Chapter 3
Sensing the City: A Creative Data Literacy Perspective

Anne Weibert and Maximilian Krüger

Introduction

As they grow up and seek to find "their" place, children and youth are confronted with several complex phenomena. Where, what, and how to learn and work; digitalization issues; environmental issues; migration and matters of cultural, social, and religious diversity, all these can touch upon every aspect of everyday life. In the urban, children and youth are "designed out" of many physical places (e.g. Hörschelmann and van Blerk 2013). Nonetheless, they are shaping the urban space (e.g. Chawla 2002; Holloway and Valentine 2000). The rural on the other hand, sees children and youth be contained in stable community and family structures (e.g. Panelli et al. 2007). But changing work structures and economies are powerful driving forces, calling for the young to turn their backs on the rural and seek their futures in the urban (e.g. McGrath 2001).

Computing can be a means to assess, express, and ease some of this complexity. Digital skills have long been recognized as a key qualification needed in the modern world (Sefton-Green et al. 2009). Digital and data literacy (DiSessa 2001; Schüller et al. 2019) are each as central a capability in the information society as the ability to read, write, and calculate. Janet Wings work on *Computational Thinking* (2006) marks a central point, bringing forward skills like logically analyzing and organizing data, visualizing data through abstraction, finding efficient solutions, using algorithms to automate solutions, and transferring solutions into other contexts (see also Barr and Stephenson 2011). This perspective also became influential in the learning sciences and educational domain (e.g. Lockwood and Mooney 2017), and the promotion of computational thinking skills in young learners between the ages

A. Weibert (✉) · M. Krüger
Institute for Information Systems and New Media, University of Siegen, Siegen, Germany
e-mail: anne.weibert@uni-siegen.de

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of 5 and 18 is now often demanded (e.g. Guzdial 2008). However, traditional methods for teaching computational thinking were found to be not very suitable for children (e.g. Boy 2013), especially for those children with more creative and nonlinear learning types. If computing was truly for everyone, then how could it be ensured that everyone was able to develop the skill set needed to participate? The human senses (Merleau-Ponty 2013) are at the core of discourse lines unfolding from there, touching upon questions of making sense of and participating in (urban) places and communities (e.g. Wolff et al. 2016).

This study argues for the inclusion of making and crafting as alternate methods for urban data literacy—the empowerment of people to solve real-world problems and make sense of what Lohr (2009) has called "the raw material of knowledge" by using and analyzing data from their everyday life in the city, thus measuring and addressing the underlying phenomena in the urban sphere. Our chapter first provides an overview on relevant works from the discourse on human sense-making and (digital) literacy in relation to crafting and making. The description of methods used as well as the setting of the three workshops is followed by our presentation of the findings. Their discussion sheds light on how making and crafting can be a creative means to foster the building of urban data literacy.

Related Works

The importance of materials for human sense-making was recognized in a methodological procedure(s) in various contexts (e.g. Pink 2015; Woodward 2019). Gabrys focused on nature itself, bringing forward environmental as well as sensor-based aspects of ubiquitous computing technologies and related sense-making practices (Gabrys 2016). Her participatory view on matters of "urban sensing" discusses the interrelation of sense-making practices and their computational sensor-based counterpart in the urban sphere. Along similar lines, Mattern has argued that the multifaceted nature of urban data calls for "a degree of sensitivity that exceeds mere computation; urban intelligence of this kind involves site-based experience, participant observation and sensory engagement" (Mattern 2021:70). A number of educational initiatives and tools have taken this perspective to the classroom (e.g. Fauville et al. 2014) and beyond, thus enabling connecting with nature (Rodgers et al. 2019) through technology in material, haptic (e.g. Soro et al. 2018) and programmable ways (e.g. Bröring et al. 2011).

Tangibles were found to be supportive for computational learning and beyond. They allow for the young learners' engagement in problem-solving with concrete physical objects, thus building "representational mappings that serve to underpin later more symbolically mediated activity after practice and the resulting 'explicitation' of sensorimotor representations" (O'Malley and Fraser 2004: 3). "Hands-on" (e.g. Dewey 1923) learning approaches focus on active experimentation with physical materials, often employed in the context of current science education (e.g. Antle et al. 2011). From a constructionist perspective (Papert 1980), knowledge is not

only conveyed in the abstract, but requires practical and cognitive (re-)construction by the learner. Learning, in Papert's view, is the process of creating artifacts of personal and social relevance; it is concerned with the connection of old and new knowledge, and with the interaction with others (for an overview see Kafai and Burke 2014: 19ff). Three perspectives are prominent in existing learning and design frameworks. Here, tangibles: (1) make use of physical objects as tokens to access digital information (Holmquist et al. 1999), (2) employ physical objects as containers to move information between devices (Ullmer et al. 2005), and (3) contain tangible interfaces where physical artifacts both represent and control the digital information (e.g. Ullmer and Ishii 2000). Calling for more work on the benefit of physical materials for learning, Marshall provided guidance for the deployment of tangible interfaces for learning (Marshall et al. 2010). Xie et al. (2008) saw the enabling of collaboration among their supportive characteristics, and Hamidi and Bajlko (2017) found their entangling with nature to be supportive for learning. Dourish has described the tangible approach to computing as part of a movement in Human–Computer Interaction seeking to broaden the range of human abilities available when interacting with computers (Dourish 2004).

At the basis of this tangible perspective is touch, which has long been discussed as a cultural technique (e.g. Ufan 1973). Touch can trigger the most basic sensemaking "seeing through the hand" (Hansen 2006: 71), as well as include complex capacity for feelings (McLuhan 1994: 314), in that case not even having an "obvious 'seat' or organ" (O'Neill 2017: 1618). Nowadays, we find ourselves surrounded by haptic media like the smartphone, the Apple watch and other wearables capable to "train and discipline touch in order to produce touch as a coherent communicative medium" (O'Neill 2017: 1616). Touch has undergone a transformation "into a sense capable of being stored, transmitted, and reconstructed by digital interfaces" (Parisi et al. 2017). E-textiles like the Lilypad Arduino (Buechley et al. 2008), paper-based electronics kits like Chibitronics[1] (Qi et al. 2015, 2018) and conductive touchboards[2] (e.g. De La Cruz and Bhatia 2018) rely on this, fostering an understanding of electronic touch-based cause-and-effect dualities and of more sophisticated, programmed effects.

Another line of discourse acknowledges the importance of sound for sensemaking (Bull et al. 2015) bringing forward the limitations of words for sensemaking (Wills et al. 2016), as well as their capability of developing and expressing a relationship with objects, things (Tilley 1999) and places (Thibaud 2003) through talk (Shankar 2006), and the lack thereof (Butler 2007). Polotti and Rocchesso (2008) brought this together in their focus on the creation of implicit and explicit musical knowledge backed in computer-mediated learning tools. Initiatives like Sonic Pi and Overtone are built on these insights, fostering computational learning embedded in creative, hands-on musical experiences (Aaron et al. 2016).

[1] https://chibitronics.com/

[2] https://www.bareconductive.com/collections/touch-board

At the desktop, computing has always been visual. Recently evolving technologies for augmented and virtual reality, however, have greatly expanded the visual sphere. They have been applied to learning in a broad range of subjects (e.g. Lu and Liu 2015), and seek to foster creativity (e.g. Yilmaz and Goktas 2017) and collaboration (e.g. Sanabria and Arámburo-Lizárraga 2017).

Also, enactment and embodiment were recognized as modes of learning (Atherton and Blikstein 2017). Antle defines embodiment as a "means how the nature of a living entity's cognition is shaped by the form of its physical manifestation in the world" (Antle 2009: 1). This view has a basis as early as Piaget (Piaget and Cook 1952), who argued that physical and mental efforts are needed to promote cognitive thinking structures in children. This has been applied to science learning (e.g. Durán-López et al. 2017). Keifert et al. (2017) pursued a similar approach through movement-based games: scientific concepts became comprehensible to children as embodied sociodramatic play, where the children imitated the behavior of, e.g., water particles. Fernaues and Tholander (2006) discuss how material artifacts in connection with physical activity like role-play can introduce children to programming concepts ("programming as performed action"). Not only do children come to a better understanding with such playful activity; programming itself becomes social, differing from the conventional screen-mouse situation, in which usually only one person makes the entry.

Making, as a concept and a practice, has the potential to combine much of the above in meaningful ways. As the act of creating tangible artifacts, making involves multiple human senses at once. It has been deployed as a means to foster learning of crafting and technology skills in combination, interlinking the digital and the physical (e.g. Rosner 2010; Peppler et al. 2016). Despite its playful character, making is described to encompass a broad set of skills, such as "cultural and material engagement, decisions around tool use, the leveraging of industrial infrastructures around materials and standards, and the crucial role of knowledge sharing and building new literacies" (Tanenbaum et al. 2013: 2604). It is concerned with individual creativity, speaking to nonlinear, hands-on learning styles (Weibert et al. 2014), collaboration (Rosner et al. 2014), and problem-solving (Lewis 2009). As *Computational Making* it combines handcrafts and the digital. It thus fosters aesthetics, creativity, construction, the visualization of multiple representations and an understanding of materials as key skills (Rode et al. 2015). It is laying a broad ground for the learning of computational skills (e.g. Juškevičienė 2020) and literacy. Urban data literacy as we explore it in our study is concerned with the ability to make sense of phenomena in the urban sphere by using, analyzing, and interpreting data and information (Schüller et al. 2019) from everyday life in the city. With our focus on crafting and making we are interested in the creative entry points to such an understanding. Our study contributes to the above laid outline of research recognizing the supportive potential of making and crafting for learning. We are exploring *crafting* and *making* as alternate methods to foster urban data literacy in young city inhabitants, as well as in those whose access to the digital urban sphere is challenged. We discuss how this can be a creative means to bring unseen city life dimensions to the fore, and to broaden access to the discourse on data and its implications for everyday city life.

Methods

This study combines principles of participatory design (Ehn et al. 2014) and action research (Kemmis et al. 2014) in a practice-based method (Wulf et al. 2018). All its workshops are conducted in the same mid-sized city in the Ruhr Area in Germany in the broader context of an initiative working to enable joint computational and media learning (Weibert et al. 2017). Situated in a neighborhood setting within that city, which is shaped by migration, our study brings together people with migration backgrounds from Afghanistan, Morocco, Poland, Romania, Russia, Syria, and Turkey (for an overview on participant numbers and recruitment, see Table 3.1). The study took place in 2019, from March to November.

Workshops

Key artifact of the workshop concept is a *city of sound.* It was collaboratively crafted by the participants of the workshops. The researchers who are also the authors of this work guided these workshops as tutors and provided help where needed. The city artifact was made from wood and equipped with programmable micro-boards. Designed in such a way, it was then used to assemble collected audio files about aspects of city life. Upon touch, these sounds could be reproduced in a certain manner from predefined spots, marked with conductive paint (see Fig. 3.1, left). The possibility to remix the sounds created a basis for discussion about abstract concepts of city life, e.g., religion and nature. Three instances of the *city of sound* were put into practice in 2019 (see Table 3.1 for an overview):

W1: This workshop was conducted as a weekend-event where children and adults from the neighborhood in focus were invited to explore the sound of the city. This was done in three steps. Children and adult participants first engaged in brainstorming and discussion about places of relevance in the neighborhood and their respective sounds. The group then set out to collect audio recordings from these places, as well as produce a city artifact from wood and paint that contained important landmarks and further details considered of relevance by the group. The collected sounds were then mapped onto the city silhouette via the touch boards and conductive paint. By touching specific places on the artifact, sounds were triggered.

Table 3.1 The workshops at a glance

	Workshop 1	Workshop 2	Workshop 3
Topic	Environment/nature	Religion/faith	Religion/faith
Location	Community center	Municipal event center	Christian church center
Participants	20/open recruitment process	~20/open participation over the course of 1 month	~20/open participation over the course of 2 months

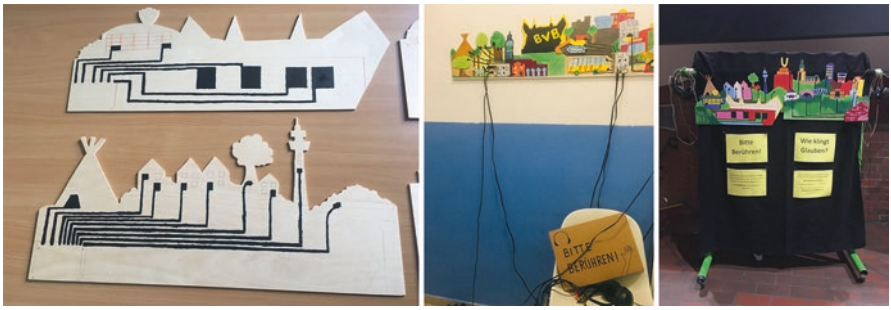

Fig. 3.1 The city of sound was crafted from wood. Equipped with programmable micro-boards, it could produce sound upon touch of designated spots which were marked with conductive paint

W2: A pre-made wooden city silhouette became a part of an exhibition in a municipal event center downtown. Publicly accessible to its audience for 1 month it invited the exploration of the "sound of faith." People of all ages could contribute sounds that were of relevance to them in two ways, (1) by joining exhibition events in person, and (2) by sending audio files via e-mail to be added to the city.

W3: This workshop invited the exploration of the "sound of faith" in a Christian church center. The crafted city artifact was publicly accessible, and youth as well as adults engaged with it at times of services and church events for 2 months.

Data Collection and Analysis

The study data presented here consists of the field notes, images and the artifacts resulting from the workshops. We documented all workshop activity including verbatim feedback of participants and attendees in short session notes, which we extended to full field notes afterward. The authors conducted the workshops in cooperation with residents from the field and provided guidance as tutors, as required. For the analysis (Fereday and Muir-Cochrane 2006) we were interested in technical and computational understanding that participants showed, and how these were used to make sense of abstract concepts of urban everyday life.

Findings and Their Discussion

Our qualitative and thematic analysis yielded *materiality, place,* and *diversity of learners* as the main themes. In the following, we discuss our findings for each concept in turn.

Materiality

Crafting activity was the initial means to structure and approach the respective topic. This was the case in W1 when the young and adult participants set out to detail the roughly pre-shaped wooden city artifact. By detailing the wooden elements, discussion was fostered exploring what's a landmark, and what places and things of (individual) importance should further be added to the city. A large, high-rise residential building complex was proposed by one of the women as one of those details: *"Everything from my everyday life is right there: family, the school of my kids, shopping…"* She discussed with her friend how to paint the building and ended up cutting an image of the building from a local newspaper, gluing it to the wood, *"to make it look realistic."*

Through these material, wooden and paper details, "the sound of the city" was then explored, e.g. when a teenager said he wanted to add a "cool car." His focus widened from the initial material decisions to make (what color, what shape) toward a broader view that included research on the sound of the engine, and discussion with two other boys, where to place the car in the city to have it "*being seen*." Another example was a boy who initially associated the sound of fighting on the street with the high-rise residential building complex he lived in. The proposal to add this sound initially caused irritation in the group, which quickly resolved to a serious conversation, where three of the women pointed to this detail, saying how the boy was right, and that there were frequent fights and violence and police operations in this area. *"If we add it to the city, we point to this problem, and people become aware."* Two women discussed where to place birds: *"In the playground maybe? They do not really have a place, have they?"*

In the case of W3, crafting as an activity fostered discussion across generations. An example for this is the conversation among a senior and a teenager, who were talking about how modes of expression had technically evolved while exploring the functionalities of the touchboard and how its size enabled an unobtrusive integration into the artfully crafted and painted city artifact. The senior had knowledge in woodcarving and audio broadcasting technology; he voiced his fascination with the individualized sound experiences that the city artifact provided to him in a programmed manner. The teenager had some coding skills; he was intrigued to apply these skills to his fascination with religious diversity (How does one translate faith and urban religious experience into code, combined with crafted wood and some paint?). Such engagements with touch-based cause-and-effect dualities as well as sophisticated, programmed effects deploying touch as "coherent communicative medium" (O'Neill 2017: 1616) prolong earlier findings on the supportive nature of touch and tangibles for learning (e.g. De La Cruz and Bhatia 2018) to the realm of data literacy in an urban context.

Diversity of Learners

By enabling sound as a part of the city design, reflection was fostered on the different shapes an information can have—a basic element of data literacy. By audio recording and editing sounds of their neighborhood, children and adults in W1 came to think and discuss their meanings: Is this noise? Music? Nature? Do I want this? Teams in the workshop collected playground sounds, a rap song a pedestrian had spontaneously performed for them, construction site noise, and cars rushing by, thus assembling the ingredients for what Mattern has described as "site-based experience" and "sensory engagement" (Mattern 2021:70). A recording of birds chirping was cherished by one woman, noting this was a sound that was easily missed in the overall soundscape of the city.

All three instances of the city supported such development of data literacy among a broad spectrum of child and adult learners by having the sounds and their combination programmed. In W1 the city was crafted in a way that a single headset was connected to several touchboards (see Fig. 3.1, middle), enabling what Hansen has coined to be "seeing through the hand" (Hansen 2006: 71): the creation of a sound collage on the spot by touching multiple places on the city in combination. Exploring "the sound of faith" as part of an exhibition in the public center downtown in W2, the touchboards were programmed in such a way that sounds were randomly assigned to the different places in the city and played upon touch (see Fig. 3.1, right). This created a soundscape that had the broad variety of religious sounds being played all over the city. A Muslim woman especially valued this in the exhibition. She was noting how this type of coding enabled the call of the imam to be heard at the city hall right in the heart of the city, whereas in the reality that she experienced, it was rather pushed to backyards and industrial areas in the city outskirts. A group of four male attendees noted in W3 how with this type of script, the image of their city as a home for soccer was supported, with stadium chants being heard everywhere in town (*"Soccer really is some kind of a religion here, too."*). Both incidents can be read as examples of an evolving literacy that is not only capable of differentiating different types of urban data, but also able to recognize how these can be turned into a statement with the crafting to include and express "site-based experience" (Mattern 2021: 70).

Place

In all of this, we saw notions of place to be a powerful factor—both with regard to topic, as well as to how the crafting and making unfolded. The city of sound in W1 was crafted in a community center, a surrounding the people participating were comfortable with. The place provided a familiar basis to engage with the topic, and children and adults did not hesitate to contribute personal views and perspectives. As a municipal event center, the place of W2 provided a more public surrounding.

This was supportive to engagement with the artifact and fostering discussion, but in a more formal manner. The difference could most vividly be observed in the reaction of some of the participants of W1: two women and their children were enthusiastic about the activity and spontaneously announced that they would attend future workshops with this topic as well—however, in the municipal event center they did not feel comfortable in the same way, so they stepped back from their initial plan. As a Christian church center, the place of W3 came with a predefined main audience, and this was reflected in how the city artifact was received. Discourse revolved around faith and its meanings in everyday life in the neighborhood—but with an emphasis on Christianity.

Conclusion

We have explored how making and crafting can be a means to foster the building of urban data literacy—a skillset that is concerned with the ability to make sense of phenomena in the urban sphere by using and interpreting data and information. We have discussed in our works with a crafted *city of sound* installation, how this can bring unseen city life dimensions to the fore, and how it is linked to digital literacy and creative data literacy: To the participants of our workshops the creativity that the crafting and making provided turned out to be a means to figure out the shape and value of an information (as seen, e.g., in the collection and processing of urban sounds in W1). The findings from our study indicate that a tactile and artistic approach to such data and its meaning in the city provides creative entrances to a topic that by speaking also to the human senses such as touch and sense of hearing go beyond established ways of sensemaking through speaking, writing, and calculating. The joint crafting around the specific data and information as enabled in our workshop activity fosters their discussion across communities, thus extending the collaboration and interaction with others that Kafai and Burke (2014) talked about earlier to a data literacy and digital literacy context. This was the case with participants in W2, who recognized the possibility to program experiences of religious exclusion into the city artifact, or in W3, where the crafting enabled collaboration and reflection across generations. Parisi, Paterson, and Archer have earlier recognized a transformation of touch "into a sense capable of being stored, transmitted, and reconstructed by digital interfaces" (Parisi et al. 2017)—in relation to the crafting of the *city of sound*, we could see it being explored as a means that can convey programmed messages to a previously identified audience thus actively fostering a sense for digital literacy and participation in an urban context. Not only did the participating children, youth, and adults recognize the joy that can be inherent to creating a beautiful or cool artifact—they discussed notions of an audience for such creation, as well as possibilities to "make a statement" with this. Such activity can thus be a creative means to add to the data basis used to legitimize urban design choices and foster a broader degree of participation.

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