

MULTIPLE VOICES IN THE MAKER MOVEMENT – A NEXUS ANALYTIC LITERATURE REVIEW ON CHILDREN, EDUCATION AND MAKING

Research paper

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Abstract

Inviting children to take part in maker movement has been advocated, especially in the context of education. Despite the numerous publications related to making, a more theoretical treatment and common vocabulary of the topic are still lacking. This paper utilizes as its theoretical lens the research framework of nexus analysis, suited for an in-depth study of complex social phenomena, to make sense of existing research on children and making. The study illustrates the value of the nexus-analytic concepts of 'discourses in place', 'interaction order' and 'historical body', the three aspects of social action, in scrutinizing the extant research as well as indicates how to utilize these concepts in educational making projects with children: when establishing relationships with children, involving children as makers, and analyzing the results. Implications for IS research, practice and education are discussed.

Keywords: Making, Digital Fabrication, Fab Lab, Children, Nexus Analysis, Education

1 Introduction

Making, i.e., crafting and tinkering, is nothing new for humankind in itself. However, the current maker movement, “the growing number of people who are engaged in the creative production of artefacts in their daily lives and who find physical and digital forums to share their processes and products with others” (Halverson & Sheridan 2014: 496), is a relatively new phenomenon. It is made possible by the availability of relatively cheap tools and material for digital fabrication (Halverson & Sheridan 2014) as well as the affordances of the Internet for online collaboration. The maker movement or making is not limited to digital fabrication: it combines various crafts and activities, from cooking to jewellery making to robotics. However, in the current and future technology-rich world, digital fabrication in particular is seen as a source for a new revolution in many different fronts through the possibilities that it offers to anybody to design and produce almost anything when they so wish (Gershenfeld 2012).

Children making is among the hottest topics in the field of education at the time of this study. Making is expected to boost children’s interest in science, technology, engineering, and mathematics (STEM) and to support their skills and mind-set needed in the 21st century (Bekker et al. 2015, Pucci & Mulder 2015). Schools acquire 3D printers and laser cutters, Fab Labs are established all around the world (Walter-Herrmann & Büching 2014), and programming is seen as a key competence (Durães 2015) with countries such as Estonia, the UK, and Finland having added programming into their curricula for primary and secondary education. Making is employed in a variety of learning spaces ranging from schools and universities to museums, libraries and non-profit organizations to gain a deeper understanding of a diversity of topics such as design (Smith et al. 2015), or democratization (Hatch 2014).

It seems obvious that Information Systems (IS) research among other disciplines should be interested in the maker movement. STEM education in schools is preparing the young generation to study IS topics and to pursue IS careers. Making in this context is expected to increase curiosity for such areas. The maker movement can even be seen as educating and empowering future digital innovators (Iivari et al. 2016), whose education can be seen to be at the heart of the IS discipline (Fichman et al. 2014). Furthermore, the maker movement is argued to have a central role in contesting the digital divide, i.e. polarization between people due to unequal access and ability to develop skills related to digital technology. The digital divide poses a serious challenge to the IS discipline, among others (e.g., Agarwal et al. 2009; Riggins & Dewan 2005; Srivastava & Shainesh 2015). The maker movement argues for offering in-depth technology knowledge for children: the goal is to educate children to design, make, and build new technology, not merely to use it (e.g., Blikstein 2013; Honey & Kanter 2013). To combat the digital divide, we maintain that inclusive education in making is valuable for the children of today, as their future will be merged with even more digital technology than now.

Despite the silence in IS research as regards children and making, there is already an abundance of studies available from diverse settings, e.g., to find appropriate methods for the purpose. Different disciplines, research and design settings as well as various actors involve different understandings and approaches to the topic of making with children. Educating children in making seems to be a complex endeavour and research topic, and a systematic analysis of the state of the art is lacking. In order to shed light on the situation, we conducted a thorough literature review on research on the maker movement targeting children. The topic is approached through the framework of nexus analysis (e.g., Scollon & Scollon 2004), which is suitable for studying complex topics in depth. Nexus analysis takes into account various social, cultural and historical aspects seeing social action as an intersection of discourses in place, as well as the historical bodies of the participants and the situationally variable interaction orders between them (Scollon & Scollon 2004). We were inspired particularly by the work of Molin-Juustila and colleagues (2015), who show that there are always and necessarily many voices influencing in the background when designing with children. In other words, every design situation is tied to its social and historical context and the relationships between the participants, which necessarily shapes the results. Consequently, we will examine ‘educating children in making’ as a complex social action, related to which we inquire the variety of participants and how their histories and mutual

interactions shape making activities with children. Moreover, we will consider how the nexus analytical framework could help in advancing making activities with children in the future.

The structure of the paper is the following. The next section introduces nexus analysis used as our theoretical lens for making sense of the literature on children and making. Next, the methodology for the literature review is presented. The fourth section discusses our findings, and the fifth section considers their implications for the IS research community, discusses their limitations, identifies interesting paths for future work and concludes the paper.

2 Nexus Analysis as a Theoretical Lens

The theoretical lens for this study is provided by *nexus analysis*, developed by Scollon and Scollon (2004) as a “historical, ethnographic and methodological arm” of ‘mediated discourse analysis’, which focuses on linkages between discourse and action and how their interplay works in complex social situations (Scollon & De Saint-Georges 2013: 73). Nexus analysis guides to mapping of semiotic cycles of people, discourses, places and mediational means involved in the (mediated) social actions (Scollon 2001, Scollon & Scollon 2004: 14). One of the general concerns of nexus analysis is how “the broad discourses of our social life are engaged (or not) in the moment-by-moment social actions of social actors in real time activity” (Scollon 2001: 139). Methodologically, a nexus analysis is an ethnographic study, involving participant observation and discourse analysis (Pan 2014).

In nexus analysis, social action (in this study: ‘educating children in making’) is the central focus of analysis and seen as mediated, emerging through the intersection (nexus) of three ‘aggregates of discourse’ in real time and space. These aggregates are called interaction order, historical body and discourses in place (Scollon & Scollon 2004: 19). *Interaction order* refers to the social arrangement between people in a group. The notion originates from Goffman’s (1955, 1983) observations on people behaving differently in different configurations of participants, e.g., in smaller ‘withs’ or in larger groupings. In the context of our study, peer pressure may affect children’s interactions and collaboration in workshops, for example. There are also more distant actors with their mutual power relationships that will contribute to the shaping of the action in question. For example, policy makers have their impact on how innovation and education strategies are defined in the school curricula, thus having an impact on daily teaching settings in the school.

The life experiences of a social actor are referred to as the individual’s *historical body*, i.e., personal habits that feel so natural that one performs actions seemingly without being told. The concept stems from Scollon’s (Scollon 2001) readings of Nishida (1958) and his interpretation of Bourdieu’s (1990) ‘habitus’, historical body being more closely tied with participants’ concrete embodied actions (Scollon & Scollon 2004: 13). In the context of our study, this shows among others in how children’s needs, passions, and dreams affect their contributions or how children recreate objects that have their origins in children’s everyday life and experiences.

The notion of *discourses in place* implies that all social actions are mediated by cultural tools or mediational means, the most salient being language (Scollon 2001: 141). The diversity of the discourses can be seen as rhizomatic in the Deleuze and Guattarian (1987) sense, i.e., heterogeneous, non-hierarchical and complexly networked (Honan 2007, Honan 2010). The same metaphor has been used to characterize nexus analysis (and multi-sited ethnography) as a methodological move that views processes and events to be observed in terms of flow and dis/connections (Pietikäinen 2015). The concept of discourses in place, characterized by Blommaert and Huang (2009: 273), also emphasizes the social space into which people have become accustomed. Space can be seen as an actor in sociolinguistic processes as communication always takes place in a spatial arena which imposes its constraints and affordances on communication (Blommaert & Huang 2009: 276).

In this study, we utilize the nexus-analytic concepts to make sense of existing literature – hence we do not have direct access to discourses in place, but examine them as they are displayed in the published literature addressing the topic. In other words, we direct our focus to the researchers’ discourses: how they positioned and motivated their studies and the phenomenon of making with children. This type of

analysis enables us to shed some light on the nexus-analytic interest in how “the broad discourses of our social life are engaged (or not) in the moment-by-moment social actions of social actors in real time activity” (Scollon 2001: 139). At least, we can show traces of broader academic and societal discourses circulating around and influencing the choices that the researchers have made in their studies.

It needs to be noted that the three aspects of social action, i.e., interaction order, historical body, and discourses in place, are analytically inseparable. Discourses arise from interactions between participants with their historical bodies, configured through their situationally emergent interaction orders (Scollon & Scollon 2004: 14). Still, they may be heuristically used as different angles to the social action under scrutiny (see e.g., Molin-Juustila et al. 2015).

3 Methodology

The literature search for this study was carried out through a number of information services that provided access to a range of electronic databases (AIS, ACM, EBSCO, Elsevier, IEEE, LNCS, ProQuest, SCOPUS, Springer, Web of Science, and Google Scholar). It relied on Boolean search with the keywords of ‘digital fabrication’, ‘maker’, ‘making’, ‘DIY’, ‘fabrication’, ‘fablab’ in combination with ‘child’, ‘teen’, ‘youth’, and ‘adolescent’ (e.g., ‘digital fabrication’ AND (‘child’ OR ‘teen’ OR ‘youth’ OR ‘adolescent’)). This was a traditional narrative literature review (Boell & Cecez-Kecmanovic, 2014) where we aimed at a comprehensive understanding of the topic instead of examining a very specific research question (cf. Boell & Cecez-Kecmanovic, 2014). For a novel research topic, such as making, a narrative literature review is recommended as the terminology has not yet become established (Boell & Cecez-Kecmanovic 2014).

We gained through the searches around two thousand hits (AIS: 7 hits; ACM: 27; EBSCO: 27; Elsevier: 6; IEEE: 1316; LNCS + Springer: 68; ProQuest: 0; Scopus: 9; Web of Science: 34; Google Scholar: 594), not all relevant though. We browsed through several hundred articles and identified around 50 most central articles for a thorough analysis. To be included, the studies had to report on actual experiences of working with children or otherwise present a recent or a thorough and widely cited account of the topic. The articles that did not contain empirical data were excluded as were very short and technology-focused papers that did not report what was done with children (e.g., papers on 3D printing). Publication years of the articles were not limited. The articles were organized in Google Drive with reference information and details on the purpose of the research, research design, and relevance from the perspective of the theoretical lens utilized in this study.

The analysis started by three of the authors examining the chosen articles drawing on the concepts of discourses in place, interaction order and historical body. Attention was paid to three specific aspects in the papers: 1) how the authors positioned their studies and the phenomenon of making with children within academic and societal discourses circulating around; 2) who were the participants involved and how the making was shaped by interactions between the participants (e.g., actual participants *in situ* such as children and researchers, but also more distant stakeholders whose voices could still be traced) and 3) issues relating to the historical bodies of the participants and how those shaped making. In the second phase of the analysis, the authors collaboratively discussed the findings, and outlined their implications. Finally, a subset from the papers was selected for presenting the results in the current study and creating a narrative synthesis on educating children in making. The next section will present the findings based on the analysis of existing studies on making with children.

4 A Nexus-Analytic Interpretation of Children and Making

Table 1 summarizes our main findings on how discourses in place, interaction order, and historical body show in our nexus-analytic inquiry on research related to children and making. Although intimately intertwined, it is also possible to identify separate key findings relating to each analytic concept (cf. Molin-Juustila et al. 2015).

Discourses in place	Interaction order	Historical body
<p>Children's learning is a major goal</p> <p>Learning is viewed from a constructionist, practice-based and participatory perspective</p> <p>Making gives children many 21st century skills</p> <p>STEM-related skills and understanding are needed in the future</p> <p>Making needs to be part of future education to ensure the competitiveness of a country</p> <p>Making emancipates and empowers children</p> <p>Making should be seen as a mindset rather than only a set of skills; maker identity is needed</p> <p>Making is not enough, a broader, designerly approach is needed</p>	<p>A multitude of participants are shaping making, both adults and children</p> <p>Facilitators: provide encouragement and guidance; influence children's making experience drawing on their own understandings and practices; need support and training for their work</p> <p>Teachers: bring along a significant resource (knowledge on children and education), but are also in need for help and training</p> <p>Peers: stimulate making, learning and sharing, but may bring along problems in peer collaboration</p> <p>Funders, governments, associations, universities, companies, and policy makers: often indirect and historically less immediate visibility; participate in the construction of the material and pedagogic environment</p>	<p>Children's interests, hobbies, everyday life experiences, and digital media experiences motivate children's making and shape the outcomes; this should be encouraged</p> <p>Available resources, visible in the space, shape the creations, but a mere replication of existing objects may also emerge</p> <p>Materials and technologies available (e.g., Fab Lab equipment) may also restrict the creative potentials</p> <p>Children's lack of skills and knowledge as well as their biases and misbeliefs may hinder making</p> <p>The traditional practices of the teachers and schools may hinder making</p> <p>The background of the facilitators may shape children's making experience</p>

Table 1. Key findings on discourses in place, interaction order and historical body in studies of children and making.

Next, the findings are discussed in more detail.

4.1 Discourses in Place

When looking at the studies of making and children from a discourse perspective, it is obvious that the researchers have mostly adopted a positive stance to making – making is celebrated and strongly advocated. Children's learning is postulated as a central focus. The researchers argue for making as it develops children's '21st century skills' (e.g., Bekker et al. 2015, Pucci & Mulder 2015). Many studies refer to Papert's (e.g., 1980, 1991) work (e.g., Blikstein 2013, Giannakos & Jaccheri 2013, Litts 2015, Wardrip et al. 2015) and advocate constructionist learning perspectives (e.g., Blikstein 2013, Fitton et al. 2015, Litts 2015, Vasudevan et al. 2015, Wardrip et al. 2015), experiential learning and practice-based (design) educational formats (Akbal et al. 2014, Pucci & Mulder 2015), culture of self-driven learning (Bar-El & Zuckerman 2016), project-based learning (Durães 2015, Vandevelde et al. 2015), principles of Reggio Emilia and Montessori education (Giannakos & Jaccheri 2013, Wardrip et al. 2015), and participatory educational approaches (Pucci & Mulder 2015). More informal, 'unstructured learning' with no formal instructors, teenagers mentoring younger children (Bar-El & Zuckerman 2016) is also called for.

The studies, however, have slightly differing perspectives on learning as well. Some researchers emphasize making as a tool educating the future workforce and for the success of society. Making is posi-

tioned as a tool for education to fill the growing demands of the future workforce. STEM literacy and capability are seen to be key skills in the future, highlighted as important for the competitiveness of countries (Beyers 2010, Christensen et al. 2015, Durães 2015, Lassiter et al. 2013, Litts 2015, Vandeveldt et al. 2015). Society is even portrayed as losing ‘new Einsteins’ if children are not provided with such basic skills (Beyers 2010). The changing needs of society are brought up as affecting what needs to be taught in schools (Blikstein 2013, Pucci & Mulder 2015); the use of digital fabrication in education is seen as something unique and progressive (Blikstein 2013), possibly enhancing children’s skills to ‘produce and envision a personal approach to current challenges in society’ (Smith et al. 2015). In addition to that, more general skills such as critical thinking, problem solving, creativity, teamwork, and communication skills are seen as important in combination with STEM-related skills (Durães 2015). In many studies, school curriculum development is brought up as an important motivator for the research (Beyers 2010, Blikstein 2013, Lassiter et al. 2013). However, children’s motivation to participate in software and hardware intensive activities needs to be understood better (Giannakos & Jaccheri 2013) as in schools, children do not necessarily have an intrinsic motivation to participate (Iversen et al. 2016), compared to voluntary activities (Christensen et al. 2015).

Some researchers, then again, relate learning more to children’s personal needs and empowerment. These studies state that as technology has such an important impact on society, understanding of technology is important for children now and especially in the future (Bekker et al. 2015, Durães 2015, Smith et al. 2015). Maker and open hardware movements are seen as empowering children through digital literacy, DIY mentality, and creative coding, giving children ‘control of their own game’ (Akbal et al. 2014, Bekker et al. 2015, Giannakos & Jaccheri 2013, Pucci & Mulder 2015, Smith et al. 2015, Telhan et al. 2014). Children should be able to build technology instead of only passively consuming it (Blikstein 2014, Vasudevan et al. 2015). This ability is seen as valuable for all citizens, not only for future engineers (Blikstein 2013, Durães 2015). Technology is seen an emancipatory tool (Blikstein 2013, Telhan et al. 2014) and children as natural users of new technology (Eisenberg 2013).

Children’s personal growth and learning are emphasized in studies on maker mind-set and maker identity (Chu et al. 2015, Litts 2015). Critique is directed on narrowing the focus only on skills related to making. Making should rather be seen as a mind-set than a set of skills (Chu et al. 2015, Katterfeldt et al. 2015). For example, children should not be building robots for building’s sake but for a purpose, aiming at self-efficacy and ‘bildung’ (deep and sustainable learning) (Katterfeldt et al. 2015). Making activities should be designed so that they help in the emergence of a maker mind-set and maker identity in children (Chu et al. 2015). The activities should be understood so that children’s personalities could also be stimulated while interacting with material reality (Katterfeldt et al. 2015). In relation to that, some researchers even maintain that focusing on making is not enough, as children should learn to understand the value of technology more generally and to adopt a broader designerly approach to problems (Bekker et al. 2015, Gourlet & Decortis 2016, Iversen et al. 2016, Smith et al. 2015).

4.2 Interaction Order

In the studies on making and children, many aspects of interaction order become apparent when using the concept as a sensitizing device. First of all, the studies show a variety of participants that may be involved in making activities beyond the single child. Facilitators, teachers, researchers, artists, university students, technical personnel, designers, parents and peers may be present in one way or another. Further, the activity may be taking place in a variety of settings, e.g., a school, museum, library, computer club, Fab Lab, youth centre, conference or university (Akbal et al. 2014, Bar-El & Zuckerman 2016, Bekker et al. 2015, Berry et al. 2010, Blikstein 2013, Christensen et al. 2015, Chu et al. 2015, Durães 2015, Fitton et al. 2015, Giannakos & Jaccheri 2013, Golsteijn et al. 2014, Katterfeldt et al. 2015, Litts 2015, Posch et al. 2010, Pucci & Mulder 2015, Smith et al. 2015, Telhan et al. 2014, Vandeveldt et al. 2015, Vasudevan et al. 2015, Wardrip et al. 2015). Some studies report on entirely voluntary making activities, e.g., in youth centres, museums, libraries or computer clubs. In other studies, the activities have been organized as part of schoolwork – sometimes as elective, after school clas-

ses or extra-curricular activities (Christensen et al. 2015, Durães 2015, Pucci & Mulder 2015, Vasudevan et al. 2015). Such a diversity in circumstances naturally influences interaction dynamics.

The studies reveal interesting findings on how different participants shape the process. Many studies emphasize the importance of facilitators or mentors. Facilitators can provide support in tool operation, materials collection and encourage the work (Bar-El & Zuckerman 2016, Litts 2015, Posch et al. 2010, Telhan et al. 2014). Thus, the background and training of the mentors or facilitators has been brought up (Bar-El & Zuckerman 2016, Litts 2015, Telhan et al. 2014). It is argued that the facilitators' identity and competence influences their practice: the disciplinary preferences and expertise of the facilitators shape children's making experiences (Litts 2015, Telhan et al. 2014). Therefore, the facilitators should be trained and encouraged to expand their maker identities and competencies (Litts 2015). Peer support and collaboration can be useful here as well as working with different kinds of external experts (Litts 2015). Pedagogical expertise is also regarded as valuable for facilitators (Litts 2015).

Schools have been seen as important partners for making projects (Akbal et al. 2014, Bar-El & Zuckerman 2016, Bekker et al. 2015, Berry et al. 2010, Smith et al. 2015). It is emphasized that through cooperation with schools, facilitators will know what kind of knowledge and skills children have (Akbal et al. 2014). Partnering with teachers is recommended (Berry et al. 2010, Smith et al. 2015, Vasudevan et al. 2015). Teachers can act as motivators and facilitators of the process (Bekker et al. 2015, Beyers 2010, Blikstein 2013). Encouraging teachers in making is important as their agency, engagement and competence as supporters of children's participation are needed (Akbal et al. 2014, Bekker et al. 2015, Eisenberg 2013, Lassiter et al. 2013, Vandeveldel et al. 2015). It is also pointed out that teachers are in need for help: they may have difficulties in facilitating the process on their own (Bekker et al. 2015, Smith et al. 2015). Training and supporting educators in curriculum development and teachers in practical deployment of making in schools is highlighted (Lassiter et al. 2013).

Peer learning and support is another prevalent theme in the studies (e.g., in Akbal et al. 2014, Beyers 2010, Chu et al. 2015, Posch & Fitzpatrick 2012, Posch et al. 2010, Pucci & Mulder 2015, Vasudevan et al. 2015, Wardrip et al. 2015). In many studies, making has been organized as group work as in self-selected friendship groups (Fitton et al. 2015) or teachers helping in group formation (Fitton et al. 2015). The studies indicate that children value working in groups as it enables them to gain new ideas and learn from each other but also makes the activity more enjoyable and creative (Giannakos & Jaccheri 2013). Children can seek and share resources and expertise (Wardrip et al. 2015) and they may be spontaneously teaching each other, evaluating each other's work, showing off to other children and sharing results (Chu et al. 2015, Fitton et al. 2015). In many studies, children are asked to present their products to others (Giannakos & Jaccheri 2013). Thus, galleries have been suggested for the participants to share their own creations and to gain inspiration (Posch et al. 2010). Children may also introduce new members to a maker space (Bar-El & Zuckerman 2016). The importance of children's power and agency has been emphasized specially in a study where teenagers acted as mentors for children in a maker space managed by children for children (Bar-El & Zuckerman 2016).

However, organizing making as group work is not without problems. The final outcome of collaborative work demands constant negotiation and interaction between the group members with potentially differing interests. If the choice is left for the group, selecting a shared and common theme for time-limited group work might turn out as a challenging negotiation between the group members (Golsteijn et al. 2014). Children's groups can be dysfunctional and sometimes it may only be part of the group that is actually engaged in the activities (Smith et al. 2015). Balancing between autonomy and instruction is challenging: in the maker space managed by kids, some children pointed out that the mentors should have been more helpful in providing more guidance and setting examples by presenting their own projects (Bar-El & Zuckerman 2016). Peer pressure may also play a role in group work. Nevertheless, children may manage to resist peer pressure. In other words, children's motivation can be triggered beyond the need of approval from the group with the promise of recognition for the skills both at school and in the making community. (Pucci & Mulder 2015)

Despite the challenges, the community aspect is also seen as beneficial in making: connecting both the youth and the facilitators (Litts 2015, Pucci & Mulder 2015, Telhan et al. 2014). The maker space can

be a collective source of information and ideas and the team's internal dynamics is important for the success of the team (Blikstein 2013). The studies also bring up an even broader context with a variety of stakeholders that need to be considered when thinking about children and making. For example, funders (Bekker et al. 2015, Litts 2015) are important actors behind the scenes as are associations related to engineering, technology and education (Eisenberg 2013), as well as the Fab foundation and associated communities (Lassiter et al. 2013). Governments participate in defining strategies for innovation and education and in setting the curricula for schools (Bekker et al. 2015, Beyers 2010). Scientists and universities give their contribution to teacher education, developing theories, methods and tools for teacher education and schools. Policy makers, publishers as well as companies and researchers are also contributing through the development of different kinds of means and tools for making (Bekker et al. 2015, Blikstein 2013, Lassiter et al. 2013).

4.3 Historical Body

The concept of historical body as a sensitizing device also enables us to identify some interesting findings from the studies addressing children and making. These findings show how the participants' historical bodies shape making projects – most notably how children's life histories and experiences shape making, while some studies also underline adult participants' and institutions' influence.

In some studies, researchers have inquired aspects of children's historical bodies as a starting point. For example, in a study on game design, the work was started by asking children to discuss their favourite games and gaming habits, after which they were invited to design their own game (Akbal et al. 2014). Children's historical bodies have been even more broadly explored, e.g., through questionnaires asking about their digital literacies and interests in STEM (Beyers 2010). The studies have also examined how dispositions toward disciplines such as mathematics and science are shaped long before future professionals begin their college studies (Christensen et al. 2015), employed interviews to map young people's lifestyles, needs, passions, common traits and dreams (Pucci & Mulder 2015) and inquired children's self-efficacy, interests, self-concept and motivation in relation to STEM and language arts such as storytelling, reading and writing (Chu et al. 2015).

Many studies have emphasized that children need to be free to choose what to do while making. Making should be about creating personally meaningful objects: children's own interests and needs should be driving the work (Bar-El & Zuckerman 2016, Bekker et al. 2015, Chu et al. 2015, Giannakos & Jaccheri 2013, Golsteijn et al. 2014, Katterfeldt et al. 2015, Posch & Fitzpatrick 2012, Pucci & Mulder 2015, Smith et al. 2015, Vasudevan et al. 2015). It is maintained that the topics should be relevant to children's world, which increases children's intrinsic motivation (Bekker et al. 2015).

Children's experiences, interests and life world also seem to be visible in the outcomes of making (e.g., Golsteijn et al. 2014, Pucci & Mulder 2015). For example, children's everyday (digital media) experiences and personal interests seem to play an important role in game design as the themes or main characters are drawn and remixed from popular music or games (Vasudevan et al. 2015). The studies show that children who like playing computer games have clearer goals and motivations to design their own games and they continue working outside the workshop (Posch & Fitzpatrick 2012). Children also seem to choose their creations based on their hobbies and interests (e.g., football) even if they are encouraged to try something else in a workshop (Katterfeldt et al. 2015). Children create objects from their everyday life and succeed in extending existing hobbies and preferences using digital fabrication (Posch & Fitzpatrick 2012). In a community design context, community specific ideas and concerns may also become expressed in the making activities: five different communities from one city were involved and very different concerns became accentuated in the creations (Telhan et al. 2014). All these examples highlight the importance of the historical bodies of children in making. They also suggest that this aspect has already been acknowledged in existing research to some extent.

The studies also highlight the influence of available resources and their prominence in making. Resources always afford and constrain particular types of interaction, and the visibility of resources (tools and materials) affects what people make (Litts 2015). Preparing the available equipment and materials for digital fabrication is thus important and even the participants may be involved in this

(Golsteijn et al. 2014, Posch & Fitzpatrick 2012). However, the cost of the materials may become an issue, thus limiting the resources available (e.g., Vandeveldel et al. 2015). Yet, the instructions and training given for the participants are significant – and influence what is done (Golsteijn et al. 2014). Appealing or inspiring demonstrations or examples may be shown (Giannakos & Jaccheri 2013, Golsteijn et al. 2014, Posch et al. 2010); however, a study shows that children may merely replicate others' creations when those are shown as examples (Bar-El & Zuckerman 2016). Then again, another study explicitly states that no copying emerged in relation to a predefined example (Fitton et al. 2015).

Some studies particularly point out how the historical bodies of children may be hindering making. Children may lack skills and knowledge about technology (Vandeveldel et al. 2015). They may also lack experience in collaborative creation and negotiation, have limited engagement with the materials for digital fabrication and lack an understanding of argumentation surrounding digital fabrication (Smith et al. 2015). Existing tools may also be difficult to use and hinder creativity (Vandeveldel et al. 2015). There may also be bias and misbeliefs influencing children's participation in making: Science and Technology subjects may be considered as boring and "only for boys" (Durães 2015). Proper education of children as part of making is thus significant for anticipating their experience and for producing feasible designs (Pucci & Mulder 2015).

The historical bodies of teachers and, thereby, the tradition of schools as institutions also become addressed in some of the studies (Bekker et al. 2015, Durães 2015, Pucci & Mulder 2015, Smith et al. 2015). The importance of fitting making in the school curriculum is emphasized (Bekker et al. 2015). The strict schedules of a school day may cause trouble for making projects (Smith et al. 2015). Teacher education and teaching in the classroom may draw on traditional methods that might pose challenges to teachers in the new situation (Bekker et al. 2015, Pucci & Mulder 2015, Smith et al. 2015). Teachers may also generally lack skills and knowledge in technology (Beyers 2010). Researchers also face the challenge of taking into account the diversity of learning techniques when teaching making for children (Bekker et al. 2015).

5 Concluding Discussion

The maker movement has recently gained worldwide recognition. Children's participation in making activities has been regarded as important especially in the context of education. The motivation for this study arose from the fact that despite the abundance of research published so far, a more theoretical treatment of the topic is still lacking. The maker movement is, nevertheless, an important area for IS research, practice, and education. In this paper, we utilized the research framework of nexus analysis (Scollon & Scollon 2004) for the review of previous studies on making with children, looking at the researchers' discourses constructing and motivating making with children, and searching for the traces of historical bodies of the participants and their mutual interaction orders as reported in the reviewed papers. The notions of 'discourses in place', 'interaction order' and 'historical body' as the essential aspects of social action were used as theoretical lenses in the analysis.

In this study, we wanted to illustrate to the IS research community the significance of making as a topic of research. Although making can be of value for IS research and practice in many ways, we focused on children and their education in particular. In this context, the study pinpoints that IS researchers and educators should, among many others, consider how to attract the young generation to the IS field. Offering children inspiring and engaging STEM education through making is one of the possibilities for doing this. The maker movement can even be seen to have an important role in educating and empowering the future digital innovators (Iivari et al. 2016), which is claimed to be at the heart of the IS discipline (Fichman et al. 2014). When integrated into the education of children, the maker movement may also help in combatting the digital divide (see above, e.g., Agarwal et al. 2009; Riggins and Dewan 2005; Srivastava and Shainesh 2015). Inclusive education in making is needed for the children of today who will be living their life full of digital technology tomorrow. In the future, occupations are likely to rely strongly on digital technology. For the young generation, it is pivotal to gain suitable skills and mind-set early on, so that they are prepared for their technology-rich adult life.

This study also had a methodological aim: we wished to show to the IS research community the value of nexus-analytic concepts in addressing the complexity related to making. We also wished to show how nexus analysis contributes to improving the practice in the field. Next these aspects are discussed.

5.1 Nexus-Analytic Insights into the Literature on Making and Children

We maintain that all the nexus analytic concepts we utilized – discourses in place, interaction order and historical body – were valuable in the analysis of studies on children and making. With the help of the **discourse** lens, we showed how the researchers constructed their objects of study in particular ways and legitimized their studies, leading their and their fellow researchers' way along certain trajectories. For example, they provided guidelines and recommended suitable learning approaches for implementing making projects with children. Such activities could be seen as contributing to the establishment of makerspaces and Fab Labs in the field of education in alignment with the school curricula reflecting government innovation and education strategies.

Our analysis showed that making and digital fabrication were constructed in the researchers' discourses as highly significant: the maker movement was seen as a valuable opportunity and even necessary for the education of children in order to educate future citizens with important skills for the future society as well as to maintain the competitive advantage of countries. In addition to this learning point of view, empowering children as real actors in the technology-rich future was highlighted. Besides advancing particular skills, making was seen as strengthening a valuable mind-set, a possibility for children to build their (maker) identities. Overall, variety in the discourses was identified in this study, but clearly discourse analysis on the maker movement – in education as well as elsewhere – offers yet untrodden paths for future work.

The notion of discourses in place as characterised by Blommaert and Huang (2009: 273), moreover, directs the attention not only to discourses emerging *in situ*, but also to the social space into which people have become accustomed. Thus, it is important to study space as an actor in sociolinguistic processes, acknowledging that communication always takes place in a spatial arena which imposes its constraints and affordances on communication (Blommaert 2009: 276). Studies on making and children already showed that making takes place in a variety of settings (e.g., school, library, museum or university). These settings constrain and afford particular kinds of discourses to emerge and to maintain. Although this has not yet been studied in detail, existing research has already indicated, for example, that children's motivation and, hence, their activities in a school environment and in a makerspace which they enter voluntarily may be different (cf. Smith et al. 2015). Existing studies also shed light on how the visible resources available in the space affect – again both constraining and affording – certain kinds of making activities (cf. Litts 2015).

As for the notion of **interaction order**, the existing literature offered many interesting findings although a number of interesting paths for future work can also be identified. Molin-Juustila and colleagues (Molin-Juustila et al. 2015) discuss the influence of peers, teachers, and parents on technology design with children. Our results are partly corroborating these results, especially as regards the significance of teachers and peers, while also new groups of actors were identified, such as facilitators and researchers as well as more distant actors such as universities, governments, funding bodies, professional associations or industry. They all bring along their historical trajectories contributing to the shaping of the making situation; some influences are desirable, encouraging and facilitating making, whereas others may hinder or restrict the process. Regarding facilitators and teachers, the literature on children and making posits that they have significant roles in making situations with children. Yet, the balance between autonomy and instructing was considered important, even if an open question. Moreover, the literature points out not only positive aspects but also problematic ones in relation to these two groups of actors. The same goes with peers. They, in particular, have been celebrated as a valuable resource for making, but some studies also foreground problems in working with peers (cf. Bar-El & Zuckerman 2016, Smith et al. 2015). Molin-Juustila and colleagues (2015) report on children imitating from peers, which as a theme was also identified in the literature reviewed in this paper (Bar-El & Zuckerman 2016), while existing examples were also recommended as valuable for children (e.g.

Giannakos & Jaccheri 2013, Posch & Fitzpatrick 2012). Overall, group work seemed to be the most typical way to organize making with children, e.g., as part of children's schoolwork or voluntary extra-curricular activities. The community aspect was also recognized as an important source for information and ideas in making projects.

Additionally, instead of merely reporting on these different influences at a general level, the nexus-analytical concept of interaction order supports us to go deeper in understanding the meaning and role of interaction order for the actual making practices as well as for related research. Both researchers and practitioners should start to consider (as well as report) more carefully the ways specific types of (macro & micro) social settings actually mediate these situated actions either purposefully (while planning) or unintentionally (when analysing the results). It is important to consider whose voices are and should be listened to and appreciated and why and what types of interaction orders are and should be considered fruitful for the specific actions.

The concept of **historical body** also enabled interesting findings to be identified from the prior research. The historical bodies of the participating children were recognized to some extent in the previous research. Some studies considered participating children's experiences, life histories, and everyday practices before the making activities, some afterwards. The literature revealed that children's interests and past experiences heavily shaped their creations. There was an agreement in the literature on the importance of supporting children's perspectives and interests in the future. Personal meaningfulness was regarded as an important driving force for the work. We see this as a valuable development. Children should, indeed, be allowed to make things that are of interest and use for them. It was also acknowledged in the previous literature that participants' historical bodies can work against making, e.g., in the sense of negative attitudes or lack of skills and knowledge. Molin-Juustila and colleagues (2015) further point out that children's historical bodies may restrict their imagination and creations. Some studies reviewed also indicated the existence of this type of a problem (Durães 2015, Smith et al. 2015). For such a situation, researchers should develop ideas on how to encourage creativity and out-of-the-box thinking among children, for avoiding excessive groupthink and mere copying of other children's ideas. The influence of available equipment, materials, instructions, examples and guidelines was already recognized to some degree in the literature. The instructions and set-up should be such that the facilitators are not guiding the process too much. These aspects have largely been neglected in studies on making so far; hence, future work on the topic is clearly needed.

Moreover, the nexus-analytical concept of historical body supports us to go deeper in understanding the meaning and role of participants' experiences and beliefs for the actual making practices and research. Both researchers and practitioners should start to pay more attention to the specific ways in which the historical bodies of the participants actually mediate (purposefully or unintentionally) the making process and the final outcomes. Important is to consider, e.g., what types of pre-inquiries are most suitable for the specific situation at hand, what ends up as being actually visible in the final outcomes, what is the (obvious) link between these two, and how the participants reflect on their own work in the end, shedding light on the reasoning behind their contributions.

5.2 Implications for Making Practice

Based on the discussion above, it is obvious that our results offer ways to improve making practice with children. We recommend that both researchers and practitioners apply the nexus-analytical concepts of discourses in place, interaction order and historical body when planning and implementing making projects with children but also when reflecting on and analysing the results (cf. Molin-Juustila et al. 2015). These concepts enable making conscious choices as regards the role of different participants as well as the resources and instructions used. When **planning** the maker space and the making project, it is important to figure out what kind of interaction dynamics are preferable: school imposes certain kinds of interactional relationships almost inevitably (cf. Iivari & Kinnula 2016), museums, libraries and universities among others have their traditions, emerged through people's historical bodies. The actual participants invited to the situation are also significant: teachers represent schools very strongly, while other kinds of facilitators also bring their affiliations with them (cf. Litts 2015). Their

experiences, preferences and disciplinary backgrounds should be considered beforehand (cf. Litts 2015). Their training is essential (cf. Bar-El & Zuckerman 2016, Litts 2015, Telhan et al. 2014). The interactions among peers should also be considered early on: peers may be helping or hindering the work and alternatives with pros and cons should be carefully weighted. Maker spaces will probably always make use of peer learning and community support; hence, interaction among peers should not be eliminated. Instead, one might try to consider how to enable all children to express themselves, take action and be creative. During the planning phase already, it might be wise to consider how the historical bodies of the participants can be relied on in inspiring and motivating the work as well as how the negative perceptions, beliefs and shortcomings could be overcome. Regarding discourses in place, the influence of space (Blommaert 2009) should be considered: e.g., a classroom at school may impose or invite very particular kinds of discourses *in situ*. On the other hand, at the societal level, by conducting a ‘discourses survey’ of the public discourses circulating around the topic (Scollon & Scollon 2004), one might be better prepared for the actual work as being informed of how the phenomenon of making is currently positioned, characterized and motivated by different stakeholders.

When **implementing** making projects with children, the concepts of discourses in place, interaction order and historical body make it possible to observe the influence of these issues on the activity and outcomes *in situ*. If problems are observed, e.g., some children not engaging in the activities at all (e.g., Smith et al. 2015) or the facilitators failing to motivate and guide the children (e.g., Bar-El & Zuckerman 2016), the working conditions or the maker space can be rearranged (e.g., seating arrangements, availability of resources, such as probes, cf. Molin-Juustila et al. 2015).

The nexus-analytic concepts are valuable tools also during the phase of **analysis**. It is possible to examine how the participating adults and other children have shaped children’s creations during the making activities or how children’s historical bodies are influencing the outcomes of making – both restricting and inspiring the work. With *in situ* data, analysis of the discourses among the participants can help to understand their underlying motivations and reasoning. Overall, we recommend these concepts for researchers for making sense of their making projects and the data received.

Generally, we recommend nexus analysis for many kinds of studies. Nexus analysis brings forth the role of the researchers’ varying motivations, values and disciplinary histories, embedded in their historical bodies, that they bring to their studies, e.g., when working with children – or people in general. Similarly, there is always a range of other people involved, with their varying configurations of historical bodies and interaction orders, influencing and shaping the process and the outcomes more or less directly, in a rhizomatic way through intertwining but heterogeneous networks.

5.3 Limitations and Future Work

Our results have some obvious limitations. As this was a literature review on the topic, we had to rely on what was reported in the published studies. The included studies did not utilize the concepts of nexus analysis or necessarily focus on the perspectives implied by them. Hence, the studies mostly offered very limited glimpses on these matters. Especially, our analysis of discourses in place suffered from the lack of access to original data. On the other hand, nexus analysis offered us an interesting lens for the literature review and to the academic discourses and research approaches. Furthermore, even if our literature review drew on a number of databases and keywords and resulted in the identification of a large number of relevant studies, it is well possible that a number of equally significant studies were excluded due to the lack of shared terminology.

Considering the directions of future studies, there are a number of possible paths to take. For example, although interesting findings have already been gained, a more systematic analysis is needed on the variety of ways in which different actors are shaping children’s making experiences (cf. Bar-El & Zuckerman 2016, Bekker et al. 2015, Litts 2015, Smith et al. 2015, Telhan et al. 2014). Peer influence – positive and negative – could be a field of interest worth research among others. Another interesting path for future work could be to inquire in more detail what kind of life experiences (hobbies, interests, technology and media experience, family background, education) enter into children’s creations

and how. A related line of inquiry would be to study the influence of available and visible resources (e.g. tools, materials, examples) in the actual maker space (cf. Litts 2015).

We also call for broader studies examining making and children in our society, acknowledging the variety of institutions and actors and their influence (cf. Bekker et al. 2015, Beyers 2010, Eisenberg 2013, Lassiter et al. 2013, Litts 2015). For example, we posit that the interaction dynamics are very different in a making situation taking place in school with teachers compared to a session in a drop-in maker space in a museum without adults present. Finally, the concept of discourses in place requires future studies at micro level in the actual making settings.

5.4 Conclusion

As our main conclusion, we wish to demonstrate to the IS community the significance of making as a topic. We recommend it for the inclusive education of the young generation to tackle the digital divide and to help them to become better prepared for their technology-rich future. We also recommend the research approach of nexus analysis for the IS research community. Nexus analysis enables to make it visible how a particular design or a making situation cannot be detached from its social and historical context and considered as an exclusive action on its own. When inviting children into the maker movement, it is important to consider the conceivable interaction orders between the participants and their historical bodies *in situ* that all shape the potential outcome of making. Making is to be about creating personally meaningful objects based on personal needs and desires. The concepts of interaction order and historical body make us see behind these needs and desires – how they are being formed in interaction with others, based on life experiences and histories. We argue that this type of analysis of studies on making with children provides valuable insights for both IS researchers and practitioners. The analysis shows that the nexus-analytic concepts are useful in shedding light on the complex dynamics involved in any social action – including making with children.

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