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Introduction

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Algorithmic and Aesthetic Literacy is a selection of texts aiming to extend current understandings of algorithmic and aesthetic literacy. The volume presents a wide array of transdisciplinary perspectives on computational and aesthetic practices and thinking. Drawing on computer and educational science, artistic research, designing and crafting, this collection delves deeply into societal and educational challenges in the wake of the digital transformation. The volume brings together diverse approaches and viewpoints to stimulate dialogue and awareness of the manifold ways in which algorithmic processes have become part of our lives. By extending our ability to respond to a data-driven world in creative and non-habitual ways, we will be better equipped to re-imagine and shape our collective future as meaningful and fulfilling.

We as editors are inspired by the idea that future-making education should dare to leave known grounds, face the unpredictable and seek to transgress disciplinary borders. This volume is inspired by the concept of STEAM, the integration of the arts in science, technology, engineering and mathematics. In this light, STEAM education is built on the idea that education creates participation and enables people and communities to respond resourcefully and creatively to ongoing changes. In this sense, the individual contributions advocate and inspire the proliferation of STEAM education across disciplines, foster awareness of its potential regarding somatic and aesthetic practices in education and research and give them a place in learning and creating.

The first two contributions in this volume are elaborate proposals to complement education in computer science and other technical disciplines with approaches from dance improvisation and design. **Susanne Martin** teaches students at the École Polytechnique Fédérale de Lausanne in Switzerland in the fundamentals of contact improvisation. In her article, she

makes a convincing case that this practice helps the development of transversal competencies in manifold ways. Practicing improvisation furthers creativity and teaches a bold approach to experimentation. It engages the students in collaborative inquiry through an empathetic and supportive attitude. Martin shows impressively how somatic practices and creative motion can guide the students to turn their awareness to their own bodies and invite them to exercise in sensory perception – dimensions of experience which are mostly excluded from the academic curriculum. Martin suggests that impulses from her work with the students can contribute to shaping the holistic engineer of the 21st century.

In a related fashion, **Simon Nestler**, **Sven Quadflieg** and **Klaus Neuburg** argue that informatics education may benefit substantially from design competencies. Design thinking employs experiment, intuition, and even improvisation. But more fundamentally, the multi-faceted training and the visionary attitude of designers allows them not to look mechanically for a solution to a given problem. On the contrary, they first study the problem and its context holistically until they arrive at a profound understanding of the situation. From this process, a redefinition of the original task may result. This ability to constructively rethink a problem is one of the core competencies to be developed in design education. The authors also emphasize the importance of manual activities such as drawing or creating physical prototypes in the design process. Manual activities can benefit the cognitive creative process, and with physical prototypes, stakeholders can easily be engaged to get feedback. This is of particular importance as most problems in informatics are "wicked". Wickedness can stem from, e.g., social complexity both in the development process and in the future use of a product. The authors present design competencies as a valuable education goal to tackle wicked problems.

The next contribution by **Ellen Harlizius-Klück** and **Alex McLean** also provides valuable inspiration for education. In this case the authors have a more fundamental, while at the same time broader concern: they aim to foster the notion that computational thinking is not a new, isolated skill that has emerged in the 20th century in connection with the invention of computers. Rather, they present a well-supported case that core aspects of computational thinking – decomposition, pattern recognition, abstraction, and algorithms – have been employed in the craft of weaving for thousands of years. Indeed, ancient Greek lyric poetry and philosophy suggest an aware-

ness of a connection between weaving and other areas of human social and intellectual activity. Harlizius-Klück and McLean are drawing on this connection in both educational and art projects: they have simulated ancient weaving techniques in software and have built their own semi-automated hand loom. By connecting these systems to live coding environments, they make explicit the close connection between traditional ways of describing weaving patterns and modern-day programming. The authors suggest that such an understanding helps better situating computational thinking in the history of knowledge, of practices, and crafts. Actual handweaving and similar practices could provide an opportunity to introduce manual activity and body awareness into, e.g., computer science education.

Hanno Schauer in his contribution (in German) presents a teaching concept to give a first introduction to people without a technical background to fundamental aspects of computational thinking. His concept can be applied equally well in secondary schools, vocational training, academic education or in any context of adult education. He focuses on a common problem which typically occurs in the planning phase of a software project: How can stakeholders with technical knowledge and stakeholders without such knowledge communicate so that they may arrive at a complete and accurate description of the requirements for the software to be developed? Schauer takes a different approach than the one followed in the preceding chapters of this volume, as he aims to educate the non-technical stakeholders and not the developers. To make it as easy as possible, he chooses a graphical language for business process modeling as a teaching tool. Business process modeling can be used to explain fundamental concepts of computational thinking without referring to computer science topics such as databases or programming languages. Schauer observes that even an incomplete, imprecise understanding of the graphical notation can in some cases foster communication within a project.

The next two contributions explicitly focus on school education. According to constructivist pedagogical theories, learning is an active, constructive process that has optimal success if the learner has at least some degree of freedom for self-directed, self-driven studying. **Michael Herczeg**, **Alexander Ohlei**, **Toni Schumacher** und **Thomas Winkler** have developed a digital infrastructure to support such a constructivist learning approach in schools. At the heart of their system there is a digital media library with teaching material. Students and teachers can upload their own works and

share them in class. Additionally, the system facilitates the discovery of related content from the internet. The developers have created a variety of access points, from large touch screens over standard PCs to mobile devices. Special applications guide the students to create videos or even augmented reality experiences with their smartphones. The system has already been deployed to more than 20 schools in Germany is currently being further developed in an ongoing research project.

Willy Noll (in German) proposes that traditional art education in schools be inspired by the maker culture as it can be found in maker spaces and fab labs. Noll argues that for a proper assessment of the role of art education in the context of digital transformation, it is necessary to acknowledge the fact that this transformation affects all aspects of society. He begins his exposition with a systems theory approach on society and on the individual and moves on to explain both learning processes and aesthetic experiences in terms of this theory. From the wide variety of phenomena emerging from the maker movement, Noll focuses on makers who intentionally produce machines or other artifacts which do not actually serve a practical purpose, but somehow come close (e.g., by comically failing). When such artifacts that are at least partially based on modern technologies reveal obvious failings or an ironical message, our conventional expectations towards technology are not met. Such a "disappointment" of expectations constitutes the beginning of an aesthetic experience and may initiate a learning process.

The next contribution presents an exploratory research process as artistic research. **Elke Mark** and **Lindsey French** have developed a micro-phenomenological interview technique to deeply investigate a person's memory of a previous sensorial experience. In the experiments, an olfactory experience was triggered by letting the participant open a jar containing a substance with an intense scent. In the interviews, participants were guided to focus less on the actual content of their memories than on the process of re-accessing it. Mark and French observed how bodily movements and gestures accompanied the process and typically preceded the verbal expression of a recollection. The authors extensively documented the process with video, accelerometers and other devices and used the recordings to create an interactive art installation which invited the visitor to take part in the reenactment of memories. Finally, the authors discuss the micro-phenomenological interview technique "as a technology" which can be used in the

context of algorithmic art as a method of reflecting on algorithms in general.

The following two contributions provide deep insights into the profound influence of algorithmic methods and digital technology on certain segments of contemporary music and art production. **Harry Lehmann** researches the transitions in the history of music that can be truly regarded as epochal caesuras. In this vein, he identifies the development of a comprehensive notation system for the Gregorian chants during the 11th and 12th century as the first historical break. Notation did not only serve as a storage and distribution medium, but also as a new medium of composition which enabled the creation of music for several voices and subsequently led to the development of a wide range of musical instruments, and to the creation of music for classical ensembles and orchestras. In the subsequent course of history, the invention of music printing, the record, the radio, and the digital distribution of music profoundly changed perception and performance practices – and allowed the development of a wide spectrum of differentiated musical styles – but sheet notation as the medium of composition remained largely unchanged. Lehman argues that the most recent development of composing in the medium of digital samples – and having digital players perform previously unplayable compositions – constitutes a second epochal caesura in the history of music.

Christoph Best's contribution focuses on the algorithmic generation of artworks by artificial intelligence systems. To enable a proper understanding and appreciation of such works, Best takes us on a quick tour through the history of computing and the history of artificial intelligence. The author then introduces us in quite some detail to the workings of Artificial Neural Networks – the most successful approach in modern AI. In a second historical walkthrough, Best explicates the origins of algorithmic art and the history of making art with computers. In passing, the author introduces the reader to fundamental concepts of computer programs. (Best's contribution may thus help readers of this volume to refresh their memory of what computers and programming are fundamentally about.) Having thus been through the fundamentals, we have the tools to understand how Generative Neural Networks can produce images which are new and unique, yet at the same time familiar and interpretable by a human observer. Best's contribution is extensively illustrated and includes reproductions of some of the most spectacular artificial artworks of the past several years.

In the final contribution of this volume, **James Bridle** investigates the abyss of child-oriented content on YouTube. The author starts out by asking: Why are there more videos depicting the opening of surprise eggs on YouTube than anybody could watch in their entire lifetime? Another major trope of the genre are countless variations of nursery rhymes. Videos of this kind, with their bright colors, soothing songs, reassuring repetition of a seemingly endless sequence of surprises can easily tie young children to the screens for hours. Not all such videos are harmless, though. Videos featuring children playing with toys sometimes devolve into gross-out scenes like food fights. Animated content of questionable quality, borrowing characters from popular movies or TV shows, depicts these characters involved in acts of violence and degradation. Bridle dissects the factors which have led to the creation of this abundance of questionable content: The financial incentives of the YouTube platform for the creators, the cheap availability of video equipment and the easy creation of animated content, the (semi-) automation of the production and the distribution processes on the platform, and YouTube's recommendation algorithm for related videos. Furthermore, Bridle discusses how it seems to be impossible to maintain platforms like YouTube as open forums for free speech and creative expression, while at the same time prevent destructive tendencies drawing on the exploitation of vulnerable groups, like young children.

Algorithmic and Aesthetic Literacy presents future-making thinking and practices beyond the individualization of disciplines. Inspirations drawn from the individual contributions should enable people and communities to respond resourcefully and creatively to continuing changes in the age of digital transformation. As editors we believe that this book makes a case for how a synergistic interplay of algorithmic and aesthetic literacy may help to prevent a gradual societal slide into a monoculturally data-driven technocratic future.