. The notion of "child as a Design Protagonist" concerning technology has recently been introduced. We conducted a narrative literature review to examine the current understanding of what it requires from children to become a Protagonist in design. The main objective of this study is to examine the concepts associated with children's competences relevant for design, such as various capitals, skills, and capacities. We identify core concepts used as well as several gaps in this literature base. We separate the competences into 1) those that need to be nurtured in children and 2) those that children already have and bring to the design process. We propose a concept of design capital for mapping these competences of child Design Protagonists.

Design Protagonist, children, teenagers, capacity, capital, skill, asset, competency, design capital

1. INTRODUCTION

Due to the digital transformation of society, there has been an increasing concern as regards children's digital competences and their empowerment so that they can not only overcome the challenges of living in a digitalized society as technology users, but feel empowered to shape their digital futures. Children's empowerment in this sense has been emphasized in the Child-Computer Interaction (CCI) community. Researchers have extensively discussed children's participation in design process during the years (see e.g. Kawas et al. 2020; Read and Bekker 2011; Yarosh et al. 2011) and it is still a valid topic for the future CCI research (Giannakos et al. 2020). Moreover, a growing body of CCI literature examines children's empowerment in relation to design and making (Iivari and Kinnula 2018; Iversen et al. 2017; Kinnula et al. 2018; Kinnula and Iivari 2019; Schepers et al. 2018; Schepers et al. 2019), calling for 'computational empowerment' of children (Dindler et al. 2020; Iversen et al. 2018). Along these lines, the notion of 'child as a Design Protagonist' has recently been introduced (Iversen et al. 2017). It complements the discussion on children's roles in the design process (see e.g. Barendregt et al. 2016; Bekker et al. 2019; Doorn et al. 2014; Druin 2002; Kinnula et al. 2018; Landoni et al. 2016; Landoni et al. 2018; Large et al. 2003; Large et al. 2006; Schepers et al. 2018), with the Design Protagonist role particularly emphasizing the key agency of children in relation to technology and digital transformation of society.

After introduction of the Protagonist role, the literature has remained quite silent about the specific skills and competences needed in that role or how to facilitate children in becoming a Design Protagonist. There is a need to explore what the main characteristics of a Design Protagonist are and why inviting children to adopt this role is challenging (Iivari and Kinnula 2018). We scrutinize what kind of competences are associated with children's design work in the existing CCI literature. There is already plenty of valuable CCI work carried out, while a systematic mapping from this perspective is lacking. We examine the following research questions: *What kind of competences need to be developed in children regarding the Design Protagonist role*? *What kind of competences children already have that they can bring to a design process*? We answer these questions through a narrative literature review (Boell and Cecez-Kecmanovic 2015), which is a suitable literature review method for topics without established terminology. With this review, we aim first, to identify the concepts currently used to examine children's existing competences in design. This provides CCI research with useful handles with which to foster children's design and technology education and the Design Protagonist role adoption,

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showing children already possess valuable competences that should be better acknowledged and appreciated in design. Second, we aim to understand what competences children lack that need to be specifically nurtured to increase their agency in designing their digital futures. As a result of the analysis, we propose the concept of 'design capital' for capturing these comperences in children. With this concept, we aim at mapping developments in the field as well as moving the field forward.

The structure of this paper is as follows. First, we describe the theoretical framing of this study as a basis for the development of the design capital concept. Second, we present the methodology employed for conducting the literature review. Third, we present the results of the literature review, including the main concepts used and their definitions. Finally, we summarize the main findings and discuss their implications for CCI research as well as their limitations and paths for future work.

2. THEORITICAL BACKGROUND

Our theoretical lens derives from Bourdieu's theory of capital, in which the notion of 'capital' refers to the resources or assets that usually take time to accumulate and are habitually distributed in different forms—economic, social, cultural, and symbolic (Bourdieu 1986). Different forms of capital are also interrelated (Bourdieu 1986), and each form of capital may potentially generate more capital (Archer et al. 2015). In this study, we focus on Bourdieu's social and cultural forms of capital. "Social capital is the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance or recognition—or in other words, to membership in a group" (Bourdieu 1986, p. 248). Furthermore, Bourdieu's cultural capital exists in three forms: an embodied state (e.g. language), an objectified state (e.g. books, pictures, instruments etc.), and an institutionalized state (e.g. educational qualification) (Bourdieu 1986) that have the potential to generate skills, competences, abilities and qualifications in children. In the same vein, the notion of "science capital" was coined by (Archer et al. 2014) as science-related forms of social and cultural capital to describe the different patterns of aspiration and educational participation of youth.

Within the educational field, various kinds of skills, competences, attitudes and practices have been associated with the capital concept. For example, information technology has been conceptualized as a form of cultural capital (Emmison and Frow 1998) as well as skills, competences and attitudes for information technology use (Tondeur et al. 2010), socialization into technology practice (Beckman et al. 2014) and involvement in techno-culture (Kapitzke 2000) "to explore the origins of students' technological knowledge, skills and tastes" in the school context (Beckman et al. 2018, p. 203; see also Apps et al. 2019). However, in the current literature, there is a lack of investigation akin to capital in the design context.

Our interest is generally in key competences of children in design work: on those they already have as well as on those to be developed and nurtured. When we use the term "competence" in this paper, we refer to abilities, skills, attitudes, knowledge and values: competence refers to "the ability to apply learning outcomes adequately in a defined context (...) A competence is not limited to cognitive elements (…) it also encompasses functional aspects (…) as well as interpersonal attributes and ethical values. A competence is therefore a broader concept that may actually comprise skills (as well as attitudes, knowledge etc.)" (Ananiadou and Claro 2009). The capital concept enables us to acknowledge even more variety in terms of resources and assets that children may possess and bring into the design process.

3. METHOD

We have explored the CCI literature to understand the conceptual basis of the studies on children's competences in design through a narrative literature review (Boell and Cecez-Kecmanovic 2015). Narrative literature reviews are considered useful in offering a broad perspective on the topic without established terminology (Green et al. 2017; Boell and Cecez-Kecmanovic 2015).

To collect data, the first author of this paper made a comprehensive literature search in the Scopus and the ACM databases during 9/2020-12/2020 for papers published by the end of the year 2020 in the leading venues publishing research on interaction design and children: International Journal of Child-Computer Interaction (IJCCI), International Conference on Interaction Design and Children (IDC), ACM CHI Conference on Human Factors in Computing Systems (CHI), Transactions on Computer-Human Interaction (ToCHI), Nordic Conference on Human-Computer Interaction (NordiCHI), Participatory Design Conference (PDC), Designing Interactive System (DIS) conference, Design Studies Journal, Design Journal, and Design Research Society (DRS) Conference. The review process was done in several steps to extract and select the papers. The keywords used to extract the papers were combinations of (child* OR student* OR pupil* OR kid* OR youth*) and (design* OR fabricate* OR maker* OR making* OR DYI*) and (capital* OR fund* OR asset* OR capacity* OR literacy* OR skill* OR competence* OR thinking* OR ability*) in the title, abstract, or keywords. The number of papers identified in this phase was 697.

We applied the following inclusion and exclusion criteria: 1) Non-peer reviewed papers, posters and workshops were excluded. 2) We included only studies that addressed design-related competences: they brought up the necessity of the skills for design or making activities and included actual design or making activities with children. Thus, the papers that only addressed competences during e.g., testing a design toolkit or application were excluded. 3) We excluded papers that described projects involving children with specific needs or disabilities as we assume the competences they have and need are at least partly different, even though they are an interesting and relevant group of children to consider in the future. Built on these criteria, the final dataset included 48 papers: 23 from IDC, 11 from IJCCI, 8 from CHI, 3 from PDC, 2 from DIS and 1 from Design Journal.

We employed Mendeley software to organize the dataset. The final dataset, their abstracts and the key findings were summarized, sorted and coded regarding the competences mentioned in each included paper in a separate excel file. Two main themes were derived from the papers in a data driven manner: 1) competences that need to be developed in children, and 2) competences that children already possess and bring to the design activities. Eventually, we discussed and synthesized the main findings, with the intention to summarize the current literature, identify any possible gaps in the existing research, and provide a framework for future research (Kitchenham 2004).

4. RESULTS

4.1 Descriptive analysis

Table 1 provides an overview of the concepts used in the included papers to discuss the competences children either bring to the design process or gain or should gain through the design process.

Table 1: *Concepts used in the papers*

Concept	# of papers	Concept	# of papers
Computational thinking	*11*	*Cultural forms*	*2*
Funds of knowledge	*9*	*Historical body*	*2*
Design thinking	*8*	*Interaction order*	*2*
Maker mindset/identity	*7*	*Making literacy*	*1*
Protagonist characteristics	*6*	*Science literacy*	*1*
Digital literacy	*5*	*Science capital*	*1*
Social & cultural capital	*3*	*Funds of identity*	*1*
Tacit knowledge	*3*		

Figure 1 presents the countries in which the design activities occurred. Most of the studies were conducted in United States (n = 22) followed by Denmark (n = 5) and Finland (n = 4).

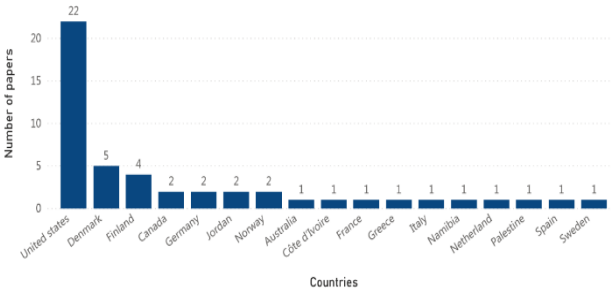

Figure 1: *Countries in the studies*

Figure 2 illustrates the age distribution of children participating in the studies. Most of the studies were conducted with 10-11-year-old children.

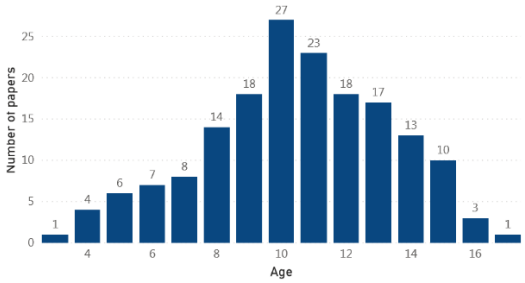

Figure 2: *Age distribution of the child participants*

Table 2 provides an overview of the publication years of the papers, showing that the number of papers has steadily grown over the years. No included paper was found before the year 2010.

Table 2: *Number of published papers in each year*

Year	#
2010	*1*
2011	*0*
2012	*1*
2013	*3*
2014	*4*
2015	*3*
2016	*6*
2017	*6*
2018	*8*
2019	*7*
2020	*9*

4.2 Narrative synthesis

Next, we present our findings structuring the text based on our research questions and the 15 central concepts used in the papers. We show how the included papers defined and utilized these concepts and we ultimately map out the concepts to discover any possible gaps in the literature (Okoli 2015).

Table 3: *Concepts and definitions of design competences that need to be developed in children*

Concepts	Definitions
Protagonist characteristics	● *The main agent in the design process (Iversen et al. 2017)* ● *"Who steer the direction of the design process and express their individual 'voice' in it" (Södergren and Van Mechelen 2019)* ● *Independent decision making in design activity (Iversen et al. 2017)(Bonsignore et al. 2013)(Södergren and Van Mechelen 2019)* ● *Independent solving of design problem (Bonsignore et al. 2013)(Iversen et al. 2017)*
Maker Mindset / Identity	● *"A frame of thinking by which the Maker addresses problems by seeking 'do-it-yourself' solutions, a belief that they either have or can acquire the means to construct a solution, and possess a creative curiosity to seek solutions that the Maker can construct on her own" (Chu et al. 2015)* ● *Self-efficacy, motivation and interest can be seen as the core of the maker mindset (Chu et al. 2015)*
Design Thinking	● *"The ability to thoughtfully engage in design processes of digital fabrication, knowing how to act and reflect when confronted with ill-defined and complex societal problems" (Smith et al. 2015)* ● *"Design thinking is a process where a need or opportunity is identified, and a design solution is developed. The consideration of economic, environmental and social impacts that result from designed solutions are core to design thinking. Design thinking methods can be used when trying to understand a problem, generate ideas and refine a design based on evaluation and testing" (NESA 2017, p. 35)* ● *"Design thinking represents both a way of thinking and a process that can foster creative thinking. In absolute terms, design thinking stands for all the cognitive processes that a person's mind goes through when performing design" (Grammenos and Antona 2018)* ● *''A discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity'' (Brown 2008)* ● *Main elements of design thinking process: "Understand, Observe, Point of View, Ideate, Prototype, Test" (Goldman et al. 2010)*
Computational thinking	● *''Thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms'' (Aho 2011)* ● *"Using abstraction and decomposition when attacking a large complex task or designing a large complex problem. It is separation on concerns. It is choosing an appropriate representation for a problem or modeling the relevant aspects of a problem to make it trackable (Wing 2006)* ● *"A problem-solving process that includes (but is not limited to) the following characteristics:* *• Formulating problems in a way that enables us to use a computer and other tools to help solve them.* *• Logically organizing and analyzing data • Representing data through abstractions such as models and simulations • Automating solutions through algorithmic thinking (a series of ordered steps) • Identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources • Generalizing and transferring this problem solving process to a wide variety of problems" (ISTE 2021)*
Digital Literacy	● *"Providing children with an understanding of the use of various digital technologies, including social media, digital fabrication techniques, sensors, actuators and computing technologies" (Bekker et al. 2015)* ● *"The ability to access networked computer resources and use them" (Gilster 1997)* ● *"The ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers" (Gilster 1997)* ● *" Digital literacy is associated with the ability to use computers, social media, and the Internet" (Hobbs 2010, p. 17)* ● *Three aspects of digital literacy are: 1."a set of discrete abilities or behaviors", 2. "the application of abstract mental models to activities involving digital content", 3. "engagement in a set of practices involving digital tools and media that are deeply embedded in a particular context or activity" (Meyers et al. 2013)*
Making literacy	● *"A Making-literate student functions effectively at all three levels of skills, mental models and practices…assimilate generalized ways of doing in their thinking and are able to apply them to various problems and scenarios". (Chu et al. 2017)*

4.2.1 Competences to be nurtured in children

Table 3 provides an overview of the employed concepts in the papers from the viewpoint of the competences that need to be developed in children with characteristics of the concepts or their definitions in the papers or in the original sources.

Protagonist characteristics. The concept of the Design Protagonist was coined by Iversen et al. (2017) to emphasize empowerment of children as regards technology development. The term Protagonist addresses the main agency of children when they are involved in design and problem-solving. Their main agency involves skills and critical reflection in and on design and technology development, which ultimately facilitates them to feel empowered to tackle challenges of digitized society (Iversen et al. 2017). Another recent study provided a detailed look into the characteristics of a Design Protagonist as children were positioned into the role in a design and making project (Iivari and Kinnula 2018). Roumelioti et al. (2020) also argue that workshops in which adults act as background facilitators empower children to adopt a Protagonist

role and perform as independent designers in digital making. Furthermore, Södergren and Van Mechelen (2019) introduce a design method for pre-schoolers to act as a Design Protagonist, who can make their own decision, "steer the direction of the design process and express their individual 'voice' in it". Additionally, Gourlet et al. (2016) did not use the term "Protagonist" but consider independent and autonomous work of children as the main objective of their study. They mention that unpacking children's reflective thinking during a design process can actively engage children in design and facilitate them to act autonomously. An earlier study states that inviting children to adopt a central role plays as a motivator for active participation of children (Bonsignore et al. 2013). Hence, several papers have addressed the Protagonist characteristics, but not described it comprehensively: the characteristics of a Protagonist are articulated yet quite vaguely, for instance, what kind of skills and competences children require, why some children can imagine themselves as a protagonist and others cannot, and how they can be motivated to adopt this role.

Maker Mindset/Identity. Maker mindset has been addressed as a design-related competence to be nurtured in children. According to Chu et al. (2015), one of the characteristics of making is that it is shaped through the synthesis of children's prior knowledge, experiences and new skills. Thus, they defined a maker mindset as "a frame of thinking by which the maker address problems by seeking 'do-it-yourself' solutions, a belief that they either have or can acquire the means to construct a solution and possess a creative curiosity to seek solutions that the Maker can construct on her own". Furthermore, self-efficacy, motivation, and interest are considered as key elements of a maker mindset. A maker mindset can be shaped in children's behaviour and thinking in design and making over time, which ultimately leads children to consider themselves as technology and science competent (Chu et al. 2015). In line with Chu et al. (2015) on making activities, Weibert et al. (2014, 2017) point out that making tangible artifacts improves children's maker mindset. Malinverni et al. (2020) addressed the importance of the child becoming the "child-as-maker" to empower them through enhancing their abilities in digital fabrication and making creative use of materials. Integrating digital fabrication and making into formal learning enhances children's maker mindset (Chu et al. 2017). In addition, as the maker mindset has been developed through Papert's theory of Constructionism (Papert 1986), engaging children in makerspaces not only promotes their maker mindset but also eventually provides opportunities for enhancing children's design thinking skills (Hatzigianni et al. 2020). However, nurturing a maker mindset in children is challenging as the core of the maker mindset is still vague in the literature and a deeper understanding of maker identity is needed (Iivari et al. 2018).

Design Thinking. In CCI studies, design thinking has been addressed: various attempts have been done targeting at finding useful and pertinent ways to introduce design thinking to children. Some studies focus on how design thinking can improve children's performance, helping them in progressively understanding the complexity of design and solving problems during the design process. Smith et al. (2015) define design thinking "as the ability to thoughtfully engage in design processes of digital fabrication, knowing how to act and reflect when confronted with ill-defined and complex societal problems". In addition, Grammenos and Antona (2018) describe that "design thinking represents both a way of thinking and a process that can foster creative thinking. In absolute terms, design thinking stands for all the cognitive processes that a person's mind goes through when performing design." Other studies refer to prior definitions of design thinking: for example, Hatzigianni et al. (2020) apply New South Wales Educational Standards Authority's (NESA 2017) definition: "Design thinking is a process where a need or opportunity is identified, and a design solution is developed. The consideration of economic, environmental and social impacts that result from designed solutions are core to design thinking. Design thinking methods can be used when trying to understand a problem, generate ideas and refine a design based on evaluation and testing." The studies maintain that design thinking enhances children's opportunities to explore new conceptual knowledge and empowers them in their everyday digitized world. Engaging children in design thinking practices fosters creativity and innovation (Grammenos and Antona 2018; Hatzigianni et al. 2020). Furthermore, Flores (2018) mentions that when children engage in making artifacts, they can benefit from design thinking and constructionist approach. Fisher et al. (2016) and Fisher and Yefimova (2016) argue that fostering children's design thinking facilitates children to find, generate, share, organize, and modify vital information that they need to deal with in their digitized life. Salvi (2017) argue that in poor and vulnerable locations design thinking increases awareness of children of local issues. Even if the important role of design thinking is highlighted, clear methods for introducing design thinking to children are lacking as well as the best approaches and levels of design thinking that match children's capability and teacher's knowledge (Bekker et al. 2015). Moreover, the possible challenges regarding teaching design thinking to children have not yet been addressed in this literature base.

Computational Thinking (CT). Studies indicate that promoting computational thinking can empower young children in a variety of problem-solving tasks.

The authors mainly utilize Wing's (2006) computational thinking definition: CT is "thinking at multiple abstractions". The studies bring up that CT is an essential skill for children to feel empowered in a digital world and actively participate in design activities. A designerly perspective to game-based design activities is also a helpful tool to promote children's CT and, more importantly, CT should be introduced based on children's funds of knowledge (Brooks and Sjöberg 2020). CT can be taught without conventional programming—rather employing children's existing knowledge, experiences and interest in a game design activity, as when children are engaged in a complex problem-solving activity, they tacitly transform their innate CT skills based on their existing interests into CT process (Lee et al. 2014). However, no method was proposed on how to teach CT built on children's funds of knowledge. Some studies argue that CT plays a key role in enhancing children's digital literacy (Tuhkala et al. 2019; Troiano et al. 2019) and that including game design practices in a constructionist learning environment lead to CT development in children (Apostolellis et al. 2014; Soleimani et al. 2016; Troiano et al. 2019; Troiano et al. 2020). Furthermore, it is reported that the utilization of spatial thinking tools in design activities nurtures children's CT skills (Soleimani et al. 2016). It is also argued that engaging children in the iterative design and debugging process which entails several constructions and deconstruction stages lead to children's CT proficiency (Litts et al. 2019). From another point of view, CT can be taught to children through tangible technologies and making artifacts (Lin and Shaer 2016) and technological tools and programming environments (Quayyum et al. 2020). Due to the importance of CT, there is an acute need to integrate it into the formal curriculum (Tuhkala et al. 2019). In addition, although CT facilitates children's problem-solving skills, it primarily encompasses computing concepts such as algorithms, decomposition and pattern recognition. CT lacks in promoting children's critical and reflective perspective on digitalization. Hence, a shift from CT to computational empowerment is argued for (Iversen et al. 2018).

Digital literacy. The concept of digital literacy has been coined by Meyers et al. (2013). Some papers studied digital literacy skills of children within the design process. According to Bekker et al. (2015) digital literacy "includes providing children with an understanding of the use of various digital technologies, including social media, digital fabrication techniques, sensors, actuators and computing technologies". Reportedly, children's digital literacy can be improved through the combination of handcrafts and digital tasks (Weibert et al. 2017), game-based learning programs (Maqsood et al. 2018), and making workshops. Eventually, children's digital literacy skills can be broadened and shaped into making literacy, which empowers children in design activity (Chu et al. 2017). Although it is reported that digital literacy can be improved through engaging children in design-based learning and digital toolkits, it can be achieved only when the digital toolkits can support learning goals and are aligned with children's various motivations for discovering modern technology (Bekker et al. 2015; Tuhkala et al. 2019).

Making Literacy. Chu et al. (2017) extended the concept of digital literacy (Meyers et al. 2013) and applied it to making activities. Thus, according to Chu et al. (2017), "A making-literate student functions effectively at all three levels of skills, mental models and practices…assimilate generalized ways of doing in their thinking and are able to apply them to various problems and scenarios". They indicate that making literacy can be taught to children if making skills and tutorials are properly adopted and children are involved in making activities.

Science Literacy. Only one paper addressed children's science literacy in design activities and no definition for science literacy was provided in this study. It is argued that utilization of a problem-solving approach as a lens in design not only promotes children's science literacy but also nurtures children's confidence and empowers them to adopt agency in a design task (Flores 2018).

4.2.2 Competences children bring to design

In Table 4, we provide an overview of the employed concepts in the papers from the viewpoint of existing competences that children already have and bring with them to the design process. Definitions of these concepts are collected from the original sources.

Funds of Knowledge (FoK). FoK is discussed in some studies as a useful tool to enhance children's opportunities to actively participate in design. FoK is defined as "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (Moll et al. 1992). According to Moje et al. (2004) four main themes for FoK are family, community, peer, and popular culture. It is argued that FoK do not occur in isolation and are not limited to children's individual knowledge, but rather are shaped through the network of family, community, and peers around children. These social networks provide opportunities for children to draw new resources, knowledge, and skills. Particularly, during the Covid-19 pandemic children have gained diverse knowledge distributed across their communities (Kucirkova et al. 2020). Children bring their FoK from home and everyday experiences and integrate it into design-related science learning

Table 4: *Concepts and definitions of competences already situated in children*

Concept	Definition
Funds of Knowledge	● *"Historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (Moll et al. 1992, p. 133)* ● *Four major themes of funds of knowledge are family, community, peer, and popular culture (Moje et al. 2004)*
Funds of Identity	● *"Historically accumulated, culturally developed, and socially distributed resources that are essential for people's self-definition, self-expression, and self-understanding (Esteban-Guitart and Moll 2014, p. 37)*
Social Capital	● *"Variety of different entities, with two elements in common: they all consist of some aspect of social structures, and they facilitate certain actions of actors-whether persons or corporate actors-within the structure" (Coleman 1988)* ● *"The aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance and recognition—or in other words, to membership in a group—which provides each of its members with the backing of the collectively- owned capital, a "credential" which entitles them to credit, in the various senses of the word" (Bourdieu 1986, p. 248)*
Cultural capital	● *"Familiarity with the legitimate culture" in society (Bourdieu 1979)* ● *Three forms of cultural capital: embodied state, objectified state, institutionalized state (Bourdieu 1986)*
Cultural forms	● *Social constructions that are historically elaborated and connected to social activities (Saxe 1991)*
Interaction order	● *Includes people's network, social interactions, and how interaction is shaped (Goffman 1983; Scollon and Scollon 2004).*
Historical body	● *Refers to the overall aggregated experiences, histories, and knowledge of people's lives which ultimately shape and embody their behaviour (Nishida 1958; Scollon and Scollon 2004)*
Science capital	● *Science-related forms of social and cultural capital. Science capital acts as a predictive model describing the probability that a child will be drawn to a career in STEM (Archer et al. 2015).*

and makerspaces. Besides the four themes mentioned above, valuable information can also be found about children's scientific FoK in informal learning such as in social media sharing apps. Children with different backgrounds mobilize their personal, cultural, and social FoK such as everyday knowledge, languages, and practices as they are engaged in sharing their everyday experiences through social media (Mills et al. 2018; Mills et al. 2019). However, a limited number of papers explicitly capitalize on different forms of FoK and apply them to investigate the value of FoK as a key resource in design activities. Some studies only mention the role of FoK in the design process without explicitly defining it (McBeath et al. 2017; Rembert et al. 2019; Yip et al. 2014). Then again, the notion of FoK provides an opportunity for design process to contemplate on transferring children's informal scientific knowledge into formal science learning contexts (Mills et al. 2018; Mills et al. 2019). In addition, it is argued that development of design activities built on children's diverse FoK not only lays the ground for children's evolving interest and motivation in design activities but also enables children to engage as designers based on their existing knowledge and competences (Brooks and Sjöberg 2020).

Furthermore, recently, a new shift has emerged in CCI that highlights a novel perspective to the notion of FoK, which is built on an asset-based approach (Kretzman and McKnight 1993). In order to empower children, the main focus in design activities should be on leveraging children's existing knowledge and competences, for instance, their parents' cultural capital, rather than their needs and lacks. (Wong-Villacres et al. 2020). The basis for this work is in 'asset-based design', a recent shift in HCI research highlighting communities' competences for sustainable development (Cho et al. 2019; Irani et al. 2018; Karusala et al. 2019; Pei and Nardi 2019; Wong-Villacres et al. 2020), the term asset being used to identify communities' existing strengths, skills and competences—rather than their shortages and needs. However, identifying these assets or varying kinds of FoK within the context of children's design capital requires work.

Tacit Knowledge. Although we found no explicit definition for tacit knowledge in the papers, some studies pointed out that children's tacit practices are associated with funds of knowledge which should be converted to explicit and formal knowledge in design activity considerations (Lee et al. 2014; Mills et al. 2018; Mills et al. 2019). Similarly, Lee et al. (2014) point out that teaching computational thinking skills to children within a design activity should be based on children's existing knowledge, experiences and interests. As children are engaged in a complex problem-solving activity, they tacitly transform their innate computational thinking skills based on their existing knowledge and interest into computational thinking process.

Funds of Identity (FoI). Only one study (Kucirkova et al. 2020) utilized the funds of identity concept and mentioned that FoI is an extension of funds of knowledge concept. FoI is considered a useful tool to promote children's opportunities to learn within design activities. The authors refer to Esteban-Guitart and Moll's definition, which describes FoI as "historically accumulated, culturally developed, and

socially distributed resources that are essential for people's self-definition, self-expression, and self-understanding" (Esteban-Guitart and Moll 2014). Children absorb resources from the network of adults around them to define themselves. That ultimately influences children to find and express themselves as an agent in design activity (Kucirkova et al. 2020).

Social and cultural capital. A limited number of the analysed papers report on social and cultural capital. In these studies, Bourdieu's notion of capital is used and linked to funds of knowledge to highlight that children's social capital is not limited to their individual knowledge, but rather distributed through networks around children. Social capital is one of the children's resources, which refers to their accumulated existing abilities and knowledge shaped through their social interactions (Wong-Villacres et al. 2020). For instance, parents as a source of social capital (Coleman 1988) are capable to facilitate learning opportunities and educational experiences for their children (Disalvo et al. 2016; Wong-Villacres et al. 2020). Furthermore, Madaio et al. (2019) utilize both Bourdieu's cultural capital and Swidler's notion of culture in action (Swidler 1986) to show how parents' values, beliefs, and aspirations for their children's education can scaffold children's knowledge in design. Moreover, children tacitly leverage their existing intangible capitals to solve their design-related problems (Wong-Villacres et al. 2020). However, children's social and cultural capital are addressed in only three papers. No explicit definitions by authors were found and only the role of parents in social and cultural capital was taken into consideration. Moreover, different forms of cultural capital such as embodied, objectified, and institutionalized (Bourdieu 1986) have so far been neglected.

Cultural forms. Children's cultural forms were reported in two studies (Horn 2013; Horn et al. 2013). Cultural forms are initially influenced by cultural funds of knowledge (Moll et al. 1992). Children's cultural forms can be seen as a key cultural resource for evoking an exploration of new competences in children within tangible design activities. The authors employ the definition of cultural forms by Saxe: cultural forms are social constructions that are historically elaborated and connected to social activities (Saxe 1991). Although cultural forms were mentioned as valuable resources, there was no discussion regarding the connection between cultural forms and related concepts.

Science Capital. Only one paper (Apostolellis et al. 2018) addresses the notion of science capital. It is argued that children's participation in informal science activities such as digital games, has an important role in generating science capital. The notion of science capital by (Archer et al. 2015) was used in the paper, describing science capital as science-related forms of social and cultural capital, which acts as a predictive model describing the probability that a child will be drawn to a career in science, engineering, technology or mathematics.

Interaction order and historical body. Nexus analysis (Scollon and Scollon 2004) was utilized in two studies (Iivari et al. 2020; Kuure et al. 2010) indicating that social action can be influenced through an intersection of children's interaction order, historical body, and discourses in place. Interaction order (Goffman 1983) resembles Bourdieu's social capital and indicates participants' networks, their social interactions, and how those are shaped. The concept of historical body (Nishida 1958) is similar to the funds of knowledge concept and refers to the overall aggregated experiences, histories, and knowledge of children, which ultimately shape and embody their behaviours. It is argued that a multidisciplinary perspective is essential in order to gain deeper insights into complex social actions of children (Iivari et al. 2020; Kuure et al. 2010).

5. DISCUSSION

5.1 Main findings

The overarching objective of this study was to identify children's competences needed for becoming a Design Protagonist. We conducted a narrative literature review and identified 48 papers that satisfied our predetermined inclusion criteria. The results indicate that various factors influence and are associated with the adoption of a Design Protagonist role. In terms of competences needed in design, several concepts were identified, including protagonist characteristics, maker mindset/identity, design thinking, computational thinking, digital literacy, computational literacy, making literacy, and science literacy. Even if a considerable number of papers mentioned the necessity of children's skills and competences, only few of them practically studied the competences needed to be nurtured within design activities with children.

An interesting insight generated in this study concerns children's competences that they bring to the design process. We identified diverse concepts including funds of knowledge, funds of identity, social and cultural capital, cultural forms, tacit knowledge, science capital, historical body, and interaction order. Even though we report a variety concepts, the limited number of papers addressing children's existing competences indicates that these concepts have been mostly ignored in CCI research. Hence, our results indicate a number of gaps in the existing CCI literature as well as insights on how to move the field forward. These are discussed next.

5.2 Implications for CCI research

Based on our analysis, we conclude that the concepts relevant to children's competences and their relationships, differences and similarities have not yet been comprehensively or systematically examined in CCI research. We take the first step to fill this gap and extend our understanding of children's competences relevant for the role of the Design Protagonist. In the light of our findings**, we propose "design capital" as an overarching concept to capture factors relevant for the adoption of the Design Protagonist role among children**. We illustrate the aspects relevant for design capital in Figure 3: the design capital concept acts as an umbrella concept that includes a wide range of concepts found in the literature, grouping them into competences that need to be developed in children and competences that are already situated in children that they can bring to the design process. Although the competences needed among children indicate a wide variety, common for all of them is the goal of "managing and mastering digitalization". We also wish to highlight that the competences already situated in children are interrelated, as the shared component that constitutes them is a historical practice—an aspect that highlights these competences have been shaping in children through their lifetime (see Figure 3). In detail, cultural capital, funds of knowledge, funds of identity, historical body, science capital, cultural forms, and tacit knowledge refer to an individual's historically accumulated knowledge, skills, and experiences, which are usually formed through an individual's social relationships and networks of people called social capital or interaction order.

We propose design capital as a powerful new theoretical concept for structuring and guiding CCI research on children's skills and competences in design. The design capital concept might not directly help children in participating and engaging in design activities, but it assists researchers to gain a better understanding of the competences needed for a child Design Protagonist. As the CCI literature has limitations in terms of theorizing and use of theoretical concepts, this literature review contributes to CCI research by introducing a valuable new theoretical concept. The concept of capital originates from a strong theoretical basis and captures significant elements in terms of competences and assets children bring into and develop in design when acting as Design Protagonists. We maintain, in line with the existing CCI research, that children possess various kinds of existing forms of design capital that they bring to the design process, and in the design process they gain new knowledge and skills, hopefully increasing their design capital and agency to act as Design Protagonists in the future. This is in line with Bourdieu's thinking that different forms of capital are interrelated (Bourdieu 1986) and that capital may potentially generate more forms of capital (Archer et al. 2015). It is also in line with the recent introduction of the asset-based approach that emphasizes the existing resources and strengths in the support of communities (see e.g. Cho et al. 2019; Irani et al. 2018; Karusala et al. 2019; Pei and Nardi 2019; Wong-Villacres et al. 2020). However, we acknowledge that the concept of capital has not yet received a lot of attention in CCI and there is a clear need to continue this conceptual work: to clarify the different characteristics of design capital, and its dynamics, evolution and consequences in time.

We propose the design capital concept to structure and inform also CCI design practice with children. Even though the importance of children's competences such as diverse forms of capital and existing knowledge has been acknowledged within the educational context, it has mostly been ignored in design practice with children. As it seems that many CCI researchers strive to raise children to become future Design Protagonists, we need to carefully consider and develop our understandings and assumptions on the competences needed as well as existing among children. This literature review identified different facets of children's existing competences for developing design learning outcomes. Similarly, this study indicated the potential of children's existing design capital for scaffolding design developments aiming at children's empowerment. We maintain that any design activity with children should provide an opportunity for children to bring in their situated capacities and assets (Wong-Villacres et al. 2020)—the different forms of capital and funds of knowledge they possess in relation to digital technology and design (e.g. their interests, experiences, creativity and problem-solving ability). For this to happen, we recommended CCI researchers and practitioners to broadly consider the concepts identified in this study in their projects with children and try to allow and encourage children to make use of their existing competences and asserts in design as broadly as possible. Moreover, CCI researchers and practitioners should also early on in their projects reflect on what kind of competences they are particularly interested in developing in children. The concepts identified in this study have different emphasis and foci, while they also share many aspects. We particularly emphasize the need to encourage children to become Design Protagonists, who feel empowered and gain a novel understanding of digital technology and its impacts on their everyday life and society.

The results of this literature review show that **further research is needed to generate more empirical evidence of children's competences in design as Design Protagonists, and of the existence, nature, and formation of children's design capital**. CCI research should also identify and

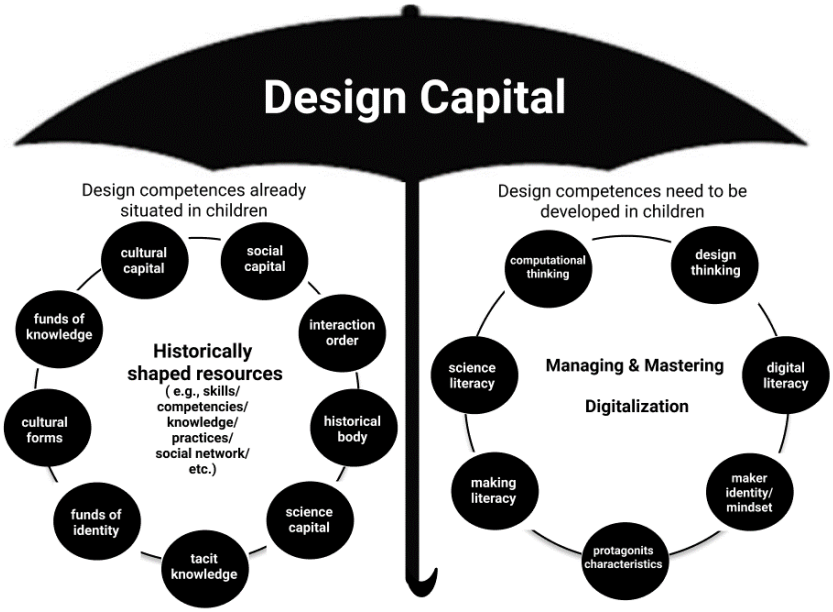

Figure 3: *Design capital*

examine the dynamics and interrelations of the underlying elements of design capital further (Figure 3). In addition, CCI researchers need to illuminate how these existing competences might mediate children's proficiency in design. Figure 3 lays a foundation for mapping children's competences in design and illustrates the variety of competences already existing in children as well as to be acquired However, we underscore that the competences for children to act as future Design Protagonists are not limited to the concepts mentioned in this study. Certainly, there are other potential competences that are pivotal for the Design Protagonist role for children. We acknowledge that some essential competences —such as skills, abilities, attitudes and values relating to leadership, activism and reflection, have so far been addressed in CCI research in a very limited manner.

5.3 Limitations

This literature review is limited to the search terms we used. It might be possible to find more studies on children's competences with using different terms. In addition, we excluded papers that described projects involving children with specific needs or disabilities. Additional concepts regarding children's competences might have been provided from that field of study, and that area provides interesting possibilities for future studies. We did not inquire about the effect of children's age on the concepts used. This could be considered in future studies. Several limitations are also concerned with generating our tables of concepts. Firstly, some of the children's competences were not covered in the included papers as we expected (e.g. habitus, various forms of cultural capital and design literacy). In addition, the number of papers addressing children's competences was limited and most papers that utilized the concepts did not provide comprehensive definitions for them. Some of the concepts were also employed in one or two studies only, so it prohibited us from comparing them with other studies to find similarities, differences, and relationships. A noteworthy limitation is also that this literature review only covered studies in the context of design with children, while there are interesting studies in the context of children's education as well as in the context of design with adults – both type of studies would bring additional insights on the competences associated with design. This review provided a first step addressing the developments within the core discipline of CCI. We also acknowledge that interesting insights would have been gained by reviewing the national curricula of basic education of different countries. The curricula would inform us on a variety of digital skills considered necessary for children, even if we wish to point out that many curricula remain negligent of children's design related competences still.

6. CONCLUSIONS

This paper is the first step towards a conceptual understanding of design capital that the future Design Protagonists would need. We argue that as we face the ongoing digital transformation of society and everyday life, there is a dire need for our children to grow to Design Protagonists who are empowered to critically reflect on their own technology use as well as on its use in society, and to make and shape our digital futures. For that, they need design capital, and the CCI community is in a key role in analysing and defining what that capital means in theory and practice as well as in taking action towards nurturing it among children.

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