Image
Knowledge
Gestaltung

An Interdisciplinary Laboratory

Image Knowledge Gestaltung

An Interdisciplinary Laboratory

Cluster of Excellence
2012 – 2018

Final Report

Final Report

Cluster of Excellence

Image Knowledge Gestaltung
An Interdisciplinary Laboratory

Bild Wissen Gestaltung
Ein Interdisziplinäres Labor

EXC 1027

Excellence Initiative / Exzellenzinitiative

Final Report / Abschlussbericht

Cluster of Excellence / Exzellenzcluster

Image Knowledge Gestaltung. An Interdisciplinary Laboratory

Bild Wissen Gestaltung. Ein Interdisziplinäres Labor

EXC 1027

Host University/Universities
Humboldt-Universität zu Berlin

DFG Project Number: 194453117

Funding Period:

1: 2012 – 2018

Final Report for Cluster of Excellence

Image Knowledge Gestaltung. An Interdisciplinary Laboratory

Bild Wissen Gestaltung. Ein Interdisziplinäres Labor

EXC 1027

Host university/universities:

Humboldt-Universität zu Berlin*

Rector/President of the host university:

Prof. Dr.-Ing. Dr. Sabine Kunst

Signature

Rector/President

Coordinators of the Cluster:

Prof. Dr. Horst Bredekamp	Prof. Dr. Dr. h. c. Peter Fratzl	Prof. Dr. Wolfgang Schäffner
Humboldt-Universität zu Berlin	Max Planck Institute of Colloids and Interfaces	Humboldt-Universität zu Berlin
Signature	Signature	Signature
Coordinator	Coordinator	Coordinator

*Speaker university/universities

Contents

List of abbreviations

BAM	Bundesanstalt für Materialforschung und -prüfung (BAM Federal Institute for Materials Research and Testing)
BMBF	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
BeST	Berlin Simulation and Training Center, Charité
Charité	Charité – Universitätsmedizin Berlin
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DOI	Digital Object Identifier
EnsAD	École Nationale Supérieure des Arts Décoratifs
ENSBA	École Nationale Supérieure des Beaux-Arts de Paris
EPFL	École Polytechnique Fédérale de Lausanne
FU Berlin	Freie Universität Berlin
HGK/FHNW	Hochschule für Gestaltung und Kunst, Fachhochschule Nordwestschweiz (FHNW Academy of Art and Design)
HKW	Haus der Kulturen der Welt
HSA	Anhalt University of Applied Sciences
HZK	Hermann von Helmholtz-Zentrum für Kulturtechnik (Hermann von Helmholtz Center for Cultural Techniques)
HTW Berlin	Hochschule für Technik und Wirtschaft Berlin (HTW University of Applied Sciences)
HU Berlin	Humboldt-Universität zu Berlin
IAI	Ibero-American Institute, Prussian Cultural Heritage Foundation
IFK	Internationales Forschungszentrum Kulturwissenschaften, Kunstuniversität Linz in Wien (International Research Center for Cultural Studies, University of Art and Design Linz)
IRIS Adlershof	Integrative Research Institute for the Sciences
KHB	Weißensee Kunsthochschule Berlin (Weißensee Academy of Art Berlin)
MfN	Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science
MPIKG	Max-Planck-Institut für Kolloid- und Grenzflächenforschung (Max Planck Institute of Colloids and Interfaces)
PIs	Principal Investigators
SPK	Stiftung Preußischer Kulturbesitz (Prussian Cultural Heritage Foundation)
TU Berlin	Technische Universität Berlin
UBA	Universidad de Buenos Aires
ZfL	Leibniz-Zentrum für Literatur- und Kulturforschung (Leibniz Center for Literary and Cultural Reseach)
ZIB	Zuse-Institut Berlin (Zuse Institute Berlin)
2-D, 3-D, 4-D	two-dimensional, three-dimensional, four-dimensional

1 General Information

1.1 Summary

Driven by the vision that *Gestaltung* is a fundamental mode of knowledge production, the Cluster of Excellence *Image Knowledge Gestaltung. An Interdisciplinary Laboratory* developed a novel form of interdisciplinary research. Initiated by humanities scholars, the Cluster brought together researchers from the natural and materials sciences, medicine, architecture, design, and humanities who jointly explored and established new architectures for knowledge generation. Within these collaborative research processes, the humanities' synthetic approach of analyzing images and knowledge structures across all scientific disciplines merged with the natural sciences' analytic and experimental procedures and—for the first time—with the design disciplines. The Cluster's central insight that "Knowledge is *Gestaltung*" and "*Gestaltung* produces knowledge" yielded the following fundamental achievements:

i. Images, architectural spaces, and processes of *Gestaltung* were developed as essential agents in the creation of knowledge and shaping of practices, for instance in neurosurgery, zoological morphology, physics, and media theory. This "turn to *Gestaltung*" was implemented by transforming design into a key actor in interdisciplinary basic research.
ii. The humanities achieved a new leading interdisciplinary role in research by introducing transversal epistemological thinking and historical genealogies into scientific laboratories and design workshops. Materials science, physics, and biology reshaped their experimental approach by integrating epistemological, historical, and design dimensions. This enabled new categories of research perspectives in the field of material code and *Strukturwissenschaft*.
iii. The Cluster developed an experimental and adaptive *Interdisciplinary Laboratory* by transforming the design of interdisciplinarity into a research challenge in its own right. Simultaneously, current interdisciplinary research processes and their history in the form of scientific collections were opened up to the public: With its innovative exhibition formats, the Cluster conceived curating as an original form of research and knowledge production.

Taken as a whole, the Cluster *Image Knowledge Gestaltung* created a model of an adaptive, collaborative architecture of knowledge that may well revolutionize the current German academic system. Both the new Cluster of Excellence *Matters of Activity* and the Hermann von Helmholtz Center for Cultural Techniques perpetuate the achieved integrated research structure of more than 40 disciplines at Humboldt-Universität zu Berlin. In this way, Humboldt's model of research, teaching, and public exchange has been reshaped by the Cluster, combining the legacies of the 200-year history of Humboldt-Universität zu Berlin and the 100-year history of the Bauhaus.

German summary

Mit der Vision, dass Gestaltung ein grundlegender Modus der Wissensproduktion ist, entwickelte der Exzellenzcluster *Bild Wissen Gestaltung. Ein Interdisziplinäres Labor* eine neue Form der interdisziplinären Zusammenarbeit. Auf Initiative der Geisteswissenschaften brachte der Cluster Forschende aus den Natur- und Materialwissenschaften, Medizin, Architektur, Design und Geisteswissenschaften zusammen, um neue Wissensarchitekturen zu erforschen und zu etablieren. Im gemeinsamen Forschungsprozess verband sich das synthetisierende Potential der Geisteswissenschaften, Bilder und Wissensstrukturen über alle wissenschaftlichen Disziplinen hinweg zu analysieren, sowohl mit den analytisch-experimentellen Verfahren der Naturwissenschaften als auch erstmalig mit den integrativen Praktiken der Designdisziplinen. Ausgehend von dem Grundsatz, dass Wissen Gestaltung bedeutet und Gestaltung neues Wissen hervorbringt, wurden fundamentale Erfolge erzielt:

i. Bilder, architektonische Räume und Gestaltungsprozesse wurden als wesentliche Akteure der Wissenserzeugung und der Ausbildung von Praktiken etabliert, zum Beispiel in der Neurochirurgie, der zoologischen Morphologie, der Physik und der Medientheorie. Mit dieser "Wende zur Gestaltung" wurden die Designdisziplinen Schlüsselakteure der interdisziplinären Grundlagenforschung.
ii. Durch die Überführung transversalen epistemologischen Denkens und historischer Genealogien in naturwissenschaftliche Labore und Designwerkstätten konnten die Geisteswissenschaften eine neuartige Führungsrolle in der interdisziplinären Forschung einnehmen. Materialwissenschaften, Physik und Biologie wiederum haben ihren experimentellen Ansatz durch die Integration epistemologischer, historischer und gestalterischer Dimensionen neu ausgerichtet. Dadurch wurden neue Forschungsperspektiven auf dem Gebiet des materialen Codes und der Strukturwissenschaft ermöglicht.
iii. Der Cluster entwickelte ein experimentelles und adaptives interdisziplinäres Labor, das die Gestaltung von Interdisziplinarität als eigenständige Forschungsaufgabe verstand. Gleichzeitig wurden aktuelle interdisziplinäre Forschungsprozesse und ihre Geschichte in Form von universitären Sammlungen für die Öffentlichkeit zugänglich gemacht: Durch innovative Ausstellungsformate etablierte der Cluster das Kuratieren als genuine Form von Forschung und Wissensproduktion.

Auf dieser Basis hat der Exzellenzcluster das Modell eines kollaborativen, adaptiven Forschungsprozesses geschaffen, das das deutsche Wissenschaftssystem revolutionieren könnte. Sowohl der darauf aufbauende Exzellenzcluster *Matters of Activity* als auch das Hermann von Helmholtz-Zentrum für Kulturtechnik setzen diese integrative Forschungsstruktur an der Humboldt-Universität zu Berlin fort. Der Cluster hat Humboldts Modell von Forschung,

Lehre und Wissenstransfer neu gestaltet und das Erbe der 200-jährigen Geschichte der Humboldt-Universität zu Berlin mit der 100-jährigen Geschichte des Bauhauses verbunden.

1.2 Key data

1.2.1 Host, speaker and other participating institutions

Table 1: Participating institutions (last funding period)

Host university/universities	Location
Humboldt-Universität zu Berlin (HU Berlin)*	Berlin
Participating universities [1)]	Location
Charité – Universitätsmedizin (Charité)	Berlin
Freie Universität Berlin (FU Berlin)	Berlin
Technische Universität Berlin (TU Berlin)	Berlin
Weißensee Academy of Art Berlin (KHB)	Berlin
Participating non-university research institutions [1)]	Location
Anhalt University of Applied Sciences (HSA)	Dessau
BAM Federal Institute for Materials Research and Testing	Berlin
HTW University of Applied Sciences (HTW Berlin)	Berlin
Ibero-American Institute, Prussian Cultural Heritage Foundation (IAI)	Berlin
Kunstbibliothek, Staatliche Museen zu Berlin, Prussian Cultural Heritage Foundation (SPK)	Berlin
Kunstgewerbemuseum (Museum of Decorative Arts), Staatliche Museen zu Berlin, Prussian Cultural Heritage Foundation (SPK)	Berlin
Leibniz Center for Literary and Cultural Research (ZfL)	Berlin
Max Planck Institute of Colloids and Interfaces (MPIKG)	Potsdam
Museum für Naturkunde (MfN) – Leibniz Institute for Evolution and Biodiversity Science	Berlin
Zuse Institute Berlin (ZIB)	Berlin

* Speaker university/universities are highlighted with an asterisk (*)

1) Institutions that were funded by the Cluster. Cooperation partners that were not funded by the Cluster but contributed their own funds to the Cluster (e.g. industrial cooperation partners, service providers, museums, cultural institutions, etc.) are listed in Table 8 in Appendix A.

1.2.2 Overview of the Cluster's structure

Tables 2A and 2B: Structure of the Cluster

The Cluster's research was divided into two phases. Starting in 2012, the exploratory phase of the Cluster *Image Knowledge Gestaltung. An Interdisciplinary Laboratory* established a culture of interdisciplinary research. In conjunction with an internal evaluation of the research projects, the Cluster's research priorities were realigned in 2015/2016: In the converging phase the Cluster focused on jointly developed research priorities.

Table 2A: Explorative phase of the Interdisciplinary Laboratory (2012-2016)

	Unit (research area)	Title	Research discipline and direction
	A	Historicizing–Experimenting	Interdisciplinary, involving Archaeology, Art and Visual Studies, Cultural History and Theory, Design, Ethnology, History of Science
	B	Analysis–Synthesis	Interdisciplinary, involving Architecture, Art and Visual Studies, Biology, Cultural History and Theory, Literary Studies, Mathematics, Medicine, Physics
	C	Materialization–Virtualization	Interdisciplinary, involving Art and Visual Studies, Computer Science, Interface Design, Library and Information Science, Materials Research and Testing, Paleontology
	D	Designing Interdisciplinarity	Interdisciplinary, involving Architecture, Art and Visual Studies, Computer Science, Cultural History and Theory, Design, Ethnology, Library and Information Science, Psychology
	Z	*Central Management*	

Table 2B: Converging phase of the Interdisciplinary Laboratory (2016-2018)

	Unit (research area)	Title	Research discipline and direction
	A	Image & Action	Interdisciplinary. Investigated the specific forms and uses of image technologies that are deployed to support and guide operations.
	B	Process of Form and Modeling	Interdisciplinary. Focused on various conditions and processes for the development and modification of form in nature and culture, as well as the relationship between form and model.
	C	Active Matter	Interdisciplinary. Investigated the relationship between intrinsic and extrinsic code in the context of active materials.
	D	Architectures of Knowledge	Interdisciplinary. Examined the operational character of spaces, processual architectures of knowledge in physical and virtual contexts, as well as collaborative forms of working and interactive spaces.
	E	Collecting & Exhibiting	Interdisciplinary. Linked the history of scientific collections, the theory and cultural technique of collecting and exhibiting with the challenges facing research and science communication today.
	Z	*Central Management*	

2 Research

2.1 Major aims and achievements of the Cluster

The starting point for the Cluster of Excellence *Image Knowledge Gestaltung. An Interdisciplinary Laboratory* was the fundamental significance of images, architectures, and processes of *Gestaltung* in scientific knowledge production and beyond. Visual modes of information have never been a secondary tool, serving to illustrate what has been produced elsewhere. Quite the contrary, images in the widest sense shape and construct, what they show. This conception of images has been reinforced essentially by the digital revolution within science, medicine, and teaching so that images moved to the center of interest as an essential agent in the creation and shaping of knowledge. Technologically advanced societies rely on the production, use, and understanding of image and *Gestaltung* practices to the extent that they influence scientific operations, decisions, and conclusions. This applies in particular to the natural and engineering sciences and medicine (e.g. surgery), which have become fundamentally dependent on images as instruments or modes of operation. At the same time, the expertise of image analysis, design research, and design practices are absent from basic research at the majority of the universities in Germany and beyond. The historical separation of design and art schools remains a fundamental institutional constraint. The Cluster, however, succeeded in integrating the design disciplines into its research processes. It has accomplished the vision of creating a categorically new understanding of the significance of the visual within modern disciplines and fostered a deeper understanding of the processes underlying *Gestaltung*.

Gestaltung, understood as a process of materialization and realization of knowledge, however, blurs disciplinary and spatial boundaries and operates both on a material and an immaterial level. The study of its processes therefore required an integrative approach and equal participation of the design disciplines and architecture. The necessary synthesis of very heterogeneous forms of knowledge in the process of design reveals the productive core of *Gestaltung*. This integrative function of *Gestaltung* was of central importance to the Cluster—*Gestaltung* was seen as the continuous communicative and synthetic nodal process of intertwining the humanities and the natural and engineering sciences. The integrative practices of *Gestaltung* fostering project-driven collaboration were complemented by the synthetic potential of the humanities for transversally combining heterogeneous fields of knowledge and practices. This is why *Bildwissenschaft* and *Cultural History and Theory* were placed at the core of the Cluster and also acted as nodal connecting points.

More concretely, the Cluster achieved the following five central goals:

i. **The Cluster redefined the active status of images and Gestaltung processes in the context of knowledge production.**

The Cluster investigated the potential for *Gestaltung* of images and imaging processes in the sciences. Since images blur disciplinary boundaries, one of the Cluster's main achievements has been to establish images as a central and homogenous research object within a broad range of disciplines. Starting from the premise that images and spaces are co-producers of what they depict or contain, a special area of focus for the Cluster was the use and impact of images and spaces in and on research processes—an area that before had not been studied at all. Thanks to its interdisciplinary nature, the Cluster was not only able to analyze the use of images theoretically and historically from the perspectives of image studies and media theory, but also incorporated the expertise of image production, interaction design, and the *Gestaltung* of images. The Cluster's systematic approach to *Bildwissenschaft,* interaction design, and architecture integrated both the analysis of the image, interaction, and spaces of knowledge production and their *Gestaltung*. In this way, it became possible to critically alter the ways in which processes of *Gestaltung* are used in scientific practices and disciplines, for example in medicine, biology, history, physics, psychology, and materials science. The theories of the active image and active space thus had an impact on a broad spectrum of disciplines that had previously regarded images and space as mere instruments. The Cluster also explored the consequences of image-guided interventions, for instance in surgery and neurosurgery. Humanities scholars, practicing medical doctors, and interaction designers jointly contributed decisively to a design-driven, patient-oriented turn at Charité, one of the largest medical research clinics in Germany.

ii. **The Cluster implemented a turn toward "Gestaltung through research" as well as "research as Gestaltung."**

The Cluster started with the vision of examining and mobilizing the processes of *Gestaltung* in scientific research. Taking *Gestaltung* as a process of materialization and realization of knowledge, the Cluster transformed it into a fundamental element of research. At the same time, research itself was revealed to be a process of *Gestaltung*. The Cluster established *Gestaltung* as an essential component of interdisciplinary research that had previously been absent in the German academic system: Design disciplines are located within the universities of the arts or applied sciences, and separated from the fundamental research disciplines of major universities. One of the Cluster's main achievements was to radically alter this former status quo. In close cooperation with Weißensee Academy of Art Berlin and HTW University of Applied Sciences, the Cluster addressed this challenge on the level of research infrastructure, methods, promotion of early career researchers and designers,

and faculty positions. From its beginning, the Cluster integrated a Design Lab (equipped with 3-D printers, CNC milling machines, laser cutters, CAD workstations, and prototyping tools, etc.) and a Sound Lab into its research framework. Together with the specialized facilities of the applied universities, this research infrastructure allowed for the successful integration of methods grounded in different levels of abstraction, including theoretical and historical analysis, experimentation, and advanced design practices. This approach has proven especially fruitful for integrating imaging technologies, virtual and augmented reality, architectural design, and 3-D printing into research and experimentation, thus fostering significant innovation in basic research, e.g. in creating a virtual model of the Roman Forum permitting the analysis of an ancient acoustic situation.

To strengthen this turn to *Gestaltung* within the next generations, the Cluster has established two international interdisciplinary master's programs: »Open Design« (HU Berlin/Universidad de Buenos Aires) and »COOP Design Research« (Anhalt University of Applied Sciences, Bauhaus Dessau Foundation), which focus on design processes. Three new Cluster professorships—»History and Theory of Form«, »Morphology and History of Forms«, and »History and Theory of Gestaltung«—systematically and sustainably contribute toward the envisioned turn to *Gestaltung* in academia. As a further step toward integrating design processes into basic research, the Cluster has laid the foundation for a practice-based PhD program at HU Berlin.

iii. **The Cluster established a new integrative role for the humanities.**

Image Knowledge Gestaltung brought together more than 40 disciplines creating an interdisciplinary research environment allowing to focus on extremely challenging questions. The special approach of the humanities, primarily represented by *Cultural History and Theory* and *Bildwissenschaft*, was an essential feature of this collaborative environment. The transversal approach of focusing on the history, theory, and practice of cultural techniques such as images, spaces, structures, and forms as fundamental modes of knowledge production provided a methodological basis for combining and integrating heterogeneous forms of knowledge and practices. The humanities thereby obtained a new integrative and synthetic role indispensable to interdisciplinary collaboration. *Bildwissenschaft* and *Cultural History and Theory* succeeded in connecting the participating disciplines. This close collaboration of highly diverse disciplines—including the design disciplines and guided by the humanities—represented an unprecedented breakthrough in the current German academic system. As a whole, the Cluster has established a culture of trust and sustainable collaboration among equal partners, including humanities scholars, natural and computer scientists, engineers, and designers at HU Berlin and beyond.

The Cluster has succeeded in establishing exceptional axes of joint interdisciplinary research that proved to be very productive and have contributed substantially to the success of the follow-up application for the Cluster of Excellence *Matters of Activity. Image Space Material* within the Excellence Strategy. These include the axis between biology and *Gestaltung* and art history, the axis between cultural theory and physics and the axis linking *Gestaltung* to cultural theory. Materials science, physics, and biology reshaped their experimental approach by integrating epistemological, historical, and design dimensions. This enabled new research perspectives in the field of material code and *Strukturwissenschaft*, e.g. a new interdisciplinary research field on folding. As a fundamental consequence, the two Cluster directors from the humanities, Horst Bredekamp and Wolfgang Schäffner, were complemented by Peter Fratzl as a third director from materials science.

iv. **The Cluster established an Interdisciplinary Laboratory to promote the integrative collaboration of scientific disciplines, which includes the analysis of collaboration, thus transforming it into an object of research and of permanent redesign.**

The Cluster set out to deepen each of its areas of disciplinary expertise through interdisciplinary interactions: The Interdisciplinary Laboratory provided a shared space in which diverse disciplinary experts who would otherwise be based in different university departments collaborated closely with each other; this, in turn, strengthened their disciplinary knowledge. The participating researchers transformed the existing dissonances between diverging research traditions and methods into a productive “synagonistic zone”. The Cluster’s approach can therefore be described as one of discipline-centered interdisciplinarity in which the intertwined processes of discipline-based and interdisciplinary practices were of decisive importance to its research. Against this background, the Cluster initiated and fostered an interaction of disciplines that was simultaneously problem-oriented convergent and method-oriented divergent in an exemplary Interdisciplinary Laboratory in order to reshape the very *Gestalt* of the university’s architecture of knowledge.

To achieve this, the Cluster considered the design of interdisciplinarity as a research challenge in its own right. It has constantly developed, tested, and adapted its own architectural environments, formats for personal interaction, and physical/virtual tools for interdisciplinary collaboration. This approach enabled collaborations to operate at a higher level of precision and high-risk research projects to be conducted in an adaptive environment characterized by high levels of complexity. The Cluster therefore succeeded in providing an overarching framework that fosters interdisciplinary research, including a dynamic research structure, a carefully designed physical architecture, flexible

management, embedding interdisciplinarity in the governing bodies as well as adequate time and space to exchange ideas and find a common terminology. By these means, the challenges that interdisciplinary research undeniably faces—such as differing disciplinary requirements in terms of publication formats and time schedules—could mostly be overcome.

v. **The Cluster established a strong link between research and public knowledge exchange as an open lab in order to emphasize the public character of research.**

The Cluster started with a mission to conduct open-lab-based research in close cooperation with museums, collections, and the general public. From its beginning, the Cluster cooperated intensively with renowned partners such as the Museum für Naturkunde Berlin, the Prussian Cultural Heritage Foundation, and the Bauhaus Foundation to explore and establish novel practices and forms of research and exhibition.

In the context of exhibition and collecting practices, the Cluster developed an approach to curating that conceives it as an original form of research and knowledge production joining scientific, aesthetic, and social practices. The Cluster's home base—the Hermann von Helmholtz Center for Cultural Techniques (HZK)—houses more than forty scientific collections of HU Berlin and oversees the development of innovative exhibition formats for the Veterinary Anatomy Theater (*Tieranatomisches Theater*)[1] and the Humboldt Labor, the exhibition space of HU Berlin within the Humboldt Forum (opening in 2020). The central Cluster-curated exhibition »+ultra. knowledge & Gestaltung« was a tremendous success and contributed to the development of new formats of knowledge transfer for the Humboldt Labor. Taking models, tools, natural objects, and images as its elements, the exhibition revealed for the first time the fundamental importance of design processes for science and research as well as the knowledge inscribed in designed objects. »+ultra« was on show in the Martin-Gropius-Bau Berlin for three months and attracted more than 35,000 visitors. Using objects from the natural world, artifacts, and interactive installations, the exhibition highlighted the growing interdependence of the human, technological, and natural spheres by offering new perspectives on processes of *Gestaltung* in academic research.[2] In total, the Cluster was involved in at least 30 exhibitions, staged in Berlin, Dresden, and Düsseldorf.

[1] Built in 1790, the Veterinary Anatomy Theater is a unique historic monument that has provided a spectacular stage for science and research for more than 200 years. Together with the HZK, the Cluster has developed this historic venue in the heart of the city as a public cultural institution with the character of a laboratory. In each exhibition, the historical spaces of the TAT acted as a constantly reconfigured operative element. The central goal was to experimentally develop innovative exhibition practices and to enable diverse forms of critical access to material knowledge cultures and scientific collections.

[2] Doll, N., Bredekamp, H., Schäffner, W., eds. (2017) for the Cluster of Excellence *Image Knowledge Gestaltung. An Interdisciplinary Laboratory*: +ultra. knowledge & gestaltung. Exhibition catalogue, Martin-Gropius-Bau, Berlin. E. A. Seemann, Leipzig.

The Cluster's vision has been to develop an experimental system—the Interdisciplinary Laboratory—designed to reshape the university's architecture of knowledge. During six years of intensive research, *Image–Knowledge–Gestaltung* have been established as three central and corresponding axes of the Cluster's interdisciplinary research. These axes embodied image research as an essential element in basic research, the analysis of structures and spaces of knowledge in scientific disciplines, and finally the analysis and design of research processes as a collaborative architecture of knowledge. Principal investigators, postdoctoral researchers, PhD candidates, and university students from a wide range of academic disciplines that are usually isolated from each other worked together in 45 research projects. Among others, art historians, materials scientists, interaction designers, cultural historians, physicists, biologists, medical doctors, computer scientists, linguists, media scientists, mathematicians, and architects jointly established a shared platform that fostered a new form of integrative research by all disciplines. The Cluster thereby revitalized the 200-year history of the Humboldtian model of research and teaching at the heart of the Berlin university bearing his name. The Cluster has forged close links between the humanities and the natural sciences, and brought them together with the design disciplines, which generally still lack a suitable place in the research landscape. By this integration, the Cluster has transformed design into a key actor in basic research and reshaped the essential role of the humanities.

2.2 An adaptive laboratory: Two phases of the Cluster's research

The Cluster's research structure was designed with a special focus on intertwining research questions, different methods, disciplines, and the range of expertise of the principal investigators. Each project addressed an interdisciplinary research question related to the conjunction of image, knowledge, and *Gestaltung*, and involved at least two principal investigators from different disciplines (humanities, natural sciences, or *Gestaltung*). This strategic project design was chosen to ensure a strong interdisciplinary perspective. Due to a very broad range of disciplines combining highly different research cultures and practices, the joint research processes represented a high-risk and high-gain endeavor. From the outset, the openness and flexibility of the Cluster's research structure was therefore used as a key strategy for assuring the quality of its research outcomes. In doing so, the Cluster made use of the unusual openness of the *Clusters of Excellence* funding line, which fosters innovative formats and new types of challenges for interdisciplinary research. The flexible format of the *Cluster of Excellence* allowed for a dynamic configuration of the Cluster's research projects: In order to achieve the central goals, which themselves were further specified as the Cluster's work progressed, the projects and research priorities were re-adjusted. These dynamic internal structures made it possible to take account of newly emerging research challenges and project constellations.

Exploratory phase of the Interdisciplinary Laboratory: The Cluster's research structure started based on "bottom-up" principles, which enabled it to incorporate the different perspectives of all participating disciplines. In problem-oriented projects, joint research questions were developed and investigated with an interdisciplinary approach. The methodological diversity of the participating disciplines was systematically transformed into productive interactions in three method-oriented research areas A–C: »Historicizing–Experimenting«, »Analysis–Synthesis«, »Materialization–Virtualization« (see left column in Fig. 1). These methodological approaches, which usually act separately, were brought together as components of the research processes of *Gestaltung* and acted as the crystallization point of each individual research project. The additional research area D »Designing Interdisciplinarity« was established as a research instrument of self-observation and reflection in order to provide feedback to the projects of the other research areas.

While research areas A–C confronted methodological divergences strategically, five key themes employed a complementary strategy in which synergies were created between the projects and their design potential was activated. The following five key themes produced convergent dynamics that allowed to use methodological divergences productively:

- **Image Agents**: One of the Cluster's key aims was the redefinition, testing, and realization of the structural and operative qualities of active images in all fields of the humanities, science and medicine.
- **Model & Scale**: Models can invert scales and enable what is invisible to be depicted. They influence *Gestaltung* on a meta-level on both large and small scales. The Cluster's aim was to investigate the specific impact and influence of models of different scales within processes of *Gestaltung*.
- **Structures Tissue Surfaces**: Microscopy increases the arsenal of known structures in unexpected ways as even solid materials dissolve into complex structural hierarchies. The Cluster's aim was to study the possibilities of *Gestaltung* that can be derived from a transdisciplinary understanding of structures possible through modern technologies.
- **Mobility**: The mobility of objects, people, and data poses a critical dilemma. Even knowledge itself is subject to mobility influencing the very nature of scientific research. The Cluster's aim was to explore different modes of mobility on nano-, micro-, and macroscales in order to provide this knowledge for the development of sustainable mobility scenarios.
- **Elements of *Gestaltung*:** The Cluster's goal was to identify elements of *Gestaltung* outside subject-specific discourses, thereby enabling new processes of *Gestaltung* to be organized. The Cluster set out to redefine *Gestaltung* explicitly as a research process.

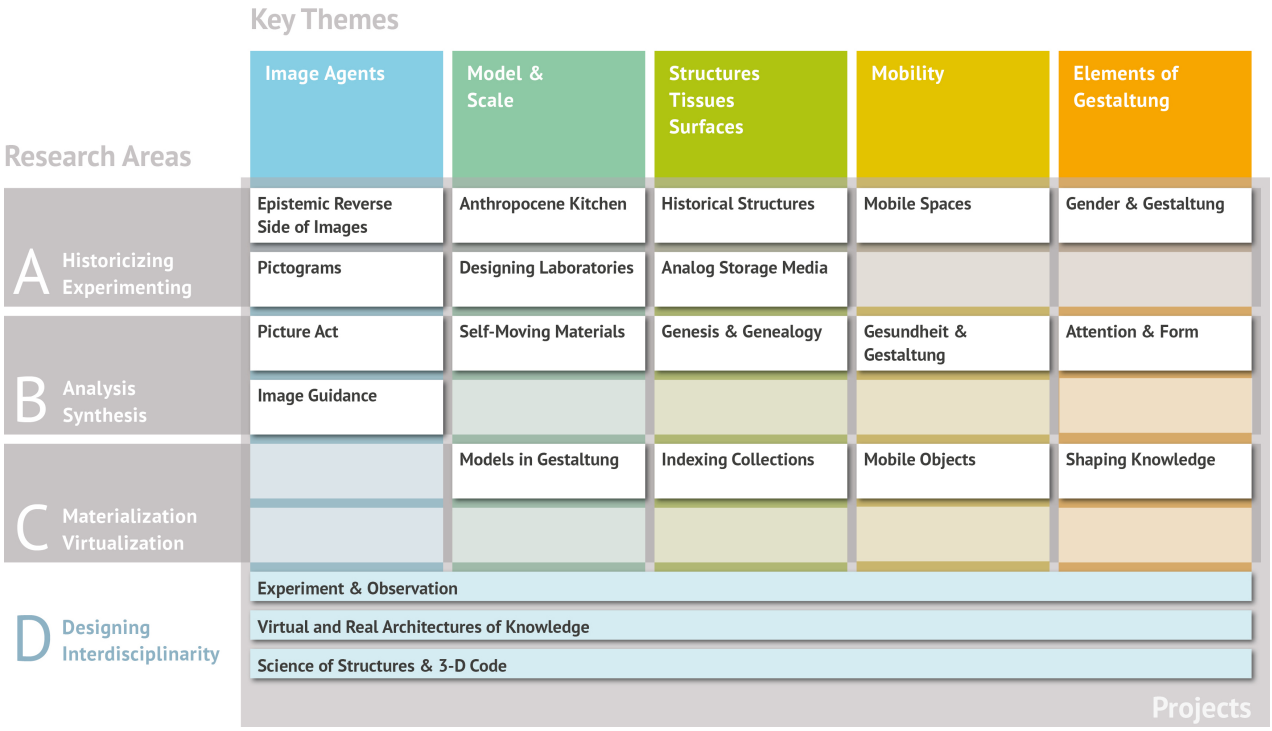


Fig. 1: Matrix-structure of the Cluster's projects in the exploratory phase (Image credits: *Image Knowledge Gestaltung*)

As can be seen in the matrix above, the divergence of the methodological approaches on the horizontal axis was rendered productive by linking them with the convergence-driven key themes on the vertical axis. This project architecture served as an essential framework and communication structure for addressing the Cluster's research objectives. It fostered the greatest possible dovetailing of researchers, methods, topics, and disciplines. This approach created a productive research atmosphere in which any sense of mutual foreignness dissipated with time because the researchers involved were working on questions that were central for all of them. For this reason, the exploratory phase not only produced wide-ranging initial results (see section 2.3.1), but also led to unforeseen constellations of researchers and projects, which jointly developed surprisingly convergent research questions. With new principal investigators and the Cluster professorships entering the Cluster, additional expertise and interests were integrated into the Cluster's research, thereby broadening the interdisciplinary insights. Joint interdisciplinary practice became the indispensable fundament of all projects and can be regarded as the Cluster's most important "intangible" result. After two-and-a-half years of fruitful research, these emerging constellations and research foci were taken as an occasion to evaluate the Cluster's own architecture. It became evident that the research structure as presented in the matrix above had been successful in bringing together researchers and the perspectives of the diverse disciplines involved, but it no longer represented the dynamic constellations of the Interdisciplinary Laboratory and the most productive joint foci that had emerged. This insight was

the starting point for a strategic reorientation and redesign of the Cluster's research areas. The mutual trust of principal investigators from a wide variety of disciplines—this being the fundamental outcome of the exploratory phase—was the prerequisite for the intensive restructuring process that followed, revealing the strength of the established collaboration.

Converging phase of the Interdisciplinary Laboratory: On the basis of the previous research processes, the Cluster re-adjusted its research structure in 2015, synthesizing and condensing what had been achieved so far. The aim was to emphasize the Cluster's strengths and at the same time to incorporate novel project ideas that emerged as a result of the dynamic interdisciplinary research process. Through discussions with all principal investigators, the research foci were ultimately organized into five priority areas: »Image & Action«, »Process of Form and Modeling«, »Active Matter«, »Architectures of Knowledge«, and »Collecting & Exhibiting«. As in the first exploratory phase of the Cluster, all priority areas were characterized by an interdisciplinary research approach with a focus on design processes, their reorientation and optimization.

Compared to the key topics of the Cluster's first phase, the research foci of the priority areas were more closely intertwined, emphasizing the converging approach of the whole Cluster:

- **Image & Action** investigated the specific forms and uses of image technologies that are deployed to support and guide operations.
- **Process of Form and Modeling** focused on the various conditions and processes for the development and modification of form in nature and culture, as well as the relationship between form and model.
- **Active Matter** explored the relationship between intrinsic and extrinsic code in the context of active materials that play a key role in materials research today.
- **Architectures of Knowledge** examined the operational character of spaces, processual architectures of knowledge, as well as collaborative and interdisciplinary forms of working in interactive spaces.
- **Collecting & Exhibiting** linked the history of scientific collections with the theory and cultural technique of collecting and exhibiting with the challenges for research and science communication today.

The strategic process of converging research priorities was combined with an evaluation of the running projects: In parallel, running and newly conceived projects had applied for funding within the Cluster. Each proposal had to demonstrate how it could contribute to the respective priority area's aims and was assessed by two external reviewers, each from different disciplines. On the basis of these assessments, the Executive Board has approved the projects presented in Fig. 2. Through the focus on the Cluster's central goals and the respective priority area's objectives,

these projects were closely linked with each other. These closer links between and within the priority areas enabled a much more targeted level of interdisciplinary collaboration than in the first phase.

Fig. 2: Matrix–structure of the Cluster's projects in the converging phase (Image credits: *Image Knowledge Gestaltung*)

2.3 Research results

The Cluster's research results presented in more than **1,100 scholarly publications** and at **200 public workshops, exhibitions, and events** enhanced the Cluster's national and international visibility. Activities and publications by the Cluster researchers are presented in the annual reports published on the Cluster website.[3]

2.3.1 Exploratory phase (2012-2016)

This section briefly describes the research areas A–D during the Cluster's exploratory phase (see also Fig. 3 on pp. 24-25) and outlines exemplary results from two projects for each area.

Research area A: Historicizing–Experimenting

In the Cluster, the historicizing of experimental systems and observational techniques in scientific laboratories and its counterpart, the experimentation of historical constellations in archeology, served as a bridge between history and experiment. The intrinsic inclusion of historical

[3] https://www.interdisciplinary-laboratory.hu-berlin.de/en/bwg/jahresdokumentation/; https://www.interdisciplinary-laboratory.hu-berlin.de/en/bwg/ueber-uns/

perspectives enabled the antagonism between historicizing and experimenting to be rendered productive. The Cluster successfully demonstrated that future-oriented *Gestaltung* benefits immensely from historical archives. The laboratory is not merely a space with an arrangement of apparatuses in which researchers determine the necessary neutral preconditions for experimental work: In the Cluster, the implicit historical, technical, and cultural conditions in effect in laboratories became an object of research in their own right. In close collaboration with natural scientists, researchers from visual and cultural theory applied their methods to different formats of physical laboratory spaces, with the objective being to productively alter historical and experimental research.

The project **»Designing Laboratories«** focused on planning a new interdisciplinary research building for the Integrative Research Institute for the Sciences in Adlershof (IRIS Adlershof). The team—formed of natural scientists, architects, designers, and art historians—visited new laboratory building projects in Europe and beyond, and examined the evolution of laboratory design in recent years. Outstanding international laboratories such as the MESA+ Institute of Nanotechnology in Twente, the Frick Chemistry Laboratory in Princeton, and the MIT Media Lab in Cambridge, MA, were studied, focusing on the emergence of new user-oriented spatial and organizational structures.[4] This research revealed the conditions under which the architecture and design of contemporary laboratories becomes productive for interdisciplinary research processes. The findings were integrated into the development of the plans for IRIS Adlershof. Due to constraints concerning the architectural competition for the project, however, the knowledge gained was only used to a limited extent in the actual design of the spatial structure of the new building, although it is documented in an edited volume. Nevertheless, by comparing the design and use of laboratory spaces across the world, a concept for an interdisciplinary research building was developed that is now influencing the planning of future laboratories.

In the project **»Historical Structural Investigations in the Laboratory«**, engineering-oriented biomaterials research was connected with historical sources in order to make zoological and morphological research conducted on dynamic biological material structures between 1870 and 1930 directly accessible. The project developed the software design for an ontology-based database, the »Historical BioData Explorer«, which makes historical biological research data on animal movements searchable in an integrative, image-oriented web interface. The database opens up the historical material to researchers today working in the fields of bioinspired materials and engineering science, architecture, and cultural and visual science via digitized texts, images,

[4] Klonk, C., ed. (2016) *New Laboratories. Historical and Critical Perspectives on Contemporary Developments*. De Gruyter: Berlin/Boston. With contributions by Göbel, R., Hansmann, S., Klonk, C., Landbrecht, C., Rabe, H., Rabe, J. P., and Verena Straub.

and objects.[5] Furthermore, together with the project »Science of Structures & 3-D Code«, which continued in the second phase and is described later, the project began to outline a new transversal science of structure.

Research area B: Analysis–Synthesis

The Cluster emphasized that image-guided research approaches in the natural and materials sciences as well as in the humanities always encompass interlinked analytic and synthetic processes instead of these being separate undertakings. Similarly important was the analysis of modeling and models, focusing on their analytic and synthetic potential, that can handle contrariness and create a productive interaction that is conducive to experimentation. This close intertwining of analytic and synthetic methods was critical to the Cluster's research focus on image and knowledge processes and their potential for *Gestaltung* as it made the detailed reconstruction of design processes possible. It provided a framework for the projects within this research area, as can be seen from the following two examples of research projects:

The project **»Attention & Form«** studied a biological collection of crustaceans in order to critically revise the culture of systematization in biology, with a special emphasis on the tension between typology and genealogy.[6] The interdisciplinary team consisting of biologists, psychologists, cultural historians, and computer scientists investigated form as a basis for classification and group formation, and thus as a source of differentiation in the respective disciplines. The project has established an interdisciplinary perspective on form-based classification and systematization.[7] The interaction between the observer and the object of observation was studied in order to broaden particular ways of seeing.[8] The comparative analysis demonstrated that cultural factors and media—such as the formation of taste and style, tradition, and economic considerations—not only influence the investigation of natural objects by introducing constraints, but can also be productive in the context of the natural sciences.

The project **»Genesis & Genealogy«** examined the conditions that determine natural and artificial forms. It addressed the question of genesis and genealogy from a comparative perspective that asked how individual objects acquired their form (constructively and

[5] Dürfeld, M. Schröter, P., Schulze, A. (2017) Der Historical BioData Explorer: Historische Texte, Bilder und Objekte neu erforschen. In: Bienerted, A., ed. *Konferenzband EVA Berlin 2017: Digitally Remastered – Kulturerbe und Virtualität*. Berlin 2017. Online: http://www.eva-berlin.de/files/EVA_BERLIN_2017_Proceedings_web.pdf

[6] Scholtz, G. (2014) Evolution of crabs – history and deconstruction of a prime example of convergence. *Contributions to Zoology*, 83, 87-105.

[7] Bruhn, M., Scholtz, G., eds. (2017) *Der vergleichende Blick. Formanalyse in Natur- und Kulturwissenschaften*. Berlin: Reimer.

[8] Reindl, A., Strobach, T., Becker, C., Scholtz, G., Schubert, T. (2015) Crab or lobster? Mental principles underlying the categorization of crustaceans by biology experts and non-experts. *Zoologischer Anzeiger*, 256, 28–35. http://dx.doi.org/10.1016/j.jcz.2015.03.001

genealogically) by examining both the formation of artifacts in design and art and the ontogeny of organisms.[9,10] The examples studied included Gothic plant ornaments,[11] individual design processes on the basis of sketchbooks,[12] and tissue patterning during bone healing.[13] Instead of focusing on finished objects, the genesis of form as a process was conceptualized as a sequence of forms; and their genealogical relationships were reconstructed.

Research area C: Materialization–Virtualization

Materialization and virtualization formed a third point of divergence for research subjects and approaches in the Cluster. Interrelationships were established between the normally separate fields of research concerning the material or the virtual (understood as immaterial) in order to ally the virtuality of the material and the materiality of the virtual: Disciplines such as archaeology and paleontology reconstructed historical objects from material remains and virtual models, thereby making the virtual real again (see results of the second phase in section 2.3.2). Furthermore, the Cluster addressed the challenge of how to form interrelationships between virtual representations and actual objects in collections. The dematerialization of virtual objects is linked to a further process of materialization, since virtual objects and the apparatus used to transmit and store them possess their own materiality. While an image of an organ lacks organic texture, the image itself, whether it is digital, a physical photograph, or an anatomical drawing, consists of material elements. Models also inhabit a peculiar mediating position, since prototypes materially preempt an object that does not yet exist. On the other hand, virtual objects, experiments, and models change our perception of materiality in a fundamental way.

The project **»Models in Gestaltung. Towards an Understanding of Design Processes«** studied the development and use of models in poietic processes, i.e. in scientific, artistic, and specifically constructing processes of design and cognition. The research team focused on models that visualize different time-critical processes. On the basis of experiments, case studies, and historical studies, poietic processes were investigated and models were identified. This enabled the project to address concepts of the processes underlying the design of models in various areas of knowledge. The project promoted an interdisciplinary understanding of design

---

[9] Scholtz, G., ed. (2017): *Serie und Serialität. Konzepte und Analysen in Gestaltung und Wissenschaft*. Berlin: Reimer. With contributions from Blümle, C., Loose, G., Ferracci, J., Scholtz, G., Schramke, S., Weinkamer, R., et al.

[10] Loose, G., Scholtz, G. (2019) The cleavage pattern of calanoid copepods – a case study. *Development Genes & Evolution,* 229: 103-124.

[11] Seliger, A., Jirikowski, G., Scholtz, G. (2015): Morphologische Analysen vegetabiler Ornamente der Gotik – eine interdisziplinäre Annäherung an kunsthistorische Reihen. In: Bredekamp, H., Schäffner, W., eds. *Haare hören – Strukturen wissen – Räume agieren. Berichte aus dem Interdisziplinären Labor »Bild Wissen Gestaltung«.* Bielefeld: transcript, 61–78.

[12] Bösl, A., Hille, K., eds. (2016) *Pflanzen–Formen–Lehre. Historische und aktuelle Positionen des zeichnerischen Pflanzenstudiums an der Universität der Künste Berlin.* Berlin: Revolver.

[13] Repp, F., Vetter, A., Duda, G. N., Weinkamer, R. (2015) The connection between cellular mechanoregulation and tissue patterns during bone healing. *Med Biol Eng Comput*, 53(9): 829-42. doi: 10.1007/s11517-015-1285-8

processes, aiming to achieve a general theory of »Models in Gestaltung«[14,15] and highlighting the significance of models in the formation of social realities. To perpetuate research of this nature, the »Internationale Gesellschaft für Modellforschung«, a society for model research, was established at the HZK. The society further develops the ideas initiated by Bernd Mahr (†2015)[16] on a lasting basis, fostering debates on the role of models and modeling.

From different methodological perspectives, the project **»Indexing Collections«** examined and cataloged a rich collection of paintings in the »Lipperheide Costume Library«, based at the Kunstbibliothek of the Staatliche Museen zu Berlin. This collection includes around 550 artifacts of fashion and costume history from the period 1450 to 1900 and has been housed in the Kunstbibliothek since 1899. In collaboration with the BAM Federal Institute for Materials Research and Testing, HU Berlin, the Kunstbibliothek, and Weißensee Academy of Art Berlin, researchers studied 20 oil paintings in an exemplary undertaking. In order to integrate the perspectives of a broad spectrum of individual disciplines, extensive research was conducted in the areas of museology and collection history, as well as art, culture, fashion history, and materials research. Special emphasis was placed on the collection in terms of its function as a set of physical objects and its virtual development and representation. This research formed the basis for the project »Culture Collaboratory« in the Cluster's second phase.

Research area D: Designing Interdisciplinarity

The key themes and research areas A–C formed two axes that fundamentally structured the research program as shown in the matrix for the Cluster's first phase. By combining these two strategies, the Cluster's research structure became a complex process of *Gestaltung*. Research was thus not only confined to thematic questions and methodological processes: The entire Cluster itself was a research object and an experiment. In this research area, researchers critically observed, formed, experimented with, and actively participated in the various layers of interdisciplinary cooperation. The subjects of interventions and *Gestaltung* were the physical architecture of the building and its furniture as well as the virtual architecture of communication structures. Working closely with all Cluster researchers, the humanities' scholars, designers, architects, and computer scientists involved in this research area provided concepts and support that enabled to establish a productive environment for collaboration and a culture of interdisciplinarity; together, these created a strong foundation for the Cluster.

---

[14] Friedman, M., Tomšič, S., eds. (2016) *Psychoanalysis: Topological Perspectives*. Bielefeld: transcript.
[15] Balke, F., Siegert, B., Vogl, J., eds. (2014) *Modelle und Modellierung*. Paderborn: Wilhelm Fink Verlag.
[16] Mahr, B. (2004) Das Mögliche im Modell und die Vermeidung der Fiktion. In: Macho, T., Wunschel, A., eds. *Science & Fiction. Teil 1: Über Gedankenexperimente in Wissenschaft, Philosophie und Literatur*. Frankfurt a. M.: Fischer Taschenbuch Verlag; Mahr, B. (2014) Formalisierende Anordnung. Notat, Zeichen und Modell. In: Balke, F., Siegert, B., Vogl, J., eds. *Modelle und Modellierung.* Paderborn: Wilhelm Fink Verlag, 115–128.

Image Knowledge Gestaltung: Exploratory phase (as of May 2015)

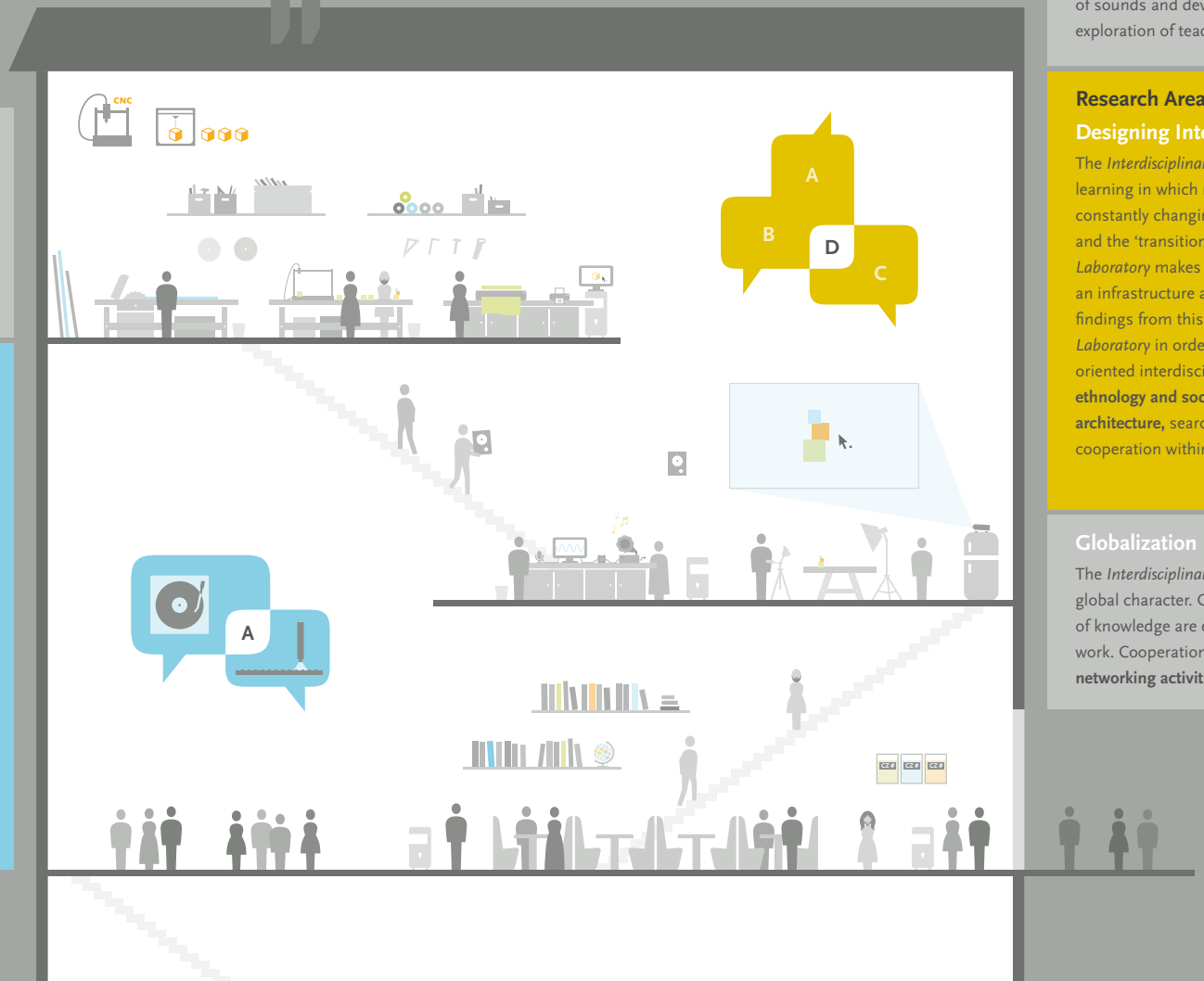
In the *Interdisciplinary Laboratory* Image Knowledge Gestaltung, more than 25 academic disciplines have joined forces to research the ways in which images, knowledge structures and processes of *Gestaltung* condition, influence and motivate each other. The extreme prevalence of images in our time is influential in posing urgent questions for knowledge. In view of the digital revolution and the astonishing shifts taking place in the field of materials science, the *Interdisciplinary Laboratory* is rethinking processes of knowledge generation in their entirety. The question of what steps we now need to take is inextricably linked to *Gestaltung*. Here, answers relating to the process of *Gestaltung* will be found not only in architectural and design fields, but in every discipline. In contributing to this inclusive approach, disciplines will not lose their individuality; in fact, it is by virtue of their distinct methods that they become an integral part of interdisciplinary work. Different fields of the humanities, natural sciences and disciplines of *Gestaltung* create an integrative connection. A collaborative effort involving people, practices, spaces and technologies are tested in order to address questions of our time that cannot be solved by a single discipline on its own.

Research Area A–C
Transfer of Methods

This cluster brings together a wide range of methods. Diversity is activated in three main constellations that focus on methodological divergences:

A Historization | Experimentalization:
Until now, the fundamental difference between the humanities and the natural sciences has been that historization and experimentalization have virtually nothing to do with each other. In this research area e.g. **physics and cultural history and theory** come together to explore new storage technologies that combine scanning probe microscopy methods with historical media such as vinyl records.

A new bridge professorship 'History and Theory of Experimental Systems' will sustainably combine cultural history and theory and physics.



Tools

The material modelling of knowledge processes and the transfer between disciplines can be achieved through the design workshop. Researchers have access to **3D printers**, a **CNC mill**, **laser cutter** and **CAD workstations** along with assistance from staff operators for generating models and prototypes. This allows macro, micro and nanostructures to be made tangible in different standards and perspectives. The internal work environment can also be adapted, exhibition concepts can be modelled and 1:1 prototypes can be developed for series production. A **digital image and video workshop** enables the production and processing of images and films for innovative application in a wide range of disciplines, while an **audio workshop** is available for the investigation of sounds and devices for the storage and transfer of knowledge and the exploration of teaching and publishing formats beyond text-based forms.

Research Area D
Designing Interdisciplinarity

The *Interdisciplinary Laboratory* regards itself as an entity capable of learning in which no element is set in stone, but whose parameters are constantly changing and capable of further development. 'Self-reflection' and the 'transition to design' are the key concepts: The *Interdisciplinary Laboratory* makes itself the subject of its own research and is building an infrastructure at the university that has not existed before. The findings from this self-observation are fed back into the *Interdisciplinary Laboratory* in order to keep improving the conditions for problem-oriented interdisciplinary research. In this research area e.g. **psychology, ethnology and sociology, together with computer science and architecture,** search for better tools and structures for interdisciplinary cooperation within an 'experimental zone'.

Globalization

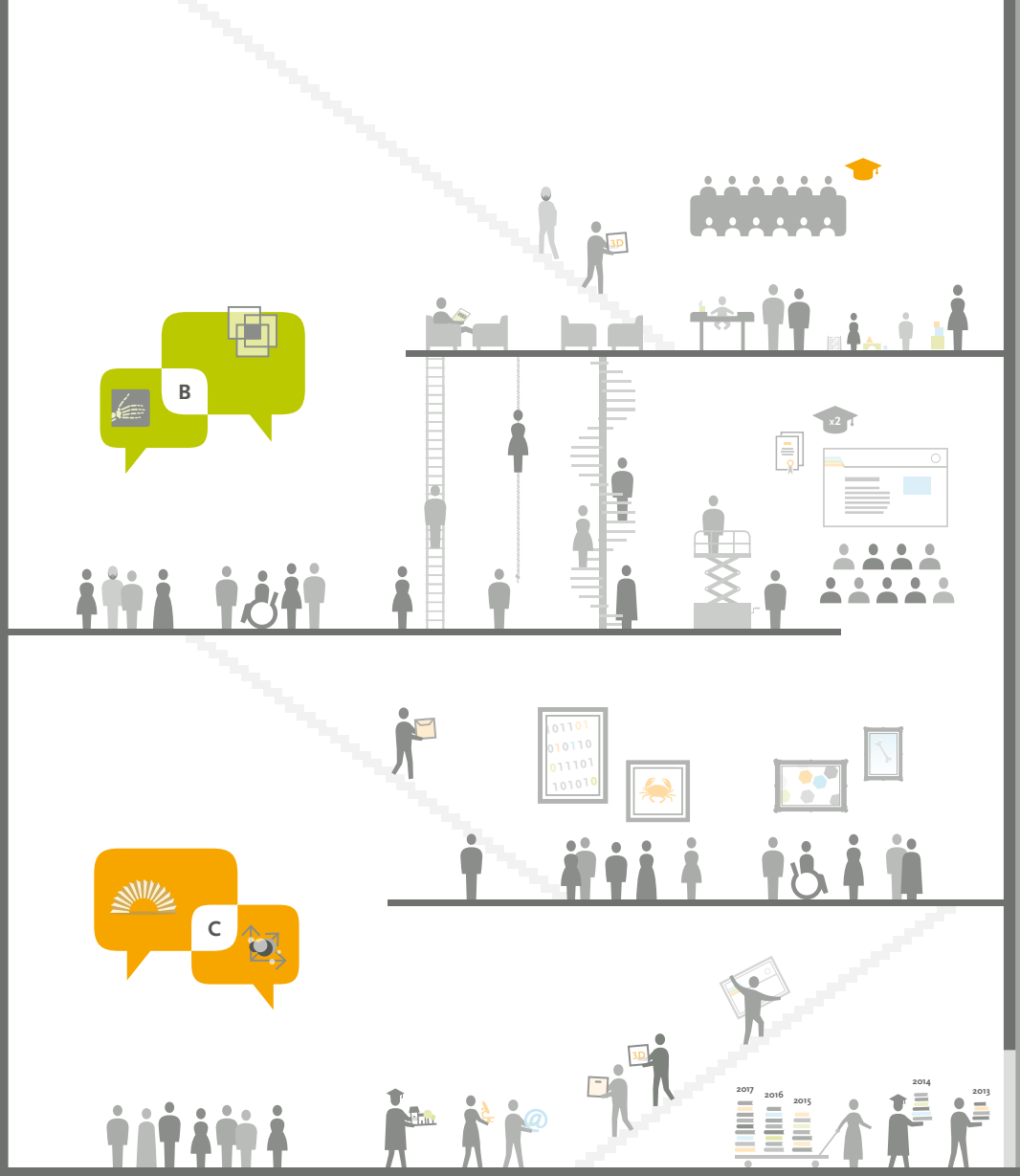
The *Interdisciplinary Laboratory* regards itself as a local site with a global character. Global practices with local, culturally influenced forms of knowledge are explicitly combined in interdisciplinary research work. Cooperation with Latin America is a specific focus **of our global networking activities.**

B Analysis | Synthesis:
Within the scope of the design process, the divergence from analytical and synthetic processes as explicitly opposed forms of passive observation and active intervention is fundamental. This research area explores e.g. **medicine, art history, media science and interaction design** as images determining medical treatments and decisions.

The bridge professorships 'Morphology (Zoology) and the History of Form' and 'History and Theory of Form' bring art history and biology together in close cooperation on design issues.

C Materialization | Virtualization:
The focus here is on concretions that solidify into knowledge as images, models and structures at different levels of materialization and virtualization. The way science and design interact with objects from nature and artefacts, in relation to their virtualization, is investigated. In this research area e.g. **architecture, material and cultural history and theory** explore the structural/functional relationships of materials.

The bridge professorship 'History and Theory of Gestaltung' firmly establishes design research in theory and practice at the university.



Interdisciplinary Support for Young Academics

- 'Diversity of Knowledge', an interdisciplinary program in cooperation with the cluster, offers **cross-faculty courses for B.A. students** and provides young academics with teaching experiences.
- A theme class of **Germany Scholarship** holders, funded by the *Ernst Schering Foundation*, enables 15 students per year to acquire interdisciplinary research experience.
- The **international Master's program 'Open Design'** offers students from all fields the opportunity to study the diversity of methods and interdisciplinary skills at the *University of Buenos Aires* and the *Humboldt-Universität zu Berlin* with **a double degree** from both universities.
- The one-year MSc. Program 'Coop Design Research' is conducted by *Anhalt University*, *Bauhaus Dessau Foundation* and the cluster, conceived as a preparatory step towards a doctoral study, especially for designers.
- The **structured doctoral program** 'Image Knowledge Gestaltung' supports PhD-students in the cluster and fosters the connection between interdisciplinary cooperation in the research projects and a disciplinary PhD-project.
- Two junior professors and **35 postdoc positions** in the research projects offer postdocs excellent options for research and qualification.
- The **internal event series for the cluster entitled 'Learn with ...'** transfers skills of all status groups and disciplines among each other, from an introduction to software by students to a professorial image description seminar.

Cooperation Partners

Federal Institute for Materials Research and Testing, Deutsches Hygiene Museum, Freie Universität Berlin, Haus der Kulturen der Welt (HKW), Anhalt University of Applied Sciences, Zuse Institute Berlin, Max Planck Institute for the History of Science, Max Planck Institute of Colloids and Interfaces, Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science, Dessau Bauhaus Foundation, Prussian Cultural Heritage Foundation (Kunstgewerbemuseum/ Museum of Decorative Arts, Staatliche Museen zu Berlin/Berlin State Museums; Kunstbibliothek/Art Library, Staatliche Museen zu Berlin/Berlin State Museums; Ibero-American Institute) Technische Universität Berlin, University of Kassel, Berlin Weissensee School of Art, ZfL (Centre for Literary and Cultural Research).

Knowledge Transfer

The *Interdisciplinary Laboratory* acts as a bridge between the theoretical knowledge of the university and practical application. The research results are published at the disciplinary and interdisciplinary levels, notably through **cross publication in journals of other fields**. The **cluster newspaper CZ#** appears weekly with pre-prints, reports and announcements. In addition to **international conferences and workshops**, the academic work of the cluster is presented for discussion in **exhibitions**, notably in a major presentation at the *Martin-Groupius-Bau* in 2016. Design interventions such as **software development**, **tool development** and **experimental architecture** are also a key part of knowledge transfer.

Working experimentally, the project **»Experiment & Observation«** revealed discipline-specific behavioral and perceptual patterns and mindsets in the use of experiments and scientific diagrams, and analyzed their advantages and disadvantages for specific work processes. This approach made it possible to design new forms of interaction, which were subsequently implemented in the Cluster.[17] This project also underlined the need to improve and standardize scientific diagrams through its critical comparison of the conventions used in the various disciplines.[18]

In collaboration with the Technical Division of HU Berlin, the project **»Architectures of Knowledge«** sought to realize an architectural environment that enables successful interdisciplinary and disciplinary research in space, creating diverse work situations adapted to numerous requirements and personal working styles. In other words, throughout its lifespan, the Cluster was simultaneously researching, testing, developing, and changing the infrastructure of the Interdisciplinary Laboratory. Utilizing a wide spectrum of design tools—plans, sketches, diagrams, physical and 3-D models, perspective views, and films—researchers critically applied various scientific methods: observing, questioning, recording, documenting, managing, and writing. Providing researchers with access to the virtual and physical laboratory via user interfaces and services established a flexible connection between the virtual and physical architectures: digitalizing the analog and materializing the digital.[19] Furthermore, thanks to the conceptual insights provided by the project, the floor plans for the Humboldt Labor have been substantially modified to allow an open exchange between the research processes presented and the visitors, who will thus become part of these processes in the spirit of an open laboratory.

As a fundamental result of the Cluster's first phase, the combined approaches of "historicizing and experimenting," "analysis and synthesis," and "materialization and virtualization" became essential components of a complex interdisciplinary research process involving all members of the Cluster. Combined with self-reflection and self-observation, this integrative structure equipped the Cluster to handle the dissonances and to prevent most potential conflicts inherent in interdisciplinary research. The initial projects were exploratory and experimental nuclei that fostered the development of a dense collaborative structure formed of different theories, practices, disciplines, and knowledge cultures: the Interdisciplinary Laboratory including more

---

[17] Hoffmeister, A.-A. (2015) Entwerfen–Verwerfen. Ein reflektierender Werkstattbericht aus dem Interaction Design. In: Bredekamp, H., Schäffner, W., eds. *Haare hören–Strukturen wissen–Räume agieren. Berichte aus dem Interdisziplinären Labor »Bild Wissen Gestaltung«*. Bielefeld: transcript, 159–170. Open access: https://www.degruyter.com/viewbooktoc/product/468481

[18] Godau, C., Gaschler, R. (2015) Wahrnehmung von Datengrafiken. Ein verzerrter Eindruck? In: Bredekamp, H., Schäffner, W., eds. *Haare hören–Strukturen wissen–Räume agieren. Berichte aus dem Interdisziplinären Labor »Bild Wissen Gestaltung«.* Bielefeld: transcript, 79-86.

[19] Busch, C., Kassung, C., Sieck, J., eds. (2017) *Kultur und Informatik: Mixed Reality*. Glückstadt: Hülsbusch. With contributions by C. Müller-Birn, J. Sieck et al.

than 40 disciplines (as shown in Fig. 3. on pp. 24-25). This structure included interdisciplinary reflection and the experimental testing of novel interactions between disciplines as a source of new disciplinary self-determination. It was only by operating on this basis that it was possible to focus the research topics into the five priority areas in the second phase of the Cluster.

2.3.2 Converging phase (2016-2018)

This section describes the priority areas during the Cluster's converging phase and outlines exemplary activities and results.

Priority Area »Image & Action«

Priority area leaders: Prof. Dr. Matthias Bruhn (Art and Media History), Dr. Kathrin Friedrich (Media Studies), Prof. Dr. John A. Nyakatura (Biology), PD Dr. Thomas Picht (Neurosurgery)

Projects: Picture Act and Body Knowledge, Image Guidance, Em•pa•thy, Patient Navigation, Epistemic Reverse Side of Instrumental Images

Selected participating institutions: Charité – Universitätsmedizin Berlin; Zuse Institute Berlin; Weißensee Academy of Art Berlin; Leibniz Center for Literary and Cultural Research; Deutsches Hygiene-Museum, Dresden

Selected collaboration partners: Surgical Planning Laboratory at Harvard Medical School (USA), Department for Thematic Studies - Technology and Social Change at Linköping University (Sweden), Medical Futures Lab at Rice University, Houston (USA)

The priority area »Image & Action« systematically addressed the action-related aspect of visual phenomena, exploring this in relation to the technical means of representing life, the operative role of images in the so-called life sciences, and the autonomous quality or activity of images that is situated between lifelikeness and artificial construction. The priority area investigated perception and the autonomous activity of images (»Picture Act and Body Knowledge«) and specific forms and applications of image technologies that are used to support and guide operations, thus influencing human activities (»Image Guidance«, »Epistemic Reverse Side of Instrumental Images«).[20] With recent technological developments, digital images are increasingly being integrated into mobile, sensor-controlled, augmented visualization systems that operate as

[20] Bredekamp, H. (2017) *Image Acts. A Systematic Approach to Visual Agency* (Image Word Action, 2). Berlin: De Gruyter.

a function of their environment and as adaptive media. The constant spatio-temporal interweaving of visualization, object, and action in the field of surgery produces new opportunities for diagnosis and treatment, but also poses challenges in relation to the perception, interpretation, and design of images, which are increasingly guiding actions and may even determine life-and-death decisions. In the project »Image Guidance«, the wide-ranging consequences of this technological transformation were studied on the basis of examples in surgical planning, training, and intervention, in a collaboration between medicine, design, and media studies. In the projects »Em•pa•thy« and »Patient Navigation«, researchers, designers, and medical doctors worked to achieve the necessary shift from the historical routines still perpetuated in today's clinical practices toward a new patient- and practice-oriented medicine through developing suitable analog and digital tools allowing patients to regain control over their data and to improve their quality of life during treatment. The understanding of the activity of images achieved by the Cluster has led to the development of applications, prototypes, and opened new research questions:

The project **»Picture Act and Body Knowledge«** centered on perception and the autonomous activity of images.[21] Its aim was to understand the conditions of embodied and image-based thinking. The research focused on the human body schema, which forms the basis for the practical handling of materials, artifacts, and motion of the person's own body. In addition to cognitive processes, it also considered subpersonal processes in which the human body is instrumental in the development and perception of form through motor resonance and habitualized influences. In this context, art historians and psychologists empirically tested the motor dispositions needed for the perception of images. The research was based on the approach formulated by the philosopher John Michael Krois that takes perception as an echo sounder and an "affordance" in the interaction between brain, body, gestures, actions, and images/artifacts. In this way, biology's anthropologically and biologically structured body image could be conceptually and experimentally linked with the philosophy of the "extended mind." Through these investigations, the project has experimentally determined the active character of images and the schematic character of body: The images' affordance reveals an activity of their own. This insight amounts to a far-reaching redefinition of culture, which currently regards the world as "a product of our merely limited perception."

[21] Lauschke, M., Schneider, P., eds. (2017) *23 Manifeste zu Bildakt und Verkörperung* (Image Word Action, 1). Berlin/Boston: De Gruyter; 25 volumes in the book series *Actus et Imago*: https://www.degruyter.com/view/serial/235015 and *Image Word Action*: https://www.degruyter.com/view/serial/495390

The project **»Image Guidance«** embedded image guidance as a concept and a process both conceptually and epistemologically within medical practice.[22,23] It explored new possibilities in the relationship between the image and the materiality of the body. The Cluster's network opened up a unique opportunity to study medical imaging and surgical practice at Charité, where a significant chapter of surgical history has been written since the 19th century and where surgeons' day-to-day work today finds them navigating images while actually cutting a physical body. Cluster researchers studied medical imaging as an applied, action-related, and time-critical phenomenon. The central focus was on visualization practices as interfaces between doctor and patient that guide action far beyond the scope of diagnosis, in particular in radiation oncology and surgery.[24,25]

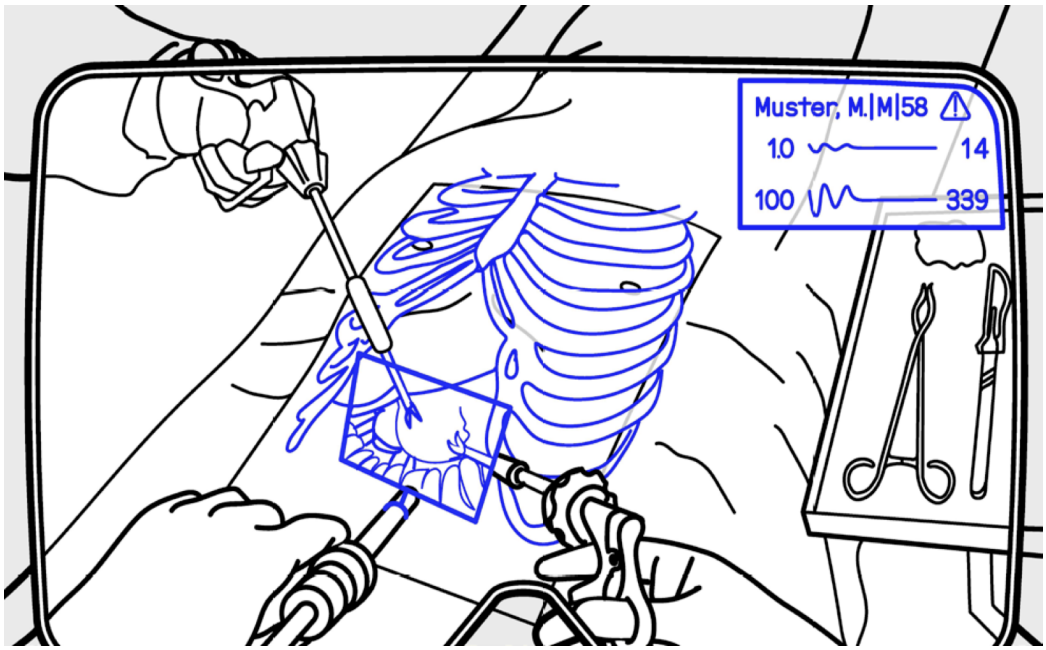


Fig. 4: Minimally invasive surgery. Overlaying the patient's body with the preoperative data set. (Image credits: M. Euler, M. Queisner | *Image Knowledge Gestaltung*)

For example, the interdisciplinary examination of neurosurgical image practices revealed that the assignment of human experience and expertise to imaging technologies can produce undesirable and even adverse effects.[26] Case studies demonstrated that visual media and patterns can actively initiate operations and interventions, and affect various levels (relating to decision-

[22] Friedrich, K., Queisner, M., Roethe, A., eds. (2016) *Image Guidance: Bedingungen bildgeführter Operation. Bildwelten des Wissens*, vol. 12. Boston: De Gruyter.
[23] Bruhn, M., Hillnhütter, S., eds. (2018) *Bilder der Präzision. Praktiken der Verfeinerung in Technik, Kunst und Wissenschaft*. Berlin: De Gruyter.
[24] Feiersinger, L., Friedrich, K., Queisner, M., eds. (2018) *Image–Action–Space: Situating the Screen in Visual Practice*. Boston/Berlin: De Gruyter.
[25] Friedrich, K. (2018) *Medienbefunde: Digitale Bildgebung und diagnostische Radiologie*. Berlin/Boston: De Gruyter.
[26] Friedrich, K., Picht, T., Queisner, M., Roethe, A. (2015) Im Bildlabor der Neurochirurgie. Ein interdisziplinärer bildgeführter Fallbericht. In: Bredekamp, H., Schäffner, W., eds. *Haare hören–Strukturen wissen–Räume agieren. Berichte aus dem Interdisziplinären Labor Bild Wissen Gestaltung*. Bielefeld: transcript, 31–43.

making, psychology, and motor skills).[27] The project analyzed how technically defined forms of visualization remain bound to epistemological conditions and aesthetic and social norms as well as design concepts.

The project **»Em•pa•thy«** (›empowerment of the patient in therapy‹) centered on the question how patients with long-term illnesses and extended treatment plans can be informed, motivated, and supported in a different and more effective way.[28] Rethinking »personalized medicine« and drawing on successful concepts from game design, the project designed an innovative mobile assistance and navigation system for patients with chronic illnesses facing long treatment plans. The app was able to enhance quality of life by adjusting treatment routines to patients' personal needs. Conceived as a modular platform with independent applications, it can be deployed where conventional forms of documentation and support fail while simultaneously making the patient the central focus of the process, for instance in oncological treatment. The interdisciplinary project team involved stakeholders from the field—from health care regulatory bodies and developers to medical staff and patients—in the design of the analog and digital tools. The project **»Patient Navigation«** focused on developing an efficient navigation system for patients using image-guided navigation in and outside of a hospital as the basis for mobility in health care.

The project **»Epistemic Reverse Side of Instrumental Images«** examined instrumental images used for the analysis of human facial expressions with reference to the knowledge that arises in connection with their development. This knowledge, which includes assumptions, proven and unproven concepts, training data sets, and open research questions, is usually not available to the relevant actors. The distance between the researchers and the epistemic and symbolic preconditions of instrumental images for facial expression analysis increases with digitalization.[29] The project linked epistemic and historical knowledge with instrumental images, working with a data bank of the Facial Action Coding System (FACS) at the Zuse Institute Berlin. As the majority of work on facial expression recognition still focuses on 2-D images, a 3-D Mimik-Archiv (facial expression archive) was created using Camera Facialis.[30,31] The project also developed an

---

[27] Moosburner, S., Remde, C., Tang, P., Queisner, M., Haep, N., Pratschke, J., Sauer, I. M. (2018) Real world usability analysis of two augmented reality headsets in visceral surgery. *Artificial Organs,* 43 (7), 694-698. https://doi.org/10.1111/aor.13396
Sauer, I.M., Queisner, M., et int, Pratschke, J. (2017) Mixed reality in visceral surgery: Development of a suitable workflow and evaluation of intraoperative use-cases. *Annals of Surgery*, 266 (5): 706–712. https://doi.org/doi:10.1097/SLA.0000000000002448

[28] Preisler, M., Rohrmoser, A., Goerling, U., Kendel, F., Bär, K., Riemer, M., Heuse, S., Letsch, A. (2019) Early Palliative Care for Those Who Care: A Qualitative Exploration of Cancer Caregivers' Information Needs during Hospital Stays. *European Journal of Cancer Care* 28 (2): e12990. https://doi.org/10.1111/ecc.12990

[29] Weigel, S.; Deutsches Hygienemuseum Dresden, eds. (2017): *Das Gesicht: Bilder–Medien–Formate*. Exhibition catalog. Deutsches Hygiene-Museum Dresden. Göttingen: Wallstein.

[30] https://www.zib.de/projects/digital-facial-morphology

[31] http://www.zib.de/projects/camera-facialis

interactive installation, the MIMIK-Explorer, designed as a platform for showcasing the research results from the project. The platform was based on game-oriented interaction design allowing to open it up to a wider audience, including young people. The MIMIK-Explorer was exhibited at the Cluster exhibition »+ultra. knowledge & gestaltung«, at »The Face. A Search for Clues« in the Deutsches Hygiene-Museum, Dresden, and at »Faszination Gesicht – Was unsere Mimik alles zeigt« in the Vögele Kultur Zentrum, Pfäffikon, Switzerland.

The priority area »Image & Action« provided vital insights into how visual practices have emerged and how they could be changed in essential fields of medical application. Moreover, the studies addressed the question of how specific disciplinary training in visualization should be adapted to new modes of display such as augmented and multimodal image outputs or 3-D modeling techniques (e.g. in medical tractography) that expand sensory and spatial experience. The application-oriented perspective followed by this priority area—which went beyond conventional product-oriented research—fostered theoretical analyses, allowed for practical testing, and made it possible to feed the concepts and practical solutions back into research, teaching, and practice of the disciplines involved. The priority area contributed significantly to the development of a modern imaging curriculum for medical students[21] and to the planning of the Berlin Simulation & Training Center (BeST) at Charité. From 2019, the interdisciplinary network of researchers established by the priority area has also continued to work on joint projects in the Cluster of Excellence *Matters of Activity*.

Priority Area »Process of Form and Modeling«

Priority Area Leaders: Prof. Dr. Claudia Blümle (Art and Image History), Prof. Dr. Gerhard Scholtz (Biology), Prof. Dr. Sabine Thümmler (Art History), Dr. Sandra Schramke (Architecture) / Dr. Angelika Seppi (Philosophy and Art History)

Projects: Dynamic Form, Matter of Typography, Form Code Milieu, Visual Gestaltung of Time, Forms and Styles of Commands

Cluster Professorships: Morphology and History of Forms (Prof. Dr. John A. Nyakatura), History and Theory of Form (Prof. Dr. Claudia Blümle)

Selected participating institutions: Kunstgewerbemuseum Berlin **(**Museum of Decorative Arts); Museum für Naturkunde Berlin – Leibniz Institute for Evolution and Biodiversity Science

Selected cooperation partners: Gutenberg Museum Mainz; École Polytechnique Fédérale de Lausanne (EPFL), Lausanne (Switzerland); International Research Center for Cultural Studies, University of Art and Design Linz, Vienna (Austria)

The priority area »Process of Form and Modeling« focused on the various conditions and processes for the development and modification of form in nature and culture, as well as the relationship between form and model. It placed special emphasis on intrinsic and extrinsic design factors and their functional and historical conditionality. The priority area analyzed the characteristics of forms and the conditions for their emergence, as well as exploring the interactions between form, its materialization and perception. Its knowledge transfer activities included exhibitions organized and curated by early career researchers, for instance »Form Follows Flower«,[32] »OROBATES. Reanimated after 300 million years«,[33] »Zoology in Pictures – Wall Charts of the Zoological Study Collection«.[34] The following projects illustrate the wide scope of research activities conducted in the priority area:

The project »**Dynamic Form**« emerged from the projects »Genesis and Genealogy« and »Attention & Form« from the Cluster's first phase and studied the dynamics and transformation of forms in natural objects and artifacts. These transformation processes present a multifaceted challenge to design, the natural sciences, and the humanities. How can processes such as growth and evolution be creatively reproduced and analyzed in charts, models, or diagrams? To what extent can a transformation of form and its transitions provide a basis for classifications, or indeed call classificatory order into question? Adopting an interdisciplinary approach, the project analyzed the shared areas of interest in transformation processes in objects and in methods. It studied the genesis of forms and their perception alongside evolutionary and cultural historical processes.

Comparing forms is an implicit yet highly complex procedure of daily practice in scientific analysis; to provide the necessary diversity of perspectives, a critical analysis of the methods was therefore conducted by researchers from biology, art, media and literature, medicine, criminalistics, psychology, and mathematics.[35] Their common starting point was the universal significance of the perception, description, and order of forms. Using methods established from the recognition of human faces and simple shapes, research conducted by biologists and

[32] Nikolai, A., Thümmler, S., eds. (2017) *Form Follows Flower. Moritz Meurer, Karl Blossfeldt und Co*. Exhibition Catalogue. Kunstgewerbemuseum–Staatliche Museen zu Berlin. Deutscher Kunstverlag, Berlin. https://www.smb.museum/ausstellungen/detail/form-follows-flower.html

[33] Lessing, J., Orlikowski, M., Nyakatura, J. A., Sattler, F., eds. (2017): *Orobates. Nach 300 Millionen Jahren reanimiert.* Exhibition Catalogue Veterinary Anatomy Theater, Humboldt-Universität zu Berlin. Berlin: BWG.

[34] Curated by G. Scholtz. Berlin: Veterinary Anatomy Theater (2019) https://www.interdisciplinary-laboratory.hu-berlin.de/en/content/zoologie-bildern-die-wandtafeln-der-zoologischen-lehrsammlung/

[35] Bruhn, M., Scholtz, G., eds. (2017) *Der vergleichende Blick: Formanalyse in Natur- und Kulturwissenschaften*. Berlin: Dietrich Reimer Verlag.

psychologists revealed that object representations of animal categories are influenced by previous perceptual information and result in adaptation aftereffects. The complexity of the visual information determines the magnitude of the adaptation aftereffects. The results indicated a high degree of flexibility in the mental representations and in the processing of representations of natural zoological specimens. Crabs and lobsters were taken as ideal objects of research as they do not allow for clear categorization due to their close phylogenetic relationship and great morphological diversity.[36]

In the project **»Matter of Typography«**, the digital and the material were interconnected by exploring typography as a cultural technique that structures symbols as both carriers of meaning and material objects. Symbols only become carriers of meaning at particular sites, which are negotiated very differently depending on the cultural context. Typography was therefore understood as a material culture of symbol distribution. »Matter of Typography« was a response to the current notion that the analog has been marginalized in the design of our culture's essential symbols—images, writing and numbers are all becoming digital. The project examined digital typography in its complex milieu of writing and text versus 3-D printed material and printing inks, and situated it alongside the printing process in the context of industrial development and mechanical engineering history with its radical cultural and social changes, such as phototypesetting and typographic forms and grids. Taking Bauhaus typography as an example of fluid branding *avant la lettre*, the project examined which actors were involved in the co-productive shaping of typographical form and in which roles, how the available hardware influences this process, and how it foregrounds relationships in shifts of meaning.[37]
Taking phototypesetting in the 1950s as a further example, the relationship between typography and light was investigated as one of interdependent and formative interaction by reconstructing its technical, media, and design process.[38] The conferences »Transformationen des Buchdrucks« (2016, 2018) in cooperation with the historic typeface foundry and letterpress workshop Offizin Haag-Drugulin and Verein für die Schwarze Kunst brought together diverse perspectives from research and application, and served as forum for discussions on the transformations of book printing. A central question here was why and how the practices and aesthetics of letterpress printing techniques still shape design practice in both analog and digital applications.

---

[36] Reindl, A., Schubert, T., Strobach, T., Becker, C., Scholtz, G. (2018): Adaptation aftereffects in the perception of crabs and lobsters as examples of complex natural objects. *Frontiers in Psychology*, 9, 1905. DOI:10.3389/fpsyg.2018.01905
[37] Meer, J. (2016) Neuer Blick auf die Neue Typographie. Die Rezeption der Avantgarde in der Fachwelt der 1920er Jahre. Bielefeld: transcript.
[38] Walter, K. (2019) Letters in the light. A media-historical approach to phototypesetting and its telegraphic antecedents. *Journal of the Printing Historical Society*, New Series 31 (in print).

The group led by the Cluster professorship »**Morphology and History of Forms**« studied form-function relationships and the evolution of vertebrates while reflecting in parallel upon this research process with a focus on the use of images in the production and dissemination of new knowledge. In cooperation with EPFL Lausanne, Friedrich Schiller University Jena, and the Royal Veterinary College London, the project sought to further understanding of the locomotion of a critical early land-living vertebrate. The group integrated methods from various disciplines, such as computer tomography, 3-D modeling and printing, and biomechanical analysis of current animals. The fossil and its movement were first digitally reconstructed[39] and then recreated as a physical walking machine, the OroBOT[40] (Fig. 5). The team systematically involved scientific illustrators in the research process, and new visual tools for the analysis of the fossil were developed.[41] With this interdisciplinary approach, the project demonstrated the analytical potential of scientific illustrations in the context of organismic biology, an aspect that was also studied from an epistemic and historical perspective.[42] In 2017, the international workshop »Knowledge needs *Gestaltung*—the role of scientific illustrations in knowledge processes« revived the role of a scientific illustrator as an essential member of the research process. Alongside this research, the role of images in the characterization of the form-function interface was constantly monitored and studied on an ongoing basis in order to maximize the potential benefits for future projects from the interdisciplinary teamwork. The exhibition »OROBATES. Reanimated after 300 million years« in the Veterinary Anatomy Theater (2016/2017) evolved around the question of how an early reptile moved 300 million years ago and how its movement can be reconstructed today. The exhibition presented original finds from the skeleton, models, x-ray footage, animations, a life-sized reptile robot, and an interactive archive of the critical history of the research process. OROBATES was curated and designed by an interdisciplinary team of students. In 2020, this working group's findings and their research process will be presented within the Humboldt Forum, thereby reaching a large audience outside academia.[43]

[39] Nyakatura, J. A., et al. (2015) A three-dimensional skeletal reconstruction of the stem amniote *Orobates pabsti* (Diadectidae): Analyses of body mass, centre of mass position, and joint mobility. *PloS one*, *10*(9), e0137284
[40] Nyakatura, J. A., et al. (2019) Reverse-engineering the locomotion of a stem amniote. *Nature* 565, 351355, http://dx.doi.org/10.1038/s41586-018-0851-2; https://www.nature.com/articles/d41586-019-00186-x
[41] Nyakatura, J. A. (2017) Description, experiment, and model: Reading traces in paleobiological research exemplified by a morpho-functional analysis. In: Bock von Wulfingen, B., ed. *Traces. Generating What Was There*. Berlin/New York: De Gruyter, 15-28.
[42] Amelung, K. M. (2019) Illustration: On the epistemic potential of active imagination in science. In: Male, A., ed. *A Companion to Illustration: Art and Theory*. Oxford: Wiley-Blackwell, 330-353.
[43] https://www.humboldtforum.org/en/pages/orobates-pabsti

Fig. 5: OroBOT is a physical replica of the stem amniote *Orobates pabsti*.
(Image credits: J. A. Nyakatura | *Image Knowledge Gestaltung*)

The Cluster professorship »**History and Theory of Form**« was dedicated to the analysis of visual forms and their historical, aesthetical, philosophical, culture- and media-theoretical contextualization. Focusing on the technical and material conditions of image and design processes, in particular on their respective interplay of showing and hiding,[44] as well as on the epistemic-historical implications of the notion and practice of form,[45] it culminated in an integrative approach toward the production and perception of artistic and scientific visual forms. The resulting aesthetics of form not only crosses the boundaries between art and design theory, history of science, philosophy, culture and media theory, but also closely linked the German and French research landscapes.[46] The Cluster professorship »History and Theory of Form« also developed the two seed-funding projects »Visual Gestaltung of Time« and »Form Code Milieu«:
The seed-funding project **»Visual Gestaltung of Time«** studied the paradigm shifts in conceptions of time in aesthetic modernity that were triggered by the creative and artistic avant-gardes on the one hand and diverging concepts of time in the natural sciences and the humanities on the other. The project studied the development of new visual concepts of time and focused on their potential to enrich and differentiate our access to the phenomenon of time and their significance for our relationship with time. Historical contextualization enabled the

[44] Blümle, C. (2019) *Schauspiele des Halbversteckten. Eine Bildgeschichte des gemalten Vorhangs*. Paderborn: Fink.
[45] Seppi, A. (2018) *Schrift und Gerechtigkeit. Kritisches zur Metaphysik*. Vienna: Passagen Verlag; Seppi, A. (2017): A line is not a line is not a line. From the capital line of metaphysics to a future ontology of the fold. In: Dorsch, S., Jutta V., eds. *SpatioTemporalities on the Line. Representations–Practices–Dynamics*. Oldenburg: De Gruyter.
[46] Blümle, C., Drews, A.-C. et al., eds. (since 2012) *Regards croisés. Deutsch-französisches Rezensionsjournal für Kunstgeschichte und Ästhetik*. https://www.revue-regards-croises.org/

identification of the preconditions under which different, divergent concepts of time and their visual *Gestaltung* influence scientific representations, visual and media designs, and artworks.[47]
In the seed-funding project **»Form Code Milieu«**, form, code and milieu–as three key concepts that relate to very different contexts–were investigated and situated within a critical intellectual history, to uncover their interrelationships and link them with contemporary approaches towards an ecologically informed theory of image, thought and space. In an interdisciplinary dialogue between philosophy, biology and physics, mathematics, and the history of art, media and technology, the project analyzed these three concepts with the focus on their historical genesis on the one hand and its relevance to current research contexts on the other. More specifically, two main lines of investigation were followed: one analyzing and historizing the limits of form and formalization from Leibniz to Lacan and thus combining form and code more closely; the other one aimed at a techno-aesthetical approach of the notion of the milieu.

Closely linked to the analysis of time was another seed-funding project, **»Forms and Styles of Commands«**, which proposed that commands should be viewed as cultural techniques that seek to activate and realize their physical or mechanical implementation, thereby modeling time as a sequential process. The project's goal was to develop a theory of commands that is grounded in sensory and media history so as to provide a framework for the description and comparison of these time-modelling processes. It focused on three areas: military and bureaucratic organization, the rearing and training of children and animals, and programming machines.

Through the research of this priority area, the focus on the evolution and perception of form shifted further to the form-function relationship and the concept that material structure can serve as a foundation for form and function emerged. The latter concept is being further developed in the project »Material Form Function« by the Cluster of Excellence *Matters of Activity*.

Priority Area »Active Matter«

Priority Area Leaders: Prof. Dr. Dr. h. c. Peter Fratzl (Materials Science), Dr. Michael Friedman (Mathematics), Dr. Karin Krauthausen (Literature Studies), Prof. Dr. Wolfgang Schäffner (Cultural History and Theory)

Projects: Science of Structures & 3-D Code, Self-Moving Materials, Architecture and Morphogenesis of Biofilms, Gender Rhizome

[47] Blümle, C., Mareis, C., Windgätter, C., eds. (2020) *Visuelle Zeitgestaltungen*. v 15. Bildwelten des Wissens. Kunsthistorisches Jahrbuch für Bildkritik, Berlin: De Gruyter; Huss, T. J. (2019) *Ästhetik der Metapher. Philosophische und kunstwissenschaftliche Grundlagen visueller Metaphorik*. Bielefeld: transcript.

Cluster Professorship: History and Theory of Gestaltung (Prof. Dr. Patricia Ribault)

Selected participating institutions: Max Planck Institute of Colloids and Interfaces, Potsdam; Anhalt University of Applied Sciences, Dessau

Selected cooperation partners: Wyss Institute for Biologically Inspired Engineering, Cambridge, MA (USA); FHNW Academy of Art and Design, Basel (Switzerland); Institut de Recherche et d'Innovation, Centre Georges Pompidou, Paris (France); École Nationale Supérieure des Arts Décoratifs, Paris (France); École Nationale Supérieure de Création Industrielle, Paris (France)

The research focus of »Active Matter« has advanced the analysis of structures toward an operative understanding of materials, which thereby exhibit all the qualities of the immaterial that have historically not been attributed to them. The history of activity and passivity in the context of materials is fundamentally linked to gender difference. The modern concept of activity evolved with the dichotomous understanding of gender, with masculinity becoming associated with activity, and femininity becoming a symbol of passivity. By shedding light on this background, the **»Gender Rhizome«** project formed a transversal connection between several priority areas. The research priority area conducted disciplinary and interdisciplinary experiments and studies on folding as an active material structure and analyzed the structure-material and code-material dualism. The project »Science of Structures & 3-D Code« investigated the extent to which structure-function relationships can be viewed as code elements for folding processes that both represent and realize their function as an operational characteristic. Through nano-, micro-, and macroscopic investigations, the project »Self-Moving Materials« analyzed movement and filter functions of self-moving materials, such as plant seeds and marine invertebrate animals, whereas the project »Architecture and Morphogenesis of Biofilms« revealed that folding is a general principle of structure building in bacterial biofilms and for the first time discovered naturally produced chemically modified cellulose.

Through the research in the project **»Science of Structures & 3-D Code«**, the Cluster has opened up folding as a new field of interdisciplinary research.[48] The joint studies have paved the way for a new understanding of folding as an operative three- and four-dimensional (3-D, 4-D) code and for a redefinition of "code" as the description of a nonlinear process of form genesis. The operation of folding was understood as a geometric paradigm for the emergence of spatial

[48] Schäffner, W., Friedman, M., eds. (2016) *On Folding. Towards a New Field of Interdisciplinary Research.* Bielefeld: transcript; Friedman, M., Seppi, A., eds. (2017) *Martin Heidegger: Die Falte der Sprache*. Vienna/Berlin: Turia + Kant; Friedman, M. (2018) *A History of Folding in Mathematics: Mathematizing the Margins* (Science Networks. Historical Studies, 59). Basel: Birkhäuser.

structures, which were studied jointly by the Cluster's experts in mathematics, philosophy, cultural studies, and materials science. Folding in nature was examined as a process by studying plant movement, tissue growth, and bacterial biofilms. The priority area further developed the ideas of soft, self-moving devices; through the geometric design of the shape and tiling of the constituent structural units, control of the actuation of cellular materials subjected to positive internal pressure was achieved, which is relevant for the development of soft robotics. The key conclusion reached was that the movement of natural systems and synthetic structures can be programmed through purely geometric, scale-independent design rules.[49,50] While research on biomaterials assumes no distinction between elements and materials in nature, architecture is genuinely concerned with the distinction between structural construction and construction materials. This contradistinction between the working methods and strategies of materials research and architecture was eradicated by experimenting with two- and three-dimensional models. The laws of transference, which depend on the respective observation of scales and are found in the parameters of the material itself, were systematically elucidated to establish new strategies for sustainable energy conservation on a theoretical and practical level. Furthermore, findings on responsive self-unfolding and self-propelling seed capsules may not only have great relevance for the development of biomimetic actuators, but also for elucidating the species' capacity to cope with climatic changes.[51,52]

The project **»Self-Moving Materials«** examined the functional mechanisms and structural coherence of the complex filigree filter shells of tunicates versus those of architectures, machines, and other biological systems. It addressed the question of how the spatial allocation of structures can encode functional movement through testing experimental microscopic processes, digital and mathematical modeling of physical parameters, and by exploring parallels from cultural history. The intrinsic code of the structures, as documented and analyzed in images, was subjected to the synthetic statements of various processes situated in the extrinsically coded worlds. The theoretical and historical analysis of similar cultural techniques enabled the project to focus on the relationship between the code and material of dynamic structures that blur the boundaries between natural and cultural processes. Through nano-, micro-, and macroscopic investigations of self-moving materials, the project analyzed their dynamic structures and

[49] Guiducci, L., Weaver, J.C., Bréchet, Y.J., Fratzl, P., Dunlop, J.W., (2015) The geometric design and fabrication of actuating cellular structures. *Advanced Materials Interfaces* 2, 1500011. DOI: 10.1002/admi.201500011
[50] Jayasankar, A. K., Seidel, R., Naumann, J., Guiducci, L., Hosny, A., Fratzl, P., Weaver, J. C., Dunlop, J. W.C., Dean, M. N. (2017) Mechanical behavior of idealized, stingray-skeleton-inspired tiled composites as a function of geometry and material properties. *Journal of the Mechanical Behavior of Biomedical Materials* 73, 86-101.
[51] Guiducci L, Razghandi K, Bertinetti L, Turcaud S, Rüggeberg M, Weaver JC, et al. (2016) Honeycomb actuators inspired by the unfolding of ice plant seed capsules. *PLoS ONE* 11(11): e0163506. https://doi.org/10.1371/journal.pone.0163506
[52] Huss, J. C., Schoeppler, V., Merritt, D. J., Best, C., Maire, E., Adrien, J., Spaeker, O., et al. (2018) Climate-dependent heat-triggered opening mechanism of Banksia seed pods. *Advanced Science* 5 (1): 1700572. https://doi.org/10.1002/advs.201700572

movement functions, and reflected on their possible applications in architecture. For instance, *Oikopleura dioica*, a tunicate, produces one of the most complicated filter houses in the animal kingdom. The tunicate lives inside it, uses it to feed itself, moves with it through the oceans and can rebuild it at any time. Modern microscopic technologies were used to study the architecture of its delicate structure and design digital models of the rudimentary and functional condition of its house.[53]

The intertwined analysis of natural and cultural processes of *Gestaltung* in the autonomous activity of materials necessitated a fundamental reflection upon *Gestaltung* and its integrative potential. The group led by Cluster Professor Patricia Ribault, **»History and Theory of Gestaltung«**, therefore examined the main theoretical core of *Gestaltung*, *Entwerfen*, and design processes. This constituted a theoretical and historical level for further in-depth research on the body and technique, the ontology of the arts and crafts, the logic of design processes, and a study of geniuses of the arts and crafts, involving concepts from the spheres of design, art, techniques, engineering design, and philosophy. As a reflection upon art and design techniques, "bricology" combines knowing and *making*, offering some productive and broad perspectives for various humanities disciplines.[54] The group also investigated camouflage as an exemplary process of cultural and natural *Gestaltung*.[55]

The priority area »Active Matter« developed a concept that information defining a material's behavior could be encoded directly into its internal structure rather than being imposed from outside.[56] The diversity of functions in nature emerges from the structural complexity (Fig. 6). Regarding material on its own as code represents a fundamental change of analysis: A special focus was placed on the relationship between intrinsic and extrinsic code in the context of active materials that play a key role in materials research today. One of the priority area's key challenges was to describe encoded material and the surrounding conditions as a mechanical, energetic, and informational structure.

---

[53] Jany S. & Razghandi K. (2020) Filterarchitektur als Modell: Eine Interdiziplinäre Auseinandersetzung mit dem Manteltier Oikopleura Dioica. In: Krauthausen, K. and Ladewig, R., eds. *Typologie der Hütte*, Diaphanes Verlag.
[54] Ribault, P. (2016) Comment *faire*? La technique comme pouvoir. In: Golsenne, T., Ribault, P., eds. Essais de Bricologie. Ethnologie de l'art et du design contemporains*. Revue Techniques et Culture* 64, Paris: éditions EHESS, 32-45.
[55] Alexandre, P., Jouannais, J-Y., Ribault, P., Semin, D., eds. (2020) *Art & Camouflage*. Paris: Beaux-Arts de Paris Edition.
[56] Schäffner, W. (2017) Active Matter. In: Lauschke, M., Schneider, P., eds. *23 Manifeste zu Bildakt und Verkörperung. Image Word Action.* De Gruyter, Berlin, 1–9.

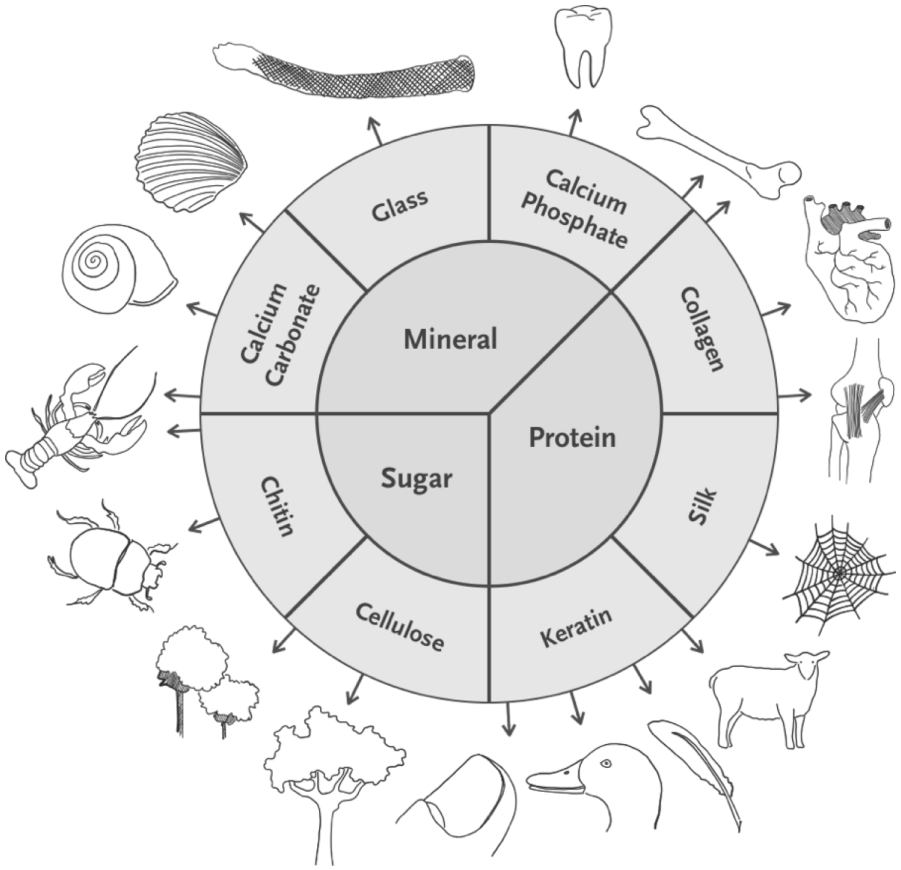


Fig. 6: Functional diversity in nature based on varieties of structures built from polysaccharides, proteins, and minerals. (Image credits: P. Fratzl and J. Blumenthal | *Image Knowledge Gestaltung*)

Taking these findings one (radical) step further, the future aim should be to use structural complexity to build devices with minimal chemical diversity, thereby significantly facilitating recycling and enabling more sustainable use of recourses.[57] Further developing this revolutionary concept is one of the major aims of the Cluster of Excellence *Matters of Activity. Image Space Material*, which commenced work in January 2019: The Cluster sets out to establish a new structural science as a research field within the humanities, natural and materials sciences, and design.

Priority Area »Architectures of Knowledge«

Priority Area Leaders: Dr.-Ing. Michael Dürfeld (Architecture), Prof. Dr. Claudia Müller-Birn (Human-Centered Computing), Prof. Dr. Wolfgang Schäffner (Cultural History and Theory), Dr. Christian Stein (Informatics and Linguistics)

[57] Eder, M., Amini, S., Fratzl, P. (2018) Biological composites—complex structures for functional diversity. *Science* 362, 543–547. DOI: 10.1126/science.aat8297

Projects: ArchitecturesExperiments, gamelab.berlin, ID+Lab, Hybrid Knowledge Interactions, Experimental Systems, Analog Storage Media. Auralization of Archaeological Spaces, Gender Rhizome

Selected participating institutions: Freie Universität Berlin**;** Technische Universität Berlin

Selected cooperation partners: Deutsches Archäologisches Institut, Berlin; Rice School of Architecture at Rice University, USA; Nolgong, USA/South Korea; Centro Internacional de Diseño del Conocimiento "Tomás Maldonado," Argentina

The priority area »Architectures of Knowledge« built on the preliminary work conducted by research area D »Designing Interdisciplinarity« during the Cluster's first phase concerning the analysis and design of knowledge spaces and architectures. The central focus of the priority area was the experimentalization and design of spaces and processes in interdisciplinary research with the aim of interlinking knowledge procedures with space. The priority area's projects have examined the operational and active character of spaces as well as processual knowledge architectures in physical and virtual contexts. More specifically, researchers from architecture, computer sciences, interaction design, and cultural and media history and theory have jointly analyzed research spaces in which scientific practices take place, gender differences in spatial performance, forms of visibility in physical and virtual spaces as well as collaborative forms of working and interactive spaces. In doing so, the priority area has addressed a central challenge of the "spatial turn"—namely the interlinking of an operational space with actors' knowledge practices.

A key instrument and output of the priority area was the creation of a lab for architectural experimentation—the Experimental Zone—within the Cluster's research building. The Experimental Zone combined both physical and virtual spaces, which could be adapted according to the users' needs and the research aims. In this sense, the Experimental Zone represented a "living" and "adapting" architecture that learned from the actors and processes. At the same time, it was a spatial instrument with integrated sensors and a room for ethnological observations. In line with the strict regulations in the field of data privacy, the priority area developed ways of carefully anonymizing its data, making it impossible to decode personal data. This careful design enabled a novel self-reflective study of interdisciplinary research processes and their architectural spaces. The following projects give an insight into the broad spectrum of research activities and outputs.

The project **»ArchitecturesExperiments«** examined the relationship between space and collaborative research processes. What is space in a comprehensive, integrative sense? How do

physical, digital, social, and cultural spaces shape our actions, knowledge, and communications? Which principles can be used as a basis for creating and modeling spaces of interdisciplinary research? In order to answer these questions, forty researchers from various disciplines conducting their own research in various room configurations decided to become the subject of observation themselves and to simultaneously be active participants in the observation process. The 300 m^2 Experimental Zone enabled a collaborative experimental setup in which design interventions and room configurations were combined with hybrid methods of data collection and evaluation,[58] turning space itself and forms of collaboration into the subjects of experimentalization. The Experimental Zone was therefore used for two completely different approaches: as a tool for architectural design but also as a tool for ethnographic observation. The procedural modeling tool *Modellapparat* was developed; this enabled the design of experimental settings, live data visualization, examination of the data in its three-dimensional context, and data analysis. In response to the methodological challenges of conducting ethnographic observations in the Experimental Zone, the software prototype »*empiric.assemblage«* was developed in order to facilitate digital ethnographic data collection and to enhance the collected data.[59] The project »ArchitecturesExperiments« also built upon the preliminary research conducted by the project »Experiment & Observation« in the Cluster's first phase by investigating the types and spaces of experimental cultures in different disciplines. Researchers from 23 disciplines of science and design reported on their perception of experimentation and provided insights into their practices and experimental setups. The results formed the basis for an anthology of contemporary experimental cultures in science and design that outlines a comparative praxeology of the experiment.[60] On a general level, the project »ArchitecturesExperiments« contributed to spatial research, workplace studies, and science and technology studies by identifying the characteristics of collaborative habitats in academia.

[58] Marguin, S., Rabe, H., Schmidgall, F. (2019) *Experimental Zone. An Interdisciplinary Investigation on the Spaces and Practices of Collaborative Research*. Zürich: Park Books.
[59] Hoffmeister, A., Marguin, S., Schendzielorz, C. (2018) Feldnotizen 2.0. Über Digitalität in der ethnografischen Beobachtungspraxis. In: Huber, M., Krämer, S., eds. *Wie Digitalität die Geisteswissenschaften verändert: Neue Forschungsgegenstände und Methoden.* ZfdG, 3. DOI: 10.17175/sb003_007
[60] Marguin, S., Rabe, H., Schäffner, W., Schmidgall, F., eds. (2019) *Experimentieren. Einblicke in Praktiken und Versuchsaufbauten zwischen Wissenschaft und Gestaltung*. Bielefeld: transcript. DOI: 10.14361/9783839446386-toc

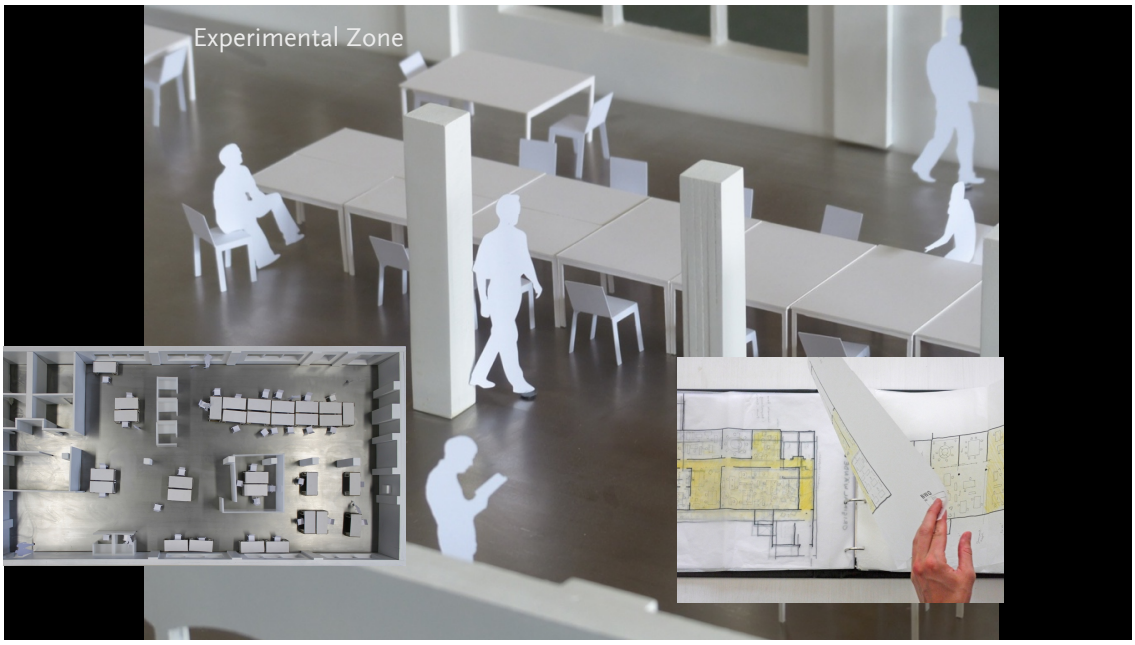


Fig. 7: Experimental zone within the Cluster's forth floor (Image credits: *Image Knowledge Gestaltung*)

The Cluster considered the design of interdisciplinarity as a research challenge in its own right. A key challenge for the priority area »Architectures of Knowledge« was not only to explore collaborative research processes but also to create digital tools that facilitate interdisciplinary and collaborative ways of working. The following three projects have explicitly contributed towards generating virtual and collaborative architectures of knowledge:

The project **»gamelab.berlin«** was initiated by early career researchers in the Cluster and investigated the possibilities and limits of the cultural technique of gaming[61] while simultaneously developing and designing serious games to generate and transfer knowledge. By linking university research and practical game design, the project opened up entirely new dimensions in the interaction between theory and practice and between gaming and knowledge production. It developed a number of prototypical applications with a focus on virtual reality and games for museums and hospitals. For instance, the project developed an app-based game for the Cluster exhibition »*+ultra. knowledge & Gestaltung«,* which fostered a more intense exploration of the exhibits. The project also developed a prototype of the tool *iWrite*, which uses current findings from motivation research to facilitate writing processes.[62]

[61] Lilge, T., Stein, C., eds. (2018) *Spielwissen und Wissensspiele. Wissenschaft und Game-Branche im Dialog über die Kulturtechnik des Spiels.* Bielefeld: transcript 2018; http://www.gamelab.berlin/en/home__en/
[62] http://iwrite.de/index.php/en/

The project **»ID+Lab«** centered on modeling interdisciplinary research contexts. [63] It started from the premise that descriptions of interdisciplinary research should account for the variety of specific actors and their relationships to each other. Taking the Cluster *Image Knowledge Gestaltung* as an example, relevant types of actors and relationships as well as modeling rules were included into the descriptions. This method was then transformed into a digital modeling tool—the »ID+App«—allowing researchers to model their own research contexts. The process of modeling enabled researchers to gain new insights into their own work as it renders explicit links to other research fields or researchers. The modeling tool was also integrated into the »ID+Stage«—a publishing platform for interdisciplinary research projects that also enables the publication of results that are valuable but not relevant in discipline-specific contexts, e. g. genesis of the project. With these outputs, the project modeled knowledge production processes while simultaneously offering in-depth insights into the operation of interdisciplinary research. Tests with relevant groups—such as the first cohort from the master's program »Open Design«—provided important empirical feedback on the modeling process.

The project **»Hybrid Knowledge Interactions«** explored the possibilities for collaborative research processes situated in the field of tension between physical and digital interaction.[64] One of its central goals was to provide simultaneous access to spatially distant physical knowledge objects and to develop novel modes for collaboratively investigating them. The project therefore developed the tool *process.annotator*,[65] which is integrated in a work environment that seamlessly connects interaction with physical and digital objects and grants all actors in the work process direct access to the research object with the greatest possible degree of autonomy. Annotations, understood as a form of object-centered organization of knowledge, form the connecting link between physical and virtual spaces. They engage the knowledge processes of the actors (persons and tele-agents) participating in the research process and thereby produce a shared, object-centered platform of understanding.[66] For researchers, the joint annotation process opened up the opportunity to produce shared knowledge structures directly linked to an object. The technical implementation of the prototype provided guidance for the design of a collaborative research environment.

---

[63] Dürfeld, M., Schultz, A., Stein, C., Thomack, B., Zeissig, N. (2018) ID+Lab - Analyzing, Modeling and Designing Interdisciplinarity. In: Nuria Rodríguez-Ortega (coord.). "Digital Humanities: societies, policies and knowledge". *Artnodes*. No. 22: 34-47. UOC. http://doi.org/10.7238/a.v0i22.3214; http://www.idpluslab.de/idplusmodel.html

[64] Hong, M.-T., Benjamin, J. J., Müller-Birn, C. (2018) Coordinating agents: Promoting shared situational awareness in collaborative sensemaking. In: *Companion of the 2018 ACM Conference on Computer-Supported Cooperative Work and Social Computing (CSCW '18)*. New York, NY: ACM, 217-220; Mackeprang, M., Khiat, A., Müller-Birn, C. (2018) Concept validation during collaborative ideation and its effect on ideation outcome. In: *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems.* New York, NY: ACM, Paper LBW033.

[65] http://forschungskreis.com/project/process-annotator/

[66] Hoffmeister, A., Berger, F., Pogorzhelskiy, M., Zhang, G., Zwick, C., Müller-Birn, C. (2017) Toward cyber-physical research practice based on mixed reality. In: Burghardt, M., Wimmer, R., Wolff, C., Womser-Hacker, C., eds. Mensch und Computer 2017 - Workshopband. Regensburg: Gesellschaft für Informatik e.V.

The question of the relationship/interaction between experiment and interdisciplinary collaboration also formed the focus of the project **»Experimental Systems«**. This project established a close collaboration between cultural history and theory and theoretical and experimental physics, which jointly investigated specific systems, focusing on how knowledge production takes place, is promoted, or hindered. Focusing on experimental systems as spaces of knowledge by combining both theoretical and experimental, abstract and material processes, theoretical physics of space, time and matter, and experimental physics of macromolecules provided the starting point for a close collaboration that was the first of its kind. Taking theory as a special form of experiment on paper performed using the cultural techniques of calculating, drawing, and writing, cultural history not only mediated and thus reshaped research in physics, but also created a fundamental collaborative axis between the humanities and the sciences. The construction, performance, and documentation of experiments and the associated formulation of theories are elements of a historical development that can only be understood and examined in their wider cultural context and then finally be fed back into physics again. The project analyzed case studies with an interdisciplinary approach, applying perspectives from anthropology, historiography, design, mathematics, philosophy, and physics.[67] The project members set up a permanent interdisciplinary discussion group and authored a number of publications, including on gravitational waves, image generating procedures at CERN, and the theory of relativity. They also developed the *Cube of Physics*, a spatial model of the architecture of physics that makes it possible to discuss physical theory formation as a walk-in octahedron in the foyer of the Department of Physics at HU Berlin.[68]

Architectural spaces and their active usage were also experimentalized in the historical context of ancient Greece and Rome. In the project **»Analog Storage Media. Auralization of Archaeological Spaces«**, classical archaeology, cultural and media studies, and audio communication came together to jointly investigate acoustics as a historical factor.[69] The project developed an experimental setup for investigating historical spatial constellations. Based on the Roman Forum and the Pnyx in Athens, the public and political centers of life in ancient Rome and Greece, “live” models of the plazas were reconstructed. Acoustic simulations and auralizations were used to explore the sensory experiences of political speeches in ancient public squares, making it possible to reconstruct and analyze the acoustics of different speakers’ platforms for

[67] Dippel, A. (2017) Das Big Data Game. Zur spielerischen Konstitution kollaborativer Wissensproduktion in der Hochenergiephysik am CERN. In: *NTM 4/2017,* 485-517. DOI: 10.1007/s00048-017-0181-8.NTM; Kassung, C. (2015) Self-writing machines: Technology and the question of the self. In: *communication +1*, vol. 4, art. 5. doi: 10.7275/R5CN71VS

[68] https://kasumac.github.io/cube-of-physics/

[69] https://www.berlin-university-alliance.de/en/impressions/20180711-forum-romanum/index.html

the first time.[70] To survey the conditions in which historical spaces were perceived and how they operated, speeches by Cicero and Demosthenes were recorded in an anechoic chamber and spatially reconstructed in a virtual audiovisual environment, thereby opening up new approaches for classical studies. The noise of the crowd from the audience was simulated using recorded background noise from a Sunday prayer by the Pope on St. Peter's Square in Rome or synthetically generated by a newly developed procedure that could account for different levels of audience arousal. Based on aspects of both the speech and the audience, computer programs simulated the sound landscape of the virtual Roman Forum or the Pnyx, and the various positions of the stage.[71] Using digital simulation, VR systems, and auralization, a concept of plausible (re)construction was developed as a scientific tool.[72,73] The combination of auditory and visual perception made it possible to enhance the levels of architectural experience in the simulation. The results of the acoustic simulations were made audible directly in the virtual environment. Users of the VR system can visit "listening points" in the scene where they can hear a political speech by Demosthenes and assess the atmosphere and the speaker's comprehensibility and visibility. The project has demonstrated how activities within architectural environments can be reconstructed—and how such reconstructions of lived spaces can be further employed in scholarly studies and to improve acoustic communication.

In a similar way, the cross-sectional project **»Gender Rhizome«** reconstructed the implicit constraints of gender based on historically developed structures with a particular focus on research processes. The project was situated between the priority areas »Architectures of Knowledge« and »Active Matter«, and fulfilled two central functions within the Cluster: On the one hand, it facilitated exchanges between the research projects on intersecting issues of gender and diversity, and acted as an internal cluster for these topics in order to raise their visibility within and outside the Cluster. For instance, the project organized the international conferences »Picturing the Body in the Laboratory, 19th and 20th Century« (2015), »Emerging Activity—Relating Things« (2017), and »The Meaning of Color in the Sciences« (2018). These conferences addressed issues such as gendered ascriptions of colors, approaches from new feminist materialism, and a dichotomous, gendered understanding of activity and passivity with regard to material, social, symbolic and epistemic levels, and analyzed them as generally invisible and implicit yet highly relevant issues that shape any research process in a fundamental

[70] Kassung, C., Schwesinger, S. (2016) How to hear the Forum Romanum. On historical realities and aural augmentation. In: Busch, C., Sieck, J., eds. *Kultur und Informatik. Augmented Reality*. Verlag Werner Hülsbusch, Glückstadt, 41–53.
[71] Holter, E., Muth, S., Schwesinger, S. (2019) Sounding out public spaces in late republican Rome. In: Butler, S., Nooter, S., eds. *Sound and the Ancient Senses.* Routledge, New York, 44-60.
[72] Kassung, C., Schwesinger, S. (2018) Saxa Loquuntur. The function of (multi-)media for antique architecture. In: Jat, D.S. et al., eds. *Digitisation of Culture. Namibian and International Perspectives.* Springer Nature, Singapore, 171-185.
[73] Holter, E., Schäfer, U., Schwesinger, S. (2020) Simulating the ancient world. Pitfalls and opportunities of using game engines for archaeological research. In: Rollinger, S., ed. *Representations of Classical Antiquity in Video Games. Playing with the Ancient World.* Bloomsbury Academic, London (in print); online footage of the audiovisual environment can be found here: https://www.youtube.com/watch?v=tTt7VveNhio&feature=youtu.be

way. These discussions were also documented in publications.[74] On the other hand, the project conducted its own diversity research, including an empirical behavioral study on body movements while giving lectures, which generated new knowledge on relationships of inequality within the Cluster and in the wider German academic landscape. In both contexts, the project critically applied approaches and concepts from gender studies, such as difference and symbolic orders. "Gender" was used as a category and a tool that is both critical and productive with the ultimate goal being to "de-gender science" and to generally democratize science and technology development through the early inclusion of the most diverse perspectives.

Priority Area: Collecting & Exhibiting

Priority area leaders: Dr. Jochen Hennig (Physics, History of Science), Prof. Dr. Christian Kassung (Cultural History & Theory), Felix Sattler (Curation)

Projects: Mobile Objects, Culture Collaboratory

Selected participating institutions: BAM Federal Institute for Materials Research and Testing, Ibero-American Institute (Prussian Cultural Heritage Foundation), Museum für Naturkunde Berlin, Kunstbibliothek Berlin (Prussian Cultural Heritage Foundation), Weißensee Academy of Art Berlin

Selected cooperation partners: Humboldt Forum Berlin Kultur GmbH

The Cluster's vision of an open lab linked research and public display. Within this concept, the priority area »Collecting & Exhibiting« regarded collections as providing a tangible state of the art in research practice. The collected objects foster the generation of relationships between them and enable showing and exhibiting to not only form an integral part of the research process but to also be open to the public. The exhibiting of material objects has indeed always been an important element in the history of modern universities—especially at HU Berlin in its past and today. The Cluster's priority area, founded in 2017, therefore defined collecting and exhibiting as cultural techniques that are linked to very specific forms of knowledge production and hence regarded them as intrinsically dependent on each other. The priority area linked the history of scientific and academic collections and the theory and cultural technique of collecting and exhibiting with the challenges facing research and science communication today. Within

[74] Bock von Wülfingen, B., ed. (2017) *Traces. Generating What Was There*. Berlin/New York: De Gruyter. With contributions from Amelung, K. A., Bock von Wülfingen, B., Jirikowski, G., Kesting, M., Kunze, A., Nyakatura, J. A., Stach, T. among others; Bock von Wülfingen, B., ed. (2019) *Science in Color. Visualizing Achromatic Knowledge*. Berlin/New York: De Gruyter.

historically and systematically broad perspectives, collection objects were analyzed in their full diversity of media and material characteristics as spatial arrangements and polysemic producers of meaning that generate different orders of knowledge in relation to the social, political, technical, epistemic, and institutional conditions in which they are embedded.

Together with the experts in collecting and curating at the HZK, the priority area has played a significant role in opening up interdisciplinary research processes at HU Berlin to the general public, enabling diverse forms of critical access to material knowledge cultures and scientific collections. The priority area has succeeded in significantly increasing interest in some of the more than forty decentralized scientific collections of HU Berlin by developing innovative exhibitions[75] as well as new exhibition design formats. The priority area viewed curating as an original form of research that brings together scientific, aesthetic, and social practices. Three stages provided by HU Berlin served as use cases and platforms for these formats:

- The Veterinary Anatomy Theater (*Tieranatomisches Theater*) was built in 1790, as a unique theater of knowledge, an architecture historically designed to simultaneously study objects and showcase research. As a research institution at HU Berlin located at the HZK, the Veterinary Anatomy Theater focuses on critically examining the multifaceted role of material culture, collections, and institutions. The priority area »Collecting & Exhibiting« developed this historic venue as a public exhibition space for experimental forms of presentation and as a laboratory for curatorial practices.
- The Object Lab (since October 2019) complements the Veterinary Anatomy Theater of the HZK with a new infrastructure to advance interdisciplinary inquiries into collection objects and materials. The priority area was responsible for developing the concept for the Object Lab. It includes an experimental laboratory for collaborative research and a workspace equipped with tools for observing, designing, and testing collaborative object research. More specifically, it consists of a material and object repository (»Materiothek«) and laboratory workstations, offering space for teaching and research and facilitating processes such as the digitization of collection objects.

[75] Lessing, J., Orlikowski, M., Nyakatura, J. A., Sattler, F., eds. (2017) Orobates. Nach 300 Millionen Jahren reanimiert. Exhibition Catalogue. Tieranatomisches Theater der Humboldt-Universität zu Berlin. Berlin: Image Knowledge Gestaltung. An Interdisciplinary Laboratory.

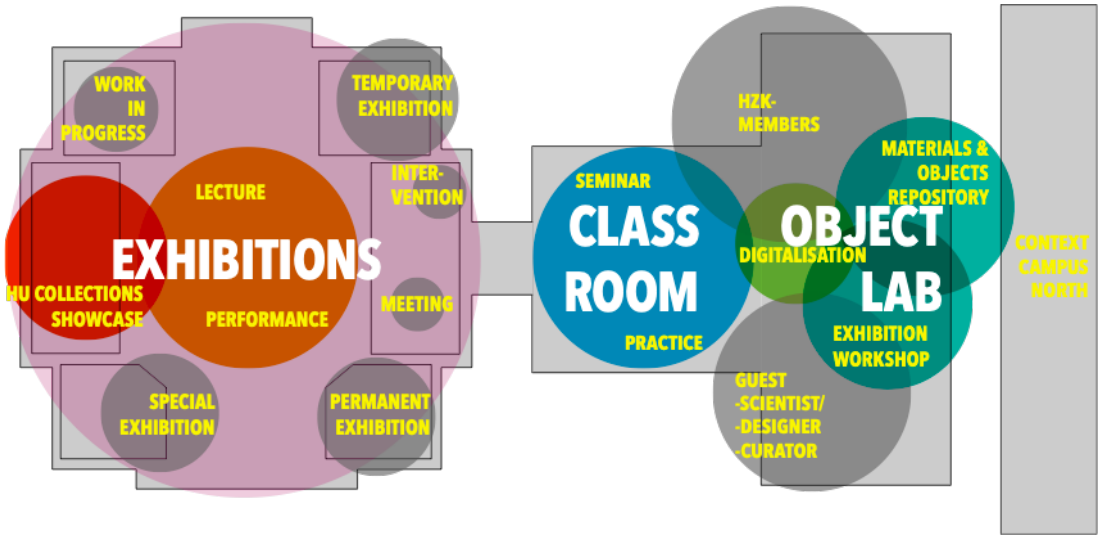


Fig. 8: Structure diagram of the Object Lab in context. (Image Credits: *Image Knowledge Gestaltung*)

- The Humboldt Labor within the Humboldt Forum (opening in 2020) will be HU Berlin's future venue for engagement with a broad public. The priority area was responsible for the planning phase of the architectural space and for drawing up the Humboldt Labor's agenda. Covering an exhibition space of more than 1,000 m^2, it will offer an unprecedented high level of public visibility for university-based research, thereby setting new standards in science communication. The public will be able to experience research processes up close in the Humboldt Labor through interactive and engaging display formats, or through direct interaction and discussion with specialists.

The following projects provide an insight into the priority area's research activities and results:

The project **»Mobile Objects«** was dedicated to research on objects from the history of science and art and design. In the Cluster's first phase, it focused on the materiality of knowledge in its local and global forms and interconnections, as well as the accompanying reciprocal relationships between agendas, practices, and objects. The project's goal in the Cluster's second phase was to examine the social, political, technical, epistemic, and institutional conditions in which museum or collection objects are historically and presently embedded. It therefore investigated the contexts of origin, movements, and transformations of different collections of natural and cultural history objects.[76] In particular, three developments were analyzed:
(a) the legal, political, and even diplomatic status of objects (in the context of open access, debates on cultural property, rights of indigenous groups, etc.),

[76] Hennig, J. (2015): Zwischen Forschung, Seminar und Depot: Spezifika von Universitätssammlungen. In: *Hamburger Journal für Kulturanthropologie* Nr. 3: SAMMELN. Zur Geschichte und Gegenwart einer alltäglichen, musealen und wissenschaftlichen Praxis, 117-129.

(b) the changing role of *object workers* and *object managers* (curators, librarians, etc.), and finally (c) the digitization of objects as one of the most important new forms of their mobilization that enables a number of material, categorical, spatial, or institutional connections.

On the basis of specific case studies, the activities, economies, and policies (institutional, national, and global) that are intertwined with the genesis of cultural and scientific objects—whether they are objects for collection or exhibition—and their mobilization were investigated.

The project was based on three closely interlinked sub-projects: The sub-project »Sensitive Things? On the Political History of Berlin's Natural History Collection« was based at the Museum für Naturkunde in Berlin, in collaboration with the scientific collections of HU Berlin. Building upon the research conducted within the project »Mobile Objects« within the Cluster's first phase, it explored the political history of the Berlin collections.[77] This sub-project has brought the debate on sensitive objects up to date through its examination of natural history collections and contributed to a better understanding of natural history as a politicized science. The sub-projects »Artistic Object Research« and »Hybrid Object Presentations« were both based at the HZK and prepared conceptualizations, drafts, and experimental utilizations for the future Object Lab.[78] The project »Artistic Object Research« developed an active and self-reflexive form of artistic practice that assimilates perspectives from the history of science and *Bildwissenschaft*. By reconstructing the practice of recording signals with a kymograph (a 19th-century scientific instrument for drawing charts), for instance, the project developed a kinesthetic understanding of how knowledge and scientific facts were and are produced, instead of reproducing the scientific results. This practice helped to bring to light new knowledge about objects in scientific collections and also revealed new insights into productive operational settings for collaborations between the creative and scientific spheres. The project »Hybrid Object Presentations« developed examples of exhibition scenarios that brought together material and virtual objects from both HU Berlin's scientific collections and those of the Museum für Naturkunde, making these objects more accessible and more open to presentation. For instance, the project curated an exhibition on volcanic basalt rocks that presented their discovery and the controversies surrounding them (the so-called *Basaltstreit*). Overall, the project »Mobile Objects« has shed light on the politicized character of natural history and contributed to new modes of knowledge production.

The project **»Culture Collaboratory«** grew out of the interdisciplinary research project »Indexing Collections«, conducted during the Cluster's first phase. Based at the Weißensee Academy of Art

[77] Bauche, M. (2016) Doing Research with Colonial Sources. Deconstructing Categories in German East Africa's Medical Reports. In: Castryck, G., Strickrodt, S., Werthmann, K., eds. *Sources and Methods for African History and Culture. Essays in Honour of Adam Jones.* Leipzig: Univerlag-Leipzig, 337–356; Bauche, M. (2016): Assoziationen von Politik und Natur. Kubanische Korallen in Ost-Berlin, 1964–1974. In: ibid./ Vogel, C., ed. Mobile Objekte. *Berichte zur Wissenschaftsgeschichte*, vol. 39, no. 4: Special Issue. Weinheim: Wiley, 311–330.

[78] Döring, S., Kassung, C., Thie, O. (2018) Eröffnung Temporäres Objektlabor, Humboldt-Universität zu Berlin, 5 October.

Berlin, its aim was to develop a digital tool that facilitates interdisciplinary exchanges in order to broaden the understanding and accessibility of cultural heritage objects. The sample collection used for the project forms part of the Lipperheide Costume Library held at the Kunstbibliothek (Art Library) of the Staatliche Museen zu Berlin. It consists of around 550 oil paintings, miniatures, and bas-reliefs, from which a sample of 20 oil paintings was studied and researched in detail. In the first stage, the project members investigated the scientific analyses and research instruments used by the conservation and material sciences and studied the research strategies and interpretative methods employed in art historical analysis. Its members also reviewed the software applications most frequently used to generate, evaluate and interpret the results of this research. The continuous feedback loop between researchers and designers enabled them to develop and refine the design concept for the new digital tool through several iteration stages. In this way, the project »Culture Collaboratory« created a virtual workspace that supports interdisciplinary teams with researching and managing collections of cultural artifacts and developed a website to present the software design.[79] The specific design of the software allows cultural artifacts to be considered in their multifaceted contexts including their historical function and meaning, the subject matter of visual artworks, as well as their material properties, origin, and age. By integrating diverse disciplinary research methods into a single shared interface, this tool supports researchers with analyzing and interpreting their findings and in forming a holistic understanding of their research objects. Its object-centered approach facilities improved understanding and assessment of complex information in interdisciplinary settings. Making full use of the potential of data visualization and visual analysis, it allows users to see and think in a new complexity. The developed tool *Culture Collaboratory* can be used in a multitude of settings: by teams creating an exhibition or researchers in academic institutions who are faced with the challenge of managing and interpreting large data sets. Smaller museums with limited resources also stand to benefit from a software that helps them to manage, research, and publish their collections. Alternative fields of use include research areas in which object-centered organization and visualization of data promises to enhance the efficiency and quality of research, for example in the healthcare sector, where the conceptual framework could be reinterpreted as a patient management system. The tool's software design has been presented at a number of conferences and institutions, including at the Getty Research Institute[80] and at the 21st annual Museums and the Web conference,[81] where it generated great interest. While the software design has been finished and

[79] http://col-laboratory.com/experienceinterface/ (Website credits: L. Dannebaum, F. Kaes, R. Lauer, C. Zwick | *Image Knowledge Gestaltung* 2016)
[80] Dannebaum, L. (2016) Culture Collaboratory - Virtual Workspace for Collections Management and Research in Interdisciplinary Collaborations. Presentation. International Terminology Working Group Meetings. Getty Research Institute, Los Angeles, CA, USA, May/August.
[81] Dannebaum, L., Kaes, F. (2017) The potential of UX and interaction design and data visualization for collections research and management software. Demonstration. MW17: Museums and the Web 2017. 21st annual conference, Cleveland, OH, USA, April.

published,[82] a future step will be to transform *Culture Collaboratory* into an operational software application.

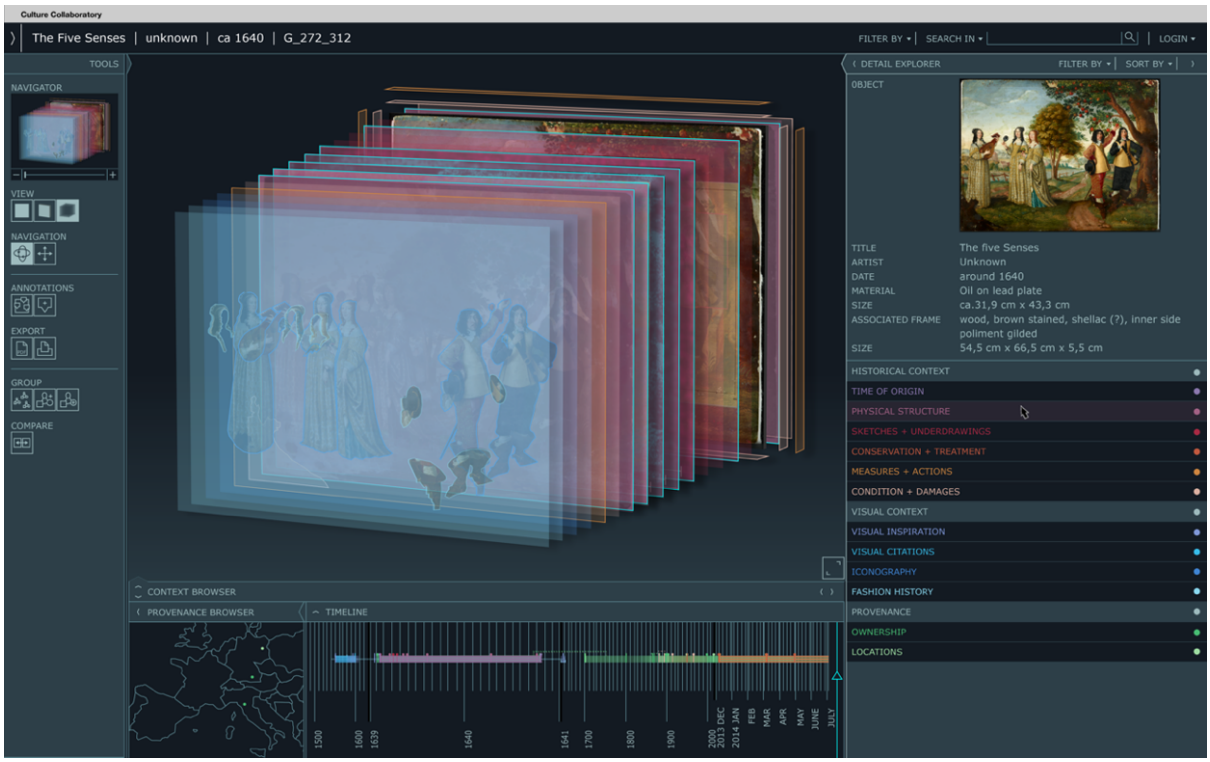


Fig. 9: Culture Collaboratory: Object interface layer
(Image Credits: L. Dannebaum, R. Lauer | *Image Knowledge Gestaltung*)

2.4 Impact

The Cluster was not uncontroversial when it was approved. Some experts doubted that the intensive and productive collaboration between more than 40 disciplines that we promised to establish would be possible. Throughout its six-year life span, the Cluster provided a vital framework for high-level interdisciplinary research that depends primarily on close interaction of the participating researchers. Cluster research and joint activities served as important training in unprecedented interdisciplinary collaboration for all the participating researchers, whose disciplinary research was also significantly influenced by this collaboration. Seen from today's perspective, the Cluster's undertaking can rightly be described as an academic revolution. The extraordinary mutual trust between researchers and designers from very diverse disciplines

[82] Lauer, R., Kaes, F. (2016) Culture Collaboratory: Digitale Forschungsumgebungen – Neu gedacht! In: Bienert, Andreas et al., eds. Konferenzband EVA Berlin 2016. Elektronische Medien & Kunst, Kultur und Historie: 23. Berliner Veranstaltung der internationalen EVA-Serie Electronic Media and Visual Arts, Heidelberg: arthistoricum.net, 2017 (2016) (EVA Berlin, Band 23). https://doi.org/10.11588/arthistoricum.256.338; Dannebaum, L., Kaes, F., Lauer, R., Zwick, C. (2017) Culture Collaboratory. Virtual Workspace for Interdisciplinary Collections Research and Management (Booklet). Zenodo. http://doi.org/10.5281/zenodo.998580

reached an intensity that has fundamentally changed all those involved in the project. We succeeded in establishing cross-departmental and even cross-cultural trust. The Cluster's integrative approach was unique in its constellation of researchers from very divergent disciplines who worked together, sharing ideas and methods. The diversity of disciplines and researchers in the Interdisciplinary Laboratory resulted in an integration of methods of different levels of abstraction and concretion, which enabled the Cluster to redefine the active status of images and to implement a turn to *Gestaltung* in research. The Cluster has demonstrated that freedom in academia can inspire immense productivity and dynamics of a kind that cannot be found elsewhere. More than 600 researchers and students who have been involved in the Cluster *Image Knowledge Gestaltung* are passing on the skills and the spirit of fruitful interdisciplinary collaboration all over the world. The fundamental question with regard to sustainability was how this complexity can be maintained and implemented in new contexts so as not to lose the potential of the integrative research structure established by the Cluster. On the one hand, this was resolved by the successful application for the Cluster of Excellence *Matters of Activity. Image Space Material* that could transfer fundamental achievements into new projects. This combination of continuity and discontinuity can be regarded as an important condition for innovative research structures creating something as paradoxical as the perpetuation of a dynamic and flexible structure of interdisciplinary research. On the other hand, institutional sustainability was achieved through the Hermann von Helmholtz-Center for Cultural Techniques (HZK) at HU Berlin, which–with its key role in the collection- and curation-oriented *Gestaltung* of research processes–embeds the concept of an interdisciplinary open lab at the university level.

3 People

3.1 Impact of the Cluster on academic positions

Academic staff

The Cluster *Image Knowledge Gestaltung* created an interdisciplinary laboratory based on an unprecedented collaboration of the humanities, the natural sciences, and the design disciplines as equal partners. The “turn to *Gestaltung*” in particular had a great impact on academic positions at every career level by establishing a position for the design disciplines within a classical university. The Cluster’s own interdisciplinary PhD program, doctoral regulations that enable a practice-based PhD program (currently being developed at the HZK), and the Cluster’s international master’s programs »Open Design« and »COOP Design Research«, which will continue even after the Cluster’s funding period, are already having a sustainable impact on the role of designers in research and academia.

What is more, the Cluster of Excellence enabled **three professorships at HU Berlin** that would otherwise not have been possible:

- In the Department of Art and Visual History, a new W3 professorship »History and Theory of Form« linking art history and the design disciplines was established and appointed in 2014. After the Cluster’s funding period, this position was permanently established at HU Berlin.
- As a bridge between the Department of Biology and the Department of Art and Visual History, the junior professorship »Morphology and History of Forms« linking zoological morphology with the history of knowledge and imagery was established as a tenured Cluster bridge professorship and appointed in 2015. After the funding period and successful evaluation, the holder of the professorship received tenure (W2 position »Comparative Zoology«) at the Department of Biology of HU Berlin.
- In the Department of Cultural History and Theory, the junior professorship »History and Theory of Gestaltung« linking the history and theory of culture to the design disciplines was established and appointed in 2015. After four years of successful substantive focus on the creative potential of scientific processes and positive evaluation, the holder of the professorship will leave HU Berlin for a new appointment. Following a competitive selection procedure, an appointment will be made for the Cluster professorship »Performative Design Research« within the follow-up Cluster *Matters of Activity*, based at Weißensee Academy of Art Berlin. In return, the Cluster *Matters of Activity* will establish, among other posts, a permanent W3 professorship of »Design and History of Knowledge« at the Department of Cultural History and Theory, thus continuing the turn to *Gestaltung* at HU Berlin.

The Cluster professorship positions were advertised internationally and within the Cluster's network, which grew continually stronger by recruiting new researchers, principal investigators, and associated investigators. The Cluster actively encouraged outstanding female researchers to apply, with the result that two of the three Cluster professorships were awarded to excellent female candidates. The Cluster professorships provide a framework for pursuing interdisciplinary research constellations in which the humanities and the design disciplines assume a fundamentally integrative role and systematically sustain the Cluster's impact at department level.

The Cluster additionally proposed a professorship of »Experimental Systems« (W3) to be jointly established in HU Berlin's Department of Cultural History and Theory and the Department of Physics; this required highly demanding dual qualifications in physics as well as in cultural history and theory and the history of science. As unfortunately no convincing candidate could be found, the respective Faculty Council recommended that the funds be used to establish the envisaged research field. Following this recommendation, the Cluster established the research group »Experimental Systems«, including two Cluster-funded postdocs (physics and cultural studies) and guest professorships. This group conducted interdisciplinary research and staged exhibition projects on the cultural techniques of research in physics, resulting in a long-term cooperation between the Department of Physics and the Department of Cultural History and Theory that takes the form of joint events, projects, and applications for external funding. This axis between physics and cultural history and theory evolved into a fundamental infrastructure for the follow-up Cluster *Matters of Activity* and bridged the gap between theoretical physics of space, time, and matter, and experimental physics of macromolecules within HU Berlin's Department of Physics for the first time.

Recruitment procedures: Recruiting postdoctoral and doctoral researchers was important to further expand disciplinary diversity and the necessary expertise for the research projects. Furthermore, international recruiting has stabilized the existing connections with Latin America and strengthened connections with the USA. Job offers for postdocs and PhD candidates were advertised internationally in the form of positions and only in exceptional cases in the form of scholarships. The official application procedure was accompanied by active recruitment measures at the Cluster's summer schools, workshops, and conferences, and by encouraging outstanding female researchers to apply. Positions (and scholarships) were awarded following a multistage selection process. Selection decisions were taken by the principal investigators of the respective project, i.e. by an interdisciplinary team of at least two people.[83] Positions for postdocs

[83] To ensure the timely start of the first research projects on November 1, 2012, individual candidates were accepted in summer 2012 without a tendering procedure provided that the candidates were qualified for research on the project or had already participated in the design of the Cluster's research endeavor during the application phase.

and PhD candidates were associated with a specific research assignment, organizational tasks in the projects, and potential teaching opportunities.

Postdocs: In total, the Cluster offered around 50 postdoctoral positions that were funded by the Cluster.[84] The Cluster promoted their disciplinary careers and publication records while simultaneously adopting a systematic approach to strengthening their interdisciplinary profiles through joint research projects and peer-to-peer learning in interdisciplinary groups. In order to further support postdoctoral career development, the Cluster's Executive Board decided to establish postdoc leaders for each of the Cluster's five priority areas in the Cluster's second phase. These positions were created instead of the planned disciplinary junior research groups, which were not implemented due to the budget cut of 29%. In collaboration with the two leading PIs, the postdoc leaders were responsible for the interdisciplinary synthesis, further development of the research focuses, and management of the respective priority area. In return, they received an additional budget that could be used for their individual research and equipment. Applicants had to be outstanding postdocs with relevant research experience, publications, and international scientific networks, and at least one year of research experience within the Cluster. As was the case for all postdoc positions in the Cluster, the selection procedure was carried out as a proper application procedure to an internal call for tenders; the selection committee consisted of the leaders of the priority areas and the Cluster's directors. In the end, seven postdocs were selected as priority area leaders, including two tandem applications, who all presented very convincing approaches for designing the respective focus areas. Overall, the concept of postdoc priority leaders proved to be very productive for the Cluster's second phase and very beneficial for the postdocs' own career development. As of today, one of the former postdoc priority leaders has been appointed to a professorship. The majority of the Cluster's postdoc priority leaders were taken over by the follow-up Cluster *Matters of Activity* following a competitive internal selection procedure. Since the Cluster *Matters of Activity* has a new research focus and was proposed as a "new" Cluster of Excellence in the application, it was internally communicated to all scientific staff that there would be no automatic continuity in terms of contracts. However, as the Cluster *Matters of Activity* was instead approved by the DFG as a follow-up project, the Cluster *Image Knowledge Gestaltung* did not receive the expected completion funding. As a consequence, all the postdocs' contracts ended abruptly, which resulted in a very unfortunate situation for the Cluster's early career researchers. However, as of today, the vast majority of the Cluster's postdocs have received an adequate postdoc position after the end of the Cluster's funding period in other research institutions or museums, for instance, in participating or collaborating institutions of the Cluster or at HU Berlin.

[84] In reasonable exceptional cases, postdoctoral fellowships in the form of scholarships were awarded upon invitation in order to promote female researchers and to attract international postdoctoral fellows.

PhD candidates: The Cluster explicitly promoted disciplinary PhDs that integrate perspectives from other disciplines by appointing a second supervisor and through the Cluster's collaborative research culture. In total, the Cluster funded around 60 doctoral positions and scholarships.[85] Accepted in three cohorts, a total of 23 of these PhD candidates were enrolled on the Cluster's structured PhD program. This program enabled doctoral candidates to successfully conduct outstanding research within the framework of a disciplinary PhD project and an interdisciplinary cooperation on the projects with dual supervision. Accredited by Humboldt Graduate School, an umbrella organization for graduate students at HU Berlin, this program proved to be highly successful and will be continued within the follow-up Cluster *Matters of Activity*: All PhD candidates enrolled on the program who have completed their thesis within the Cluster's funding period today have a postdoc or similar position at research institutions or museums. Two of the program's alumni have even been appointed as professors at art schools.

Alongside the structured program, the Cluster also supported PhD candidates who were writing a relevant thesis at HU Berlin's departments without being enrolled on the structured PhD program. These PhD candidates also took part in the Cluster's activities and certain elements of the structured training program. Since monitoring these theses within the Cluster proved to be difficult, it was decided that all PhD candidates within the follow-up Cluster *Matters of Activity* will be enrolled on the structured program.

Non-academic staff

The former academic manager of the Cluster *Image Knowledge Gestaltung* received a permanent position at HU Berlin as the HZK's academic manager, a new position established by HU Berlin in order to strengthen the role of the HZK. Furthermore, the management office of the Cluster *Image Knowledge Gestaltung* was taken over by the follow-up Cluster *Matters of Activity*, thereby ensuring that the new Cluster would be able to start work immediately. The future transfer of management office staff into HU Berlin's administrative pool will ensure that the expertise gained in interdisciplinary project management will be sustainably maintained.

3.2 Promotion of early career researchers

Promoting early career researchers was a matter of central concern for the Cluster. In accordance with HU's Institutional Strategy "Educating Enquiring Minds—Individuality, Openness, Guidance," a series of differentiated measures were implemented throughout the

[85] In the Cluster's first phase, scholarships were used due to the 29% cut in the funds applied for. In the second phase, scholarships were only awarded in exceptional cases. The Cluster's PhD program provided scholarships only as an extension option for the final phase of a candidate's thesis and during the transition to the Cluster's second phase: All the Cluster's doctoral students whose projects were not included in the priority areas were given the opportunity to apply for up to six months' additional funding.

entire qualification and training period for early career researchers. Most importantly, the Cluster's organizational structure based around problem-oriented projects provided a superb scientific environment for training researchers through close collaboration between renowned and experienced researchers and young scholars. The collaborative research constellations in the projects established an outstanding culture of mentoring and mutual support: The Cluster created a dedicated space for young researchers to reflect on their own field and share views with contemporaries from other disciplines. Cluster meetings and workshops, such as the *LunchTalk*, provided a safe platform for young researchers to present their work, exchange ideas, and receive feedback and support from all the members of the Cluster and invited national and international guests. Additionally, early career researchers were trained in project management by assuming administrative, coordinating, and organizational responsibilities. The Cluster designed measures adapted to different target groups:

Outreach activities for school-age children

With the »Interdisciplinary Summer Universities for Children« in 2013 and 2014, the Cluster opened up the university to school-age children (aged from 10 to 15), allowing them to gain a better sense of a contemporary scholar's work. By taking a peek behind the curtains of research, the children learned about topics such as producing an exhibition and took a close look at wood in art history and furniture-making. A trip to the countryside to harvest and cook potatoes with discussions about the role of cooking in the development of human beings rounded off the program. This concept received the prize Family-Friendly Project 2013 from HU Berlin. In collaboration with the Professional School of Education and the HUmanities Lab at HU Berlin, which provided expertise in didactics, the project »The Anthropocene Kitchen« has developed a teachers' handout on food in the age of globalization.

Early integration of students

Student assistants: HU Berlin student representatives have praised the Cluster, and the Excellence Initiative in general, for creating a significant number of highly interesting student assistant positions. They were involved in active research, working on the projects, and in scientific management and workshop organization. More than a hundred student assistants worked in the Cluster; some of them joined the Cluster as research assistants after completing their studies.

Each year from 2014 to 2018, on average 15 outstanding students from different disciplines joined the Cluster in a theme class with the aim of learning through research, receiving *Deutschlandstipendien* from the *Schering Stiftung*. These students were given an opportunity to conduct independent research within the scope of the Cluster's research. Regular meetings and workshops provided a forum for them to exchange ideas and network with other members. Each

year, the diverse results of the theme class's research were published as an anthology, including a hybrid printed and analog edition of Cluster Letters of Understanding (CLoU).[86]

The international master's program »Open Design« offered students from all fields the opportunity to study the diversity of methodologies and interdisciplinary skills at the University of Buenos Aires and Humboldt-Universität zu Berlin, and to gain a double degree from both universities. The program is structured into four semesters, the first two semesters taking place in Buenos Aires at the UBA and the third semester in Berlin at HU. For the fourth semester, students worked on their master's theses in either Buenos Aires or Berlin. In the first cohort, 26 students from 9 countries studied design in research and design as research in theoretical and practical modules.

Together with Anhalt University of Applied Sciences and the Bauhaus Dessau Foundation, the Cluster offered the accredited one-year MSc. program »COOP Design« on Design Research at Gropius' Bauhaus in Dessau. The program is conceived as a preparatory step toward doctoral study and integrates design and research, which are often perceived as separate disciplines. The participants gained an extensive scholarly grounding and wide-ranging competencies from a practice-oriented and forward-looking curriculum. The Cluster also cooperated with the interdisciplinary study program »Diversity of Knowledge« at HU Berlin, which offers cross-faculty courses for B.A. students of all disciplines with a focus on the history of knowledge and science through the study of actual objects. Several of the Cluster's research assistants served as visiting professors and lecturers on this program.

Promotion of doctoral researchers

The Cluster provided training and support for PhD candidates through the structured doctoral program *Image Knowledge Gestaltung* accredited by Humboldt Graduate School (HGS), an umbrella organization for graduate students at Humboldt-Universität zu Berlin. The program enabled doctoral candidates to successfully conduct outstanding work within the framework of a disciplinary PhD project and an interdisciplinary cooperation on the projects with dual supervision.[87] The Cluster explicitly promoted disciplinary PhDs that integrate perspectives from other disciplines by appointing a second supervisor and through the Cluster's collaborative research culture.

Accepted in three cohorts, a total of 23 PhD candidates from 9 different disciplines were enrolled on the PhD program. The doctoral candidates were given the freedom to determine their own

[86] https://www.interdisciplinary-laboratory.hu-berlin.de/de/content/deutschlandstipendium-themenklasse/

[87] For example: Hadjinicolaou, Y. (2019): *Thinking Bodies – Shaping Hands. Handeling in Art and Theory of the late Rembrandtists*. Leiden: Brill Academic Publishers | Kunze, F. (2018): *Opake Fotografien. Die Sichtbarmachung fotografischer Materialität als künstlerische Strategie*. Berlin: Reimer | Cedeño Montaña, R. (2017): *Portable Moving Images. A Media History of Storage Formats*. Berlin: De Gruyter.

focus of interest while receiving continuous support. The training program consisted of four modules: *Research Project*, *Progress Review*, *Practice*, and *Research&Skills*. As outlined in the supervision agreements, the progress of the PhD research projects was regularly monitored by an advisory panel and the doctoral committee (formed of the program director and coordinator, one representative from the natural sciences, the humanities and the design disciplines respectively, and one representative from the doctoral candidates). The content of the *Practice* and *Research&Skills* modules was tailored to suit the candidate's individual areas of competency and was adapted to a widely varying range of research subjects and interdisciplinary backgrounds. As part of the training program, various workshop and lecture formats such as »Learning With…«, »Research Associates' Workshops«, and »Doctoral Candidates Club« have been developed, primarily to focus on subject-specific training, to provide early career researchers with a chance to gain their first teaching experience within the Cluster and to foster interdisciplinary exchanges of knowledge. Most of the events were open not only to program members but to all doctoral candidates in the Cluster. For example, the »Doctoral Candidates Club«, which had its own budget, was a self-organized regular meeting for all doctoral candidates and enabled them to exchange ideas on research and to jointly organize colloquiums and symposiums. The doctoral program provided funding for up to six months to enable the students to visit the Cluster's international cooperation partners, thereby supporting them in establishing their own international networks and gaining intercultural experience. The Cluster's individual support funding line was used by the doctoral students to fund further career-enhancing measures. The Cluster's management staff provided advice and support, for example on project management and external grant applications. Complementary skills training was provided through HGS and included courses on teaching, presentation, and publishing, among other areas, as well as career-oriented activities such as networking, coaching, and mentoring. The doctoral program's curriculum was open to individual doctoral candidates working in the Cluster.

In 2012 and 2013, the Cluster hosted two KOSMOS Summer Universities, which enabled early career researchers to combine interdisciplinary research and international collaboration. For two weeks, more than 40 international researchers and young academics from 13 disciplines and of different nationalities worked together on new possibilities for designing mobility concepts at the KOSMOS Summer University 2012 »Mobility«. The program focused on an interdisciplinary and innovative approach to mobility concepts in urban space. Professors and postgraduate students from the humanities and natural sciences worked on four key topics together with designers and transport experts. The summer university was organized by the Institute of Cultural History and Theory of HU Berlin in cooperation with the Universidad de Buenos Aires.

The second international KOSMOS Summer University »Modern Walking—Innovative Urban Mobility« was hosted in 2013. Together with experts from São Paulo (Universidade de São Paulo) and Bogotá (Universidad Nacional de Colombia), researchers gathered to develop and

discuss new forms of mobility in urban space within the concept of walking as an efficient, energy-saving, and sustainable mode of transport.

Promotion of postdoctoral researchers

Around 70 postdoctoral researchers made substantial contributions to the research projects.[88] The Cluster promoted their disciplinary careers and publication records while simultaneously adopting a systematic approach to strengthening their interdisciplinary profiles through joint research projects and peer-to-peer learning in interdisciplinary groups. The Cluster's postdocs were involved in the coordination, administration, and management of the Cluster's joint research projects. For each *priority area,* two postdoctoral researchers were appointed as leaders, sharing with the PIs the responsibility for organizing and administering the projects. In addition, two representatives of the postdoctoral researchers were elected to the Cluster's Executive Board. The postdocs also benefited from the opportunity to apply for direct project funding for their own interdisciplinary research proposals. The Cluster actively supported its postdoctoral researchers in obtaining the teaching experience necessary to qualify for a professorship, for instance by teaching on the interdisciplinary study program »Diversity of Knowledge« at HU Berlin. The Cluster's postdoctoral researchers also taught parts of the interdisciplinary courses on the Cluster master's programs. The Cluster supported its young researchers in developing publications strategies, applying for external funding, and undertaking international research trips and residencies. In addition, the Cluster offered a wide range of career-enhancing measures such as leadership and management skills, grant application training, and individual career counseling.

Junior Cluster professorships

The professorship of »Morphology and History of Forms« was embedded in the Cluster's interdisciplinary network, thereby interlinking the humanities and the natural sciences. More specifically, the professorship acted as a bridge between the Department of Biology and the Department of Art and Visual History. The working group has undertaken both biological basic research on form-function relationships and the evolution of vertebrates, and in parallel reflected upon this research process with a focus on the images used within it. After the funding period and successful evaluation, the holder of the professorship received tenure (W2 position »Comparative Zoology«) at the Department of Biology of HU Berlin.

Mediating between the humanities, the natural sciences, and the engineering disciplines, the Cluster's professorship »History and Theory of Gestaltung« in the Department of Cultural History and Theory reflected upon the creative potential of scientific processes and how this can be made productive. After four years of successful work and a positive evaluation, the holder of the

[88] Thereof around 50 positions were funded by the Cluster.

professorship was designated, within the framework of a competitive selection procedure, for the W2 Cluster professorship »Performative Design Research«. This professorship is offered by the follow-up Cluster *Matters of Activity* and will be based at Weißensee Academy of Art Berlin.

Statistical data on the Cluster's doctoral researchers are summarised in Appendix A, Table 9.

3.3 Promotion of gender equality

For the Cluster as an interdisciplinary laboratory, plurality of perspective was vitally important. In accordance with the DFG's Research-Oriented Standards on Gender Equality and HU Berlin's Equal Opportunities Strategies, the goal of equal opportunity as a **leadership-level mission** was pursued both top-down and bottom-up. The Cluster's recruitment strategy was directed by the principle of diversity, and equal opportunity was promoted by specific measures designed, implemented, and evaluated by a Diversity Officer in close collaboration with the Cluster's directors and management. Moreover, the Cluster addressed gender- and diversity-related questions as an integral element of its research program (cf. the priority area »Architectures of Knowledge« in section 2.3.2).

To provide some quantitative results/evidence, in 2016 the proportion of female professors at HU Berlin at 32%[89] was higher than the German average of 23.4%.[90] The proportion of female professors in the Faculty of Humanities and Social Sciences was 44.6%, while in the Faculty of Mathematics and Natural Sciences women hold just 16.2% of the professorships. As an interdisciplinary project, the Cluster made equal opportunities a priority for all research disciplines. The Cluster's commitment to this goal is clearly demonstrated by the data collected for the DFG: In 2017, 60% of PhD positions, 52% of postdoc positions, and 67% of professorships that were funded by the Cluster *Image Knowledge Gestaltung* were held by women.

Recruitment measures and equal opportunities

Recruitment. To address the underrepresentation of women in academia (particularly in the natural and engineering sciences) and the associated loss of innovation potential and plurality of perspective, the Cluster actively encouraged outstanding female academics to apply. When it came to choosing between equally well-qualified and equally suitable applicants, women were

[89] Including junior professorships, correct as of 09/30/2016.
[90] Including junior professorships, correct as of 01/12/2016.
Source: GWK. Chancengleichheit in Wissenschaft und Forschung. 22. Fortschreibung des Datenmaterials (2016/17) zu Frauen in Hochschulen und außerhochschulischen Forschungseinrichtungen. https://www.gwk-bonn.de/fileadmin/Redaktion/Dokumente/Papers/22._FS_Frauenbericht_2018_Heft_60.pdf

given preferential consideration for principal investigator positions, professorships, junior research group leader and postdoc positions. Positions were advertised internationally to increase the diversity of applicants and to promote diverse research teams, perspectives, and approaches. To support international researchers and academics with children with relocating, the Cluster worked closely with services such as HU's *International Scholar Services* and its *Family Service Center*.

Equality-oriented financial management. To promote the careers of its female researchers, the Cluster allocated 1% of its total budget to supporting female doctoral students from the natural and engineering sciences in particular as well as female postdoctoral researchers from all disciplines. The funds were used in a variety of ways to further their individual career development (e.g. coaching, networking, training, student assistants).

Assistance and support. The Diversity Officer organized and offered training courses in areas such as management, presentations, scientific rhetoric, and writing applications. In addition, the Diversity Officer provided career counselling and conflict resolution support during weekly consultation hours. A peer-to-peer mentoring scheme was established to build a network between female postdocs. Female early career researchers and junior professors received support and advice on strengthening their research profiles based on their interdisciplinary connections and specific research experiences within the Cluster. The Cluster succeeded in forming a network for support and exchanges not only among the Cluster members, but also extending to other Clusters of Excellence in Berlin via collaborations.

Family-friendly arrangements. Cluster-related events were held at family-friendly times, and, when this was not possible, professional childcare was provided via *Kids-Mobil*. Furthermore, mobile play areas were created within the Cluster's facilities to support employees whose children were cared for professionally within the Cluster. With the goal of making research and family life compatible, the Cluster also enabled parents to work from home and to adopt flexible working hours. In addition, the Cluster collaborated with HU's *Family Service Center*, which provided further advice and support. The compatibility of family life and career was also one of the central topics discussed in the context of the diversity working groups during the annual Cluster retreats.

Gender equality and diversity activities. Annual working groups in the context of Cluster retreats that discussed aspects of diversity and gender were very well received by participants. The outcomes of these events included the implementation of gender-neutral writing and speaking guidelines for Cluster activities. In addition, special attention was devoted to ensuring that important information was available in English and that events were also held or introduced in English. Another measure worth mentioning is the »Inequalities« working group. Following a couple of workshops during 2015, a colloquium was hosted during 2016-2017; this provided a framework for discussion that addressed academic studies on inequality and categories of

difference used in intersectionality research. Other activities and measures included awareness campaigns, serious games, and calls for action in the context of International Women's Day. Gender was also embedded on a theoretical level as an important cross-cutting research topic for the Cluster within the projects »Gender and Gestaltung« and »Gender Rhizome«, as is discussed in more detail in the research section (cf. the priority area »Architectures of Knowledge« in section 2.3.2).

4 Structures

4.1 Organisation and management of the Cluster

The Cluster *Image Knowledge Gestaltung* was closely affiliated on the basis of its research agenda with the Hermann von Helmholtz Center for Cultural Techniques (HZK), and on an administrative level with the Faculty of Humanities and Social Sciences at HU Berlin. Integrating researchers and designers from different institutions and over 40 disciplines, the Cluster benefited from a flexible management structure that allowed it to accommodate a wide range of diverse actors' needs and to ensure strong internal communication.

Governance

The following scientific bodies had strategic responsibility for the Cluster's operations. Their interaction was defined in the Cluster regulations:

- The **Directors** represented the Cluster within the university and externally, coordinated the Cluster's research strategy and academic administration, and summoned its organs.
- The **Executive Board** was composed of the directors and elected representatives of the HU Berlin faculties involved, the partner institutions, and the postdoctoral researchers. It planned the Cluster's research program and budget, decided on the allocation of funds, and reported to the General Assembly. The academic manager held an advisory role.
- The **General Assembly** comprised all direct members, including principal investigators, postdoctoral and doctoral researchers, technical staff, and the management office. Meeting twice a year, it elected the Executive Board and approved changes to the Cluster's statutes.
- The **Academic Advisory Board** consisted of six renowned international researchers and designers. It advised the Executive Board on the development of the future research program and on increasing the Cluster's international visibility.

With the exception of the Cluster's directors, the natural sciences, humanities, and design disciplines were represented in all the Cluster's governing and advisory bodies, even though the

Cluster was classified as a humanities Cluster by the DFG. Until September 2016, the two directors were humanities scholars from the Institute of Art and Visual History (Prof. Dr. Bredekamp) and the Institute of Cultural History and Theory (Prof. Dr. Schäffner) at HU Berlin. With the strategic reorientation of the Cluster in 2016, a third director from the materials science was elected (Prof. Dr. Dr. h. c. Fratzl, Director of MPIKG and Honorary Professor at HU Berlin). His election underlined the central development in the Cluster's research focus and its culture of the collaboration between different disciplines as equal partners.[91]

Research and teaching in the Cluster was conducted, supervised, and supported by:

- Principal investigators. (Further PIs were appointed by the Executive Board as new research areas and topics were developed).
- Associated investigators and members as appointed by the Executive Board
- Three Cluster professors
- Visiting professors and fellows
- Postdoctoral researchers and doctoral students
- Scholarship holders
- Technical and scientific staff for the laboratories and workshops
- Student assistants

The management office was headed by an academic manager (supported by a deputy) and consisted of a secretariat, a funding administration team, and HR management. The management office was responsible for administering the funds in accordance with the Cluster's budget and DFG regulations, for staffing matters, and communication with HU Berlin's administrative bodies and its *Research Service Center*. It also provided scientific support and acted as a coordinator in the following areas: publications, science communication, IT, third-party funding, equal opportunities, early career researchers, and international programs.

[91] In the follow-up Cluster *Matters of Activity*, interdisciplinarity is further embedded at the level of the directors' disciplinary backgrounds, which span the humanities, the natural sciences, and design.

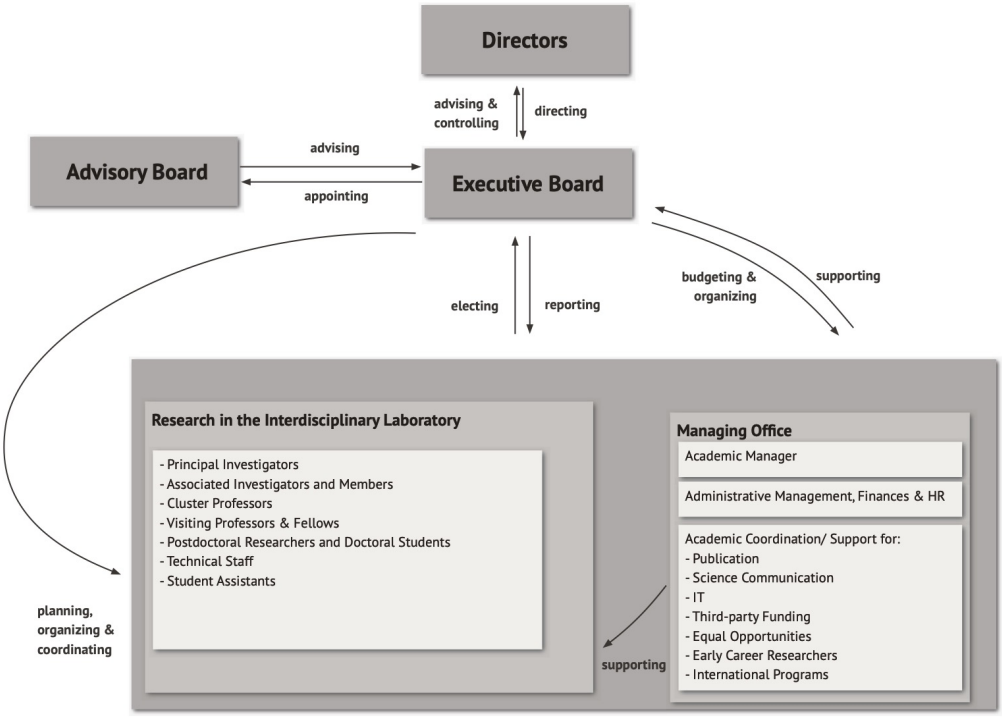


Fig. 10: The overview summarizes the organization and functions of the Cluster's central bodies, decision-making committees, and research and management units. (Image Credits: *Image Knowledge Gestaltung*)

Quality assurance and allocation of internal funds

In the beginning, the Cluster's research was based on four interrelated levels of varying degrees of interdisciplinary complexity: (1) research projects; (2) research areas A–C; (3) key themes; and (4) research area D. Within research area D, the Cluster created an instrument for reflecting upon both the Cluster's research activities and its organization. This served to internally evaluate research practices and contributed to assuring the quality of the Cluster's research activities. All research projects were developed by at least two principal investigators from different disciplines and received funding upon application to, and approval by, the Executive Board. Upon the DFG's approval of the Cluster, the Cluster had to face the challenge that it received only 71% of the requested funding and needed to adapt its budget plans. In order not to destroy the trustful collaborative spirit of the principal investigators, which was the foundation of the Interdisciplinary Laboratory, the Executive Board decided not to withdraw any individual project, but to reduce the internal funding period for projects as well as their staffing and equipment. As a consequence, the projects had to readjust their work programs, resulting in a loss of interdisciplinary scope. The Executive Board approved project funding for an initial period of two years. Following a successful continuation application, the funding periods for research projects were extended. With the support of the management office, the projects were responsible for administering their own funds. The Cluster encouraged cross-project collaboration and allocated specific funding for such activities, such as seed funding. All members of the Cluster's research staff were eligible to

apply for internal project funding. For example, »gamelab.berlin« was initiated by several early career researchers and finally funded as a new Cluster project. After the first phase (November 2012 to December 2015), the Cluster's research structure was reorganized into five priority areas to better accommodate jointly developed and convergent projects. The priority areas were headed by two principal investigators and two postdoctoral researchers (upon application the postdoctoral co-leaders were selected by the Executive Board). The priority area leaders jointly formulated specific funding criteria for research projects within their priority area. During this transition, new and already existing projects were invited to apply by the Executive Board. Each project proposal—including project goals, work plan, and proposed budget—was externally evaluated by two reviewers from different disciplines. On the basis of these external assessments and the criteria formulated by the priority area leaders, the Executive Board decided on the funding. This reorganization enabled the Cluster to strengthen its focus on specific topics (see matrix-structure of the second phase, p. 19). Through this prioritization process, the Cluster modified the procedure for internal approval of projects, incorporating a quality assurance procedure. The priority area leaders were responsible for, and coordinated, an assessment of the current status of research activities and research results in their priority areas. Through regular meetings with the priority area researchers, they consolidated and brought together research themes and achievements, initiated processes for developing research perspectives and for generating new objects and themes of study.

Publication strategy and outreach activities

Multiple authorships transcending the boundaries between the humanities, the natural and engineering sciences, and the *Gestaltung* disciplines were of central importance to the publication of research results. The results of interdisciplinary research were intentionally placed in discipline-specific journals of a broad range of scientific publishers. At the same time, the Cluster used the cross-disciplinary repository Zenodo as a central repository for open access publications. However, the turn to *Gestaltung* within the Cluster called for a variety of publication methods and outputs: from traditional books to films and product prototypes, from high-profile international conferences to serious games and podcasts, from new software to radically innovative exhibition formats, and even including hybrid publications. The Cluster therefore promoted the publication of research objects requiring a specific publication format. This diversity of outputs increased the Cluster's outreach, extending it beyond the academic system. Exhibitions played a central role within the Cluster's publication strategy, and they were regarded as a specific form of research and *Gestaltung*, operating under an independent set of rules. In accordance with the principle of "research and display," the Cluster was involved in numerous exhibitions. The central Cluster exhibition »+ultra. knowledge & gestaltung« was on show from September 2016 to January 2017 in the Martin-Gropius-Bau Berlin, where it occupied 1,000

square meters of exhibition space and received more than 35,000 visitors in three months. Using objects from the natural world, artifacts, and interactive installations, the exhibition presented the growing *interdependence* of the human and technological spheres by offering new perspectives on processes of *Gestaltung* in academic research. In addition to playing an app-based game developed specially for this exhibition, visitors had the opportunity to participate in numerous accompanying events designed to communicate the exhibition's themes to both the public in general and specific target groups, such as high school students. The Cluster actively involved students in the conceptualization and curation of exhibitions in HU's Veterinary Anatomy Theater as part of their training.

With the »Interdisciplinary Summer Universities for Children« in 2013 and 2014, the Cluster opened up the university even further to school-aged children. The project »The Anthropocene Kitchen« published its results *inter alia* in the form of a science comic that explores the use of resources and changes in eating cultures all over the world in the age of globalization.[92] Other publications were designed for use in teaching, such as the handbook »Image Guidance«, which is aimed at medical students.[93]

4.2 Relationship between the Cluster, the host university/universities and the participating partners

Host university: The initiative for creating the Cluster originated from the Department of Art and Visual History and the Department of Cultural History and Theory at HU Berlin, which had conducted joint interdisciplinary research at the HZK for more than a decade up until that point. The Cluster was therefore initially led by two professors from the humanities: Professor Horst Bredekamp from the Department of Art and Visual History and Professor Wolfgang Schäffner from the Department of Cultural History and Theory. With the ongoing integration of the natural sciences and the disciplines of *Gestaltung*, Professor Peter Fratzl, Director of the Max Planck Institute of Colloids and Interfaces, was elected as a third Director of the Cluster in 2016. His election underlined and intensified the collaborative approach of different disciplines and institutions as equal partners within the Cluster. The Cluster's leadership team reflects its successful establishment of exceptional axes of joint interdisciplinary research within HU Berlin and beyond. The Cluster provided a shared space in which diverse disciplinary experts who would otherwise be based in different university departments now collaborated closely with each other. The interdisciplinary knowledge and practices gained from the cooperation were fed back

[92] Leinfelder, R., Hamann, A., Kirstein, J., Schleunitz, M.-A., eds. (2016) *Eating Anthropocene: Curd Rice, Bienenstich and a Pinch of Phosphorus - Around the World in Ten Dishes*. Berlin: Springer.
[93] Friedrich, K., Moritz Q., Roethe, A., eds. (2016) Image guidance: Bedingungen bildgeführter Operation. Bildwelten des Wissens, Band 12. Boston: De Gruyter.

into the disciplinary departments at HU Berlin with a lasting effect. This, in turn, strengthened disciplinary knowledge. At the same time, the Cluster professorships—*History and Theory of Form*, *History and Theory of Gestaltung*, and *Morphology and History of Forms*—have systematically strengthened interdisciplinary collaboration at an intra-university level, for instance between the Department of Biology and the Department of Art and Visual History. As a result of the Cluster's strategies and via its networks, the links between two historically and geographically separated HU Berlin campuses, Mitte and Adlershof, were intensified with a sustainable impact. At the same time, the Cluster *Image Knowledge Gestaltung* became a tremendous engine for innovation in knowledge transfers and science communication within HU Berlin and beyond: In the Veterinary Anatomy Theater of HU Berlin, the Cluster created a unique knowledge space in which exhibitions are designed as a laboratory where the university can address society at large. The Cluster further promoted the development and museological refinement of HU Berlin's over 40 university collections, resulting, inter alia, in the planned relocation of HU Berlin's Sound Archive to the Humboldt Forum. As a result, the Cluster's activities were transformed, via the HZK, into a unique, sustainable institutional structure at HU Berlin for implementing design processes in research (cf. section 4.3).

Participating institutions and cooperation partners in Berlin and Germany: The Cluster fostered intense collaboration between more than 40 disciplines and many institutions, all represented by renowned researchers. In addition to researchers from the various disciplines represented at HU, participants in the Cluster included members of (applied) universities, museums, cultural institutions, and non-university research institutions based in Berlin and the region, thus creating an integrated research environment. This broad and diversified network formed by the Cluster made it possible to pool highly specialized equipment and infrastructure, for instance for the design disciplines and the natural sciences, and to learn from each other in terms of interdisciplinary research processes. Most importantly, it enabled the close integration of practice- and theory-based design expertise into the Cluster's basic research and the promotion early career researchers, for instance, via joint master's programs and a joint doctoral program.
The following universities and research institutions were integrated in the Cluster's research structure: Charité, FU Berlin, HTW Berlin, TU Berlin, Weißensee Academy of Art Berlin, Anhalt University of Applied Sciences, BAM Federal Institute for Materials Research and Testing, Kunstbibliothek of the Staatliche Museen zu Berlin (Prussian Cultural Heritage Foundation), Kunstgewerbemuseum of Staatliche Museen zu Berlin (Prussian Cultural Heritage Foundation), Ibero-American Institute (Prussian Cultural Heritage Foundation), Leibniz Center for Literary and Cultural Research (ZfL), Max Planck Institute of Colloids and Interfaces, Museum für Naturkunde, and Zuse Institute Berlin. In addition, the following institutions contributed to the Cluster's research as its most important national cooperation partners: Bauhaus Dessau Foundation,

Centre for Contemporary History Potsdam, Deutsches Hygiene-Museum Dresden, Filmuniversität Babelsberg, Haus der Kulturen der Welt (HKW), Humboldt Forum, Max Planck Institute for the History of Science, University of Kassel (Architectural Theory and Design).
The Cluster initiated formalized joint agreements with all participating institutions and with all important national cooperation partners for the time frame of the Cluster's funding period. In addition, the Cluster established the permanent interdisciplinary MSc. program »COOP Design Research« together with its partners in Dessau (Anhalt University of Applied Sciences, Bauhaus Dessau Foundation); this program explores design as research, education, and projection. In the case of Charité, HTW University of Applied Sciences Berlin, and the Weißensee Academy of Art, the close cooperation with the Cluster *Image Knowledge Gestaltung* led to joint appointments of Cluster professorships within the follow-up Cluster *Matters of Activity*. The close cooperation with the Weißensee Academy of Art Berlin and the HTW University of Applied Science in Berlin laid the ground for the establishment of new regulations for a practice-based interdisciplinary PhD program at the HZK as an essential infrastructure for promoting interdisciplinary early career researchers.

Focused internationalization: Fostering internationalization is one of HU Berlin's central strategic goals that brings together the interests of all its departments and calls for its conceptual embedding in all areas of research and teaching and in the university's administrative structures. The *Cluster Image Knowledge Gestaltung* was an integral part of this approach. Thanks to the worldwide network of the Cluster's researchers and its collaborative relationships with the international institutions (for instance the ties with the École Nationale Supérieure des Arts Décoratifs and the École Nationale Supérieure des Beaux-Arts in Paris, the FHNW Academy of Art and Design in Basel, and the IFK International Research Center for Cultural Studies in Linz), the Interdisciplinary Laboratory was a local site with a global character. In the Americas, close relationships were forged in the US with the Bard Graduate Center in New York and the Wyss Institute at Harvard University as well as in Latin America—in particular with the Universidad de Buenos Aires (Argentina), the Universidade de São Paulo (Brazil), the Universidad Nacional de Colombia in Bogotá, and the Universidad Austral de Chile in Valdivia. These collaborations initiated by the Cluster explicitly continued the Humboldtian tradition of HU Berlin. Within these cooperations, interdisciplinary spaces and design processes were developed in accordance with local conditions, reflecting and integrating cultural specificities in the *Gestaltung* of knowledge. The Cluster thus rose to the challenge of combining global practices with locally and culturally determined knowledge. At the same time, these collaborative relationships were used to promote early career researchers in an intercultural environment. Together with the Universidad de Buenos Aires in Argentina, the Cluster established the international master's program »Open Design«, which focuses on interdisciplinary design processes. The double degree program

offered by HU Berlin and the Universidad de Buenos Aires has been permanently established to bridge the “traditional” gap between design and the classical research disciplines within the next generation of researchers.

4.3 Sustainability

Impact on the research profile of HU Berlin and the Berlin University Alliance: Independence of research, the integration of the humanities and the natural sciences, and the unity of research and teaching are the main principles upon which HU Berlin was founded in 1810. As one of only six Clusters initiated by the humanities in the last funding period of the Excellence Initiative, *Image Knowledge Gestaltung* significantly enhanced HU Berlin’s profile in a new kind of humanities and its leading role in interdisciplinary research, increasing its national and global visibility, and advancing the Humboldtian model of higher education. At the same time, the Cluster *Image Knowledge Gestaltung* became a tremendous engine for innovation in knowledge transfers and science communication within HU Berlin and beyond: The Cluster played a significant role in opening up interdisciplinary research processes at HU Berlin to the general public, enabling diverse forms of critical access to material knowledge cultures and scientific collections. In the Veterinary Anatomy Theater of HU Berlin, for instance, the Cluster created a public exhibition space for experimental forms of presentation and a laboratory for curatorial practices. The Cluster also promoted the accessibility of, and new research perspectives regarding, HU Berlin’s over 40 university collections, resulting, inter alia, in the planned relocation of HU Berlin’s Sound Archive to the Humboldt Forum. The Cluster was also responsible for the planning phase of the architectural space and for drawing up the agenda of the Humboldt Labor, which will serve in the future as HU Berlin’s open laboratory in the Humboldt Forum. The Cluster thus contributed substantially to expanding the humanities and their collaborative structures with the natural sciences and the design disciplines into a new field of interdisciplinary openness, and to a novel kind of science communication on the future core focuses of HU Berlin. Further, it was a key driver for the Core Research Area »Art, Design and Cultural Heritage« and for Strategic Objective 2, »Fostering Knowledge Transfer«, of the *Berlin University Alliance*, which will be funded within the Excellence Strategy starting from November 2019.

Institutional sustainability: Providing sustainability for a dynamic and flexible research structure is a particular challenge for any research institution. The aim was not to perpetuate a specific research topic studied by *Image Knowledge Gestaltung*, but rather the interdisciplinary platform so as to guarantee a kind of dynamism and adaptability in interdisciplinary research that is embedded at the university level and remains open to changes and innovation. At the beginning,

one of the Cluster's research projects was concerned with the construction of a flexible, physical architecture of knowledge by transforming a historical library building into a new, adaptive research building that would function as a permanent location for an Interdisciplinary Laboratory of HU Berlin. Due to the special requirements relating to the preservation of historic monuments and the environmentally unacceptable requirements of air conditioning technology, it was impossible to carry out central reconstruction measures on the building. At the same time, it became evident that the HZK, where the Cluster was affiliated, offers a different but extraordinary architectural framework for continuing the Cluster's vision of an interdisciplinary open lab as a strategic project of HU Berlin. In the context of the Cluster's plans, the HZK was strengthened, becoming a central institute of HU Berlin with interdisciplinary faculty status in 2012.[94] The key role in the collection- and curation-oriented *Gestaltung* of research processes assumed by the HZK within HU Berlin today situates the Cluster's goals within the university's profile development. In order to sustain the interdisciplinary research focuses and dynamic structures of the Cluster *Image Knowledge Gestaltung* at HU Berlin*,* the HZK was further equipped with an Object Lab (since October 2019) and a permanent budget for staff and equipment. Starting in 2020, professorships will be directly appointed at the HZK to further sustain the Cluster's approach of combining design and interdisciplinary research with teaching and science communication. For instance, at the HZK it is planned to establish the professorship »Theory and Practice of Curation«, which will conduct research in the context of the Humboldt Labor. What is more, in 2018 the HZK assumed concretized permanent functions as follows:

- As a central institute of HU Berlin, the HZK pursues project-related interdisciplinary research and teaching as well as designing interdisciplinary research.
- It combines research on cultural techniques and on scientific collections with object- and material-oriented teaching and with curating as a novel form of science communication in the Humboldt Labor of the Humboldt Forum.
- Through its unique venues (the Veterinary Anatomy Theater with a historical seminar room and the Object Lab, the Humboldt Labor in the Humboldt Forum, HU's scientific collections), the HZK links historical and future-oriented perspectives in research on cultural techniques at the level of practices, materials, collection objects, and design processes.

The HZK thus provides a unique institutional sustainability for the Cluster's project. It combines the permanent status of a faculty with flexible research constellations and the mandate for HU Berlin's scientific collections and science communication. On the level of facilities, it offers a technically equipped Object Lab for object- and material-oriented research, a historical classroom for combining research and teaching, and two extraordinary exhibition spaces, the Veterinary Anatomy Theater and the Humboldt Labor. With this unique infrastructure, the HZK guarantees

[94] Founded in 2000, the HZK was initially established as an interdisciplinary center to strengthen HU Berlin's interdisciplinary profile.

that the essential links between the two separated HU Berlin campuses Mitte and Adlershof that were intensified by the Cluster continue beyond the funding period: Currently, more than 20 professors from ten HU Berlin departments are affiliated as members of the HZK, working jointly on projects and training early career researchers. What is more, the Cluster professorships—*History and Theory of Form* (permanent full professor), *History and Theory of Gestaltung,* and *Morphology and History of Forms* (tenure)—assure the sustainability of the interdisciplinary research structure at the intra-university level, and continue the turn to *Gestaltung* at HU Berlin. In addition to perpetuating the Cluster's goal of being an open lab and fostering dynamic research constellations for interdisciplinary research at HU Berlin, the HZK is also the permanent home to the Cluster's innovative formats for the interdisciplinary promotion of early career researchers. The Cluster has established two permanent interdisciplinary master's programs, which focus on design processes and design research: the master's program »Open Design«, a double degree program that is offered jointly by HU Berlin and the Universidad de Buenos Aires, and the master's program »COOP Design Research«, offered jointly with Anhalt University of Applied Sciences and the Bauhaus Dessau Foundation. As a further step toward integrating design processes into basic research, the Cluster—together with the Weißensee Academy of Art Berlin and the HTW University of Applied Science Berlin—has laid the foundation for a practice-based PhD program at the HZK. All these measures will be implemented on an ongoing basis at the HZK.

With regard to the interdisciplinary collaborations with partner institutions, both the HZK and the follow-up Cluster *Matters of Activity* will continue the established partnerships with Berlin universities, applied universities, museums, and non-university institutions in Europe and abroad, integrating them into new research projects, for instance by strengthening the research axis between Berlin and Paris.

Follow-up Cluster *Matters of Activity*: Harnessing the collaborative potential of HU Berlin and the city of Berlin as a thriving and diversified center for research and design, *Image Knowledge Gestaltung* has established an interdisciplinary laboratory based on a culture of mutual trust and collaboration as equal partners between humanities scholars, natural and computer scientists, engineers, and designers at HU Berlin and beyond. This unprecedented interdisciplinary culture of research enabled the leaders of the Cluster *Image Knowledge Gestaltung* to initiate a successful application for a Cluster of Excellence within the new Excellence Strategy: The research focus on the activity of materials coded into their structure, which emerged during the Cluster's second phase in the priority area »Active Matter«, became the crucial foundation for the research program of the follow-up Cluster *Matters of Activity*. The follow-up Cluster thus builds on the convergent and integrative concept of active matter, a challenging issue that is driving developments at the heart of a whole range of disciplines, including the materials sciences,

physics, biology, medicine, cultural and science studies, art history, media theory, anthropology, philosophy, and the design disciplines. Since this research topic cannot be addressed adequately by the disciplines individually, a close collaboration between the humanities, natural sciences, engineering, and design is a fundamental requirement for the Cluster. While research, industry, and our whole society are moving toward a new expansion and implementation of the digital into all spheres of life, the Cluster *Matters of Activity* proposes to explore the opposing direction by addressing a new culture of the material. The Cluster *Matters of Activity* will therefore explore materials' own inner activity, which can be discovered as a new source of innovative strategies and mechanisms for rethinking the relationship between the analog and the digital, and for designing more sustainable, energy-efficient technologies. The Interdisciplinary Laboratory established by the Cluster *Image Knowledge Gestaltung* is the unquestionable basis for the ambitious research plans of the Cluster *Matters of Activity*. In the Cluster *Matters of Activity*, interdisciplinarity is further emblematically embedded at the level of the directors' disciplinary backgrounds, which span the humanities, the natural sciences, and design. This creates a new model for research that combines the Humboldtian university with the tradition of the Bauhaus.

5 Overview of the Cluster's Resources

5.1 Resources

5.1.1 Staff

Table 3: Staff

Staff	Funded by the Cluster			Funded by other sources		
	Number of persons					
Academic staff	f	m	total	f	m	total
Professors (W2-W3)	6*	1*	7	16	51	67
Professors (W1)	1	1	2	3	2	5
(Junior) group leaders	0	1	1	0	4	4
Postdocs (including temporary substitute positions for clinicians)	22	25	47	5	15	20
Doctoral researchers	39	21	60	3	4	7
Research associates/other academic staff	30#	20#	50	0	0	0
Guest researchers	17	41	58	0	0	0
Non-academic staff	15	1	16	0	0	0

* This counting includes deputy professorships.
# This counting includes designers who did not pursue a PhD.

5.1.2 Infrastructure

Table 4: Major infrastructure measures since the Cluster's set-up

Infrastructure measure	Costs (in €K)	Funded by

Items included in Table 5 are not listed here.

Table 5: Major research equipment provided by the Cluster's set-up

	Year of purchase	Amount [€k]
Major research equipment (exceeding €150,000 per item)		
Total [€k]		

Items included in Table 4Table 4 are not listed here.

5.2 Expenditures

Table 6: Cluster expenditures

	2012/13	2014	2015	2016	2017	2017/18	Sum
in €k							
Professors (W2-W3)	0	43	206	227	173	228	**877**
Professors (W1)	0	0	196	210	0	86	**492**
(Junior) group leaders and postdocs	386	824	1.225	1.582	1.029	1.561	**6.607**
Doctoral researchers [1)]	1.275	2.050	2.800	2.378	1.945	2.465	**12.913**
Other staff	444	634	805	1.013	669	750	**4.315**
Sum (staff)	**2.105**	**3.551**	**5.232**	**5.410**	**3.816**	**5.090**	**25.204**
Research equipment [2)]	59	100	139	11	0	47	**356**
Other costs [3)]	674	986	1.428	2.215	1.377	1.287	**7.967**
Total [€k]	**2.838**	**4.637**	**6.799**	**7.636**	**5.193**	**6.424**	**33.527**

[1)] Including fellowships
[2)] > €10,000 per item
[3)] Including minor research equipment (< €10,000 per item)

6 Comments to the DFG

The adaptability of the Cluster's research structure was a key strategy for assuring the quality of its research outcomes. In doing so, the Cluster *Image Knowledge Gestaltung* made use of the unusual openness and de-bureaucratized format of the *Clusters of Excellence* funding line, which cannot be found anywhere else in the German research system. We would therefore like to thank the DFG for offering such an important funding line that fosters innovative formats and enables

researchers to tackle new kinds of interdisciplinary research challenges. The flexible format of the *Clusters of Excellence* allowed for a highly flexible research process, including the dynamic elaboration of the Cluster's research projects, their ongoing adjustment and completion. The adaptive research process and dynamic internal structures made it possible to take account of shifting or newly emerging project constellations and research priorities, which, in turn, further specified and refocused the Cluster's central goals, as stated in the Cluster's initial proposal. We believe that the trust that the DFG offers researchers with such a format is of immense value to the German science and research system because only freedom in academia can lead to new and courageous perspectives and to innovation.

Great flexibility was also allowed in terms of the Cluster's management, especially with regard to the transfer of resources from one year to the next so that the budget could be adapted to actual needs. The informal network of academic managers (CEOs) of the Clusters of Excellence proved to be very helpful and productive in enabling flexible solutions. The cooperation with the responsible scientific and administrative officers of the DFG's Head Office was always very constructive and trustful.

In complete contrast to these excellent research management possibilities were the problems of the Cluster's start: The budget cut of 29% transformed the Cluster's beginning into its most critical moment. Readjusting the new budget to the proposed and positively approved Cluster program resulted in a real gap between the envisioned program and the actually feasible activities. The decision to not suspend any project but to shorten the projects' running time and to scale back the disciplinary diversity had profound effects on the implementation of the envisioned fundamental interdisciplinary collaboration in all projects.

Another negative aspect was the very late timing of the decision not to grant completion funding, which was not made until shortly before the end of the Cluster's funding period. Since the Cluster *Matters of Activity* has a new research focus and was proposed as a "new" Cluster of Excellence in the application, it was internally communicated to all scientific staff that there would be no automatic continuity in terms of contracts. However, as the Cluster *Matters of Activity* was instead approved by the DFG as a follow-up project, the Cluster *Image Knowledge Gestaltung* did not receive the expected completion funding. As a consequence, all the postdocs' contracts ended abruptly, which resulted in a very unfortunate situation for the Cluster's early career researchers. We therefore propose that the decision on whether a Cluster initiative is to be classified as a new Cluster project or as a follow-up Cluster should be made at least six months before the end of the initial Cluster's funding period, ideally at the same time as the decision on the draft proposals in the first application stage. This will guarantee that early career researchers have the opportunity to look for new positions in good time.

7 Appendix A (Non-Confidential)

7.1 Most important publications of the Cluster

2019

Amelung, Kathrin Mira (2019): **Illustration: On the Epistemic Potential of Active Imagination in Science.** In: Male, Alan (Ed.): A Companion to Illustration: Art and Theory. Oxford: Wiley-Blackwell, 330-353.

Blümle, Claudia (2019): **Schauspiele des Halbversteckten. Eine Bildgeschichte des gemalten Vorhangs.** Paderborn: Fink.

Bock von Wülfingen, Bettina (Ed.) (2019): **Science in Color. Visualizing Achromatic Knowledge**. Berlin: De Gruyter.

Bredekamp, Horst (2019): **Galileo's Thinking Hand. Mannerism, Anti-Mannerism and the Virtue of Drawing in the Foundation of Early Modern Science.** Berlin: De Gruyter.

Geipel, Finn/Hansmann, Sabine (Eds.) (2019): **Raummaschine. Exploring Manifold Spaces.** Berlin: Jovis.

Hadjinicolaou, Yannis (2019): **Thinking Bodies – Shaping Hands. Handeling in Art and Theory of the late Rembrandtists.** Leiden: Brill Academic Publishers. (PhD thesis, Freie Universität Berlin)

Huss, Till Julian (2019): **Ästhetik der Metapher. Philosophische und kunstwissenschaftliche Grundlagen visueller Metaphorik**. Bielefeld: transcript. (PhD thesis, Humboldt-Universität zu Berlin)

Jany, Susanne (2019): **Prozessarchitekturen. Medien der Betriebsorganisation (1880-1936)**. Konstanz: Konstanz University Press. (PhD thesis, Humboldt-Universität zu Berlin)

Kunze, Franziska (2019): **Opake Fotografien. Das Sichtbarmachen fotografischer Materialität als künstlerische Strategie**. Berlin: Reimer. (PhD thesis, Humboldt-Universität zu Berlin)

Liptau, Ralf (2019): **Architekturen bilden. Das Modell in Entwurfsprozessen der Nachkriegsmoderne**. Bielefeld: transcript. (PhD thesis, Universität der Künste Berlin)

Marguin, Séverine/Rabe, Henrike/Schäffner, Wolfgang/Schmidgall (Eds.) (2019): **Experimentieren. Einblicke in Praktiken und Versuchsaufbauten zwischen Wissenschaft und Gestaltung.** Bielefeld: transcript.

Marguin, Séverine/Rabe, Henrike/Schmidgall, Friedrich (2019): **The Experimentalzone. An Interdisciplinary Investigation on the Spaces and Practices of Collaborative Research**. Zürich: Park Books.

Nyakatura, John A./Melo, Kamilo/Horvat, Tomislav/Karakasiliotis, Kostas/Allen, Vivian R./Andikfar, Amir/Andrada, Emanuel/Arnold, Patrick/Lauströer, Jonas/Hutchinson, John R./Fischer, Martin S./Ijspeert, Auke J. (2019): **Reverse-engineering the locomotion of a stem amniote**. In: Nature, vol. 565, 351–355. DOI: 10.1038/s41586-018-0851-2

Pawel, Anja (2019): **Abstraktion und Ausdruck: Bildende Kunst und Tanz im frühen 20. Jahrhundert (Image Word Action, 8).** Berlin: De Gruyter. (PhD thesis, Humboldt-Universität zu Berlin)

Scheidt, Adrian/Wölfer, Jan/Nyakatura, John A. (2019**): The evolution of femoral cross-sectional properties in sciuromorph rodents: Influence of body mass and locomotor ecology**. In: Journal of Morphology, no. 280, 1156-1169. DOI: 10.1002/jmor.21007

Trabant, Jürgen: **Giambattista Vico – Poetische Charaktere (Image Word Action, 7).** Berlin: De Gruyter 2019.

Wölfer, Jan/Amson, Eli/Arnold, Patrick/Botton-Divet, Léo/Fabre, Anne-Claire/van Heteren, Anneke H./Nyakatura, John A. (2019): **Femoral morphology of sciuromorph rodents in light of scaling and locomotor ecology**. In: Journal of Anatomy, vol. 234, no. 6, 731-747.
DOI: 10.1111/joa.12980

2018

Acker, Güliz/Schlinkmann, Nicolas/Piper, Sophie K./Onken, Julia/Vajkoczy, Peter/Picht, Thomas (2018): **Stereoscopic Versus Monoscopic Viewing of Aneurysms: Experience of a Single Institution with a Novel Stereoscopic Viewing System**. In: World Neurosurgery, vol. 119, e491-e501. DOI: 10.1016/j.wneu.2018.07.189

Bruhn, Matthias/Hillnhütter, Sara (Eds.) (2018): **Bilder der Präzision. Praktiken der Verfeinerung in Technik, Kunst und Wissenschaft.** Berlin: De Gruyter. With contributions from Matthias Bruhn, Katharina Lee Chichester, Anne Dippel, Kathrin Friedrich, Nina Samuel et al.

Busch, Carsten/Kassung, Christian/Sieck, Jürgen (Eds.) (2018): **Kultur und Informatik: Hybrid Systems.** Glückstadt: Verlag Werner Hülsbusch. With contributions from Jürgen Sieck, Erika Holter, Una Schäfer, Kerstin Germer, Maja Stark, Tiago da Costa e Silva et al.

Caspar, Mark-Oliver (2018): **Social Enactivism. On Situating High-Level Cognitive States and Processes (Image Word Action, 6).** Berlin: De Gruyter. (PhD thesis, Humboldt-Universität zu Berlin)

Casper, Mark-Oliver/Nyakatura, John A./Pawel, Anja/Reimer, Christine/Schubert, Thorsten/Lauschke, Marion (2018): **The movement-image compatibility effect: embodiment theory interpretations of motor resonance with digitized photographs, drawings, and paintings.** In: Frontiers in Psychology, vol. 9, no. 991. DOI: 10.3389/fpsyg.2018.00991

da Costa e Silva, Tiago (2018): **The Logic of Design Process. Invention and Discovery in Light of the Semiotics of Charles S. Peirce**. Bielefeld: transcript. (PhD thesis, Universität der Künste Berlin)

de Günther, Sabine/Zitzlsperger, Philipp (Eds.) (2018): **Signs and Symbols. Dress at the Intersection between Image and Realia**. Berlin: de Gruyter.

Dürfeld, Michael/Schultz, Anika/Stein, Christian/Thomack, Benjamin/Zeissig, Nadia (2018): **ID+Lab – Analyzing, Modeling and Designing Interdisciplinarity.** In: Nuria Rodríguez-Ortega (coord.): Digital Humanities: societies, politics and knowledge. Artnodes. no. 22.
DOI: 10.7238/a.v0i22.3214

Eder, Michaela/Amini, Shahrouz/Fratzl, Peter (2018): **Biological composites—complex structures for functional diversity.** In: Science, vol. 362, no. 6414, 543–547.
DOI: 10.1126/science.aat8297

Feiersinger, Luisa/Friedrich, Kathrin/Queisner, Moritz (Eds.) (2018): **Image – Action – Space. Situating the Screen in Visual Practice**. Berlin: De Gruyter.

Friedman, Michael (2018): **A History of Folding in Mathematics: Mathematizing the Margins** (Science Networks. Historical Studies, 59). Basel: Birkhäuser.

Friedrich, Kathrin (2018)**: Medienbefunde: Digitale Bildgebung und diagnostische Radiologie**. Berlin: De Gruyter. (PhD thesis, Humboldt-Universität zu Berlin)

Grewe, Carl Martin/le Roux, Gabriel/Pilz, Sven-Kristofer/Zachow, Stefan (2018): **Spotting the Details: The Various Facets of Facial Expressions.** In: IEEE International Conference on Automatic Face and Gesture Recognition, 286-293. DOI: 10.1109/FG.2018.00049

Holter, Erika/Muth, Susanne/Schwesinger, Sebastian (2018): **Sounding out Public Space in Late Republican Rome.** In: Butler, Shane/Nooter, Sarah (Eds.): Sound and the Ancient Senses. London: Routledge, 44–60.

Kassung, Christian/Schwesinger, Sebastian (2018): **Saxa Loquuntur: The Function of (Multi-) Media for Antique Architecture.** In: Dharm Singh Jat et. al. (Ed.): Digitisation of Culture: Namibian and International Perspectives. Singapur: Springer, 171–185.
DOI: 10.1007/978-981-10-7697-8_11

Knötel, David/Becker, Carola/Scholtz, Gerhard/Baum, Daniel (2018*):* **Global and Local Mesh Morphing for Complex Biological Objects from microCT Data.** In: Eurographics Workshop on Visual Computing for Biology and Medicine (VCBM) 2018, 179 - 183.
DOI: 10.2312/vcbm.20181243

Lilge, Thomas/Stein, Christian (Eds.) (2018): **Spielwissen und Wissensspiele. Wissenschaft und Game-Branche im Dialog über die Kulturtechnik des Spiels.** Bielefeld: transcript.

Mareis, Claudia/Windgätter, Christof (Eds.) (2018): **Wild Thing. Unordentliche Prozesse in Design und Wissenschaft.** Berlin: Kadmos.

Montañez-Rivera, Irene/Nyakatura, John A./Amson, Eli (2018): **Bone cortical compactness in 'tree sloths' reflects convergent evolution.** In: Journal of Anatomy vol. 233, no. 5, 580-591. DOI: 10.1111/joa.12873

Moser, Jeannie/Vagt, Christina (Eds.) (2018): **Verhaltensdesign: Technologische und ästhetische Programme der 1960er und 1970er Jahre (Edition Kulturwissenschaft, 167).** Bielefeld: transcript.

Reindl, Antonia/Schubert, Torsten/Strobach, Tilo/Becker, Carola/Scholtz, Gerhard (2018): **Adaptation aftereffects in the perception of crabs and lobsters as examples of complex natural objects.** In: Frontiers in Psychology vol. 9, no. 1905. DOI: 10.3389/fpsyg.2018.01905

Seppi, Angelika (2018): **Schrift und Gerechtigkeit. Kritisches zur Metaphysik**. Wien: Passagen Verlag.

Thongsomboon, Wiriya/Serra, Diego O./Possling, Alexandra/Hadjineophytou, Chris/Hengge, Regine/Cegelski, Lynette (2018) **Phosphoethanolamine cellulose: a naturally produced chemically modified cellulose**. In: Science, vol. 359, no. 6373, 334-338. DOI: 10.1126/science.aao4096

2017

Bock von Wülfingen, Bettina (Ed.) (2017): **Traces. Generating what was there.** Berlin: De Gruyter. With contributions from Kathrin Mira Amelung, Bettina Bock von Wülfingen, Günther Jirikowski, Marietta Kesting, Sophia Kunze, John A. Nyakatura, Thomas Stach et al.

Braun, Katrin/Stach, Thomas (2017): **Structure and Ultrastructure of Eyes and Brains of Thalia Democratica (Thaliacea, Tunicata, Chordata).** In: Journal of Morphology. DOI: 10.1002/jmor.20722.

Bredekamp, Horst (2017): **Image Acts. A Systematic Approach to Visual Agency (Image Word Action, 2).** Berlin: De Gruyter.

Bruhn, Matthias/Scholtz, Gerhard (Eds.) (2017): **Der vergleichende Blick. Formanalyse in Natur- und Kulturwissenschaften**. Berlin: Reimer.

Busch, Carsten/Kassung, Christian/Sieck, Jürgen (Eds.) (2017): **Kultur und Informatik. Mixed Reality.** Glückstadt: Hülsbusch. With contributions from Claudia Müller-Birn, Thomas Lilge, Moritz Queisner, Jürgen Sieck, Jochen Hennig et al.

Cedeño Montaña, Ricardo (2017): **Portable Moving Images. A Media History of Storage Formats**. Berlin: De Gruyter. (PhD thesis, Humboldt-Universität zu Berlin)

Cojal González, José D./Iyoda, Masahiko/Rabe, Jürgen P. (2017): **Templated bilayer self-assembly of fully conjugated π-expanded macrocyclic oligothiophenes complexed with fullerenes.** In: *Nature Communications* 8, 14717. DOI: 10.1038/ncomms14717

Drews, Ann-Cathrin/Martin, Katharina D. (Eds.) (2017): **Innen – Außen – Anders. Körper im Werk von Gilles Deleuze und Michel Foucault.** Bielefeld: transcript.

Doll, Nikola/Bredekamp, Horst/Schäffner, Wolfgang for the Cluster of Excellence »Image Knowledge Gestaltung. An Interdisciplinary Laboratory« (Eds.) (2017): **+ultra. knowledge & gestaltung.** Exh. cat. Martin Gropius Bau, Berlin. Leipzig: E. A. Seemann.

Faghani, Abbas/Donskyi, Ievgen S./Gholami, Mohammad Fardin/Ziem, Benjamin/Lippitz, Andreas/Unger, Wolfgang E. S./Böttcher, Christoph/Rabe, Jürgen P./Haag, Rainer/Adeli, Mohsen (2017): **Controlled Covalent Functionalization of Thermally Reduced Graphene Oxide To Generate Defined Bifunctional 2D Nanomaterials**. In: Angewandte Chemie Internationale Edition, vol. 56, 2675 –267. DOI: 10.1002/anie.201612422

Friedman, Michael/Seppi, Angelika (Eds.) (2017): **Martin Heidegger: Die Falte der Sprache**. Wien/Berlin: Turia + Kant.

Hoffmeister, Anouk/Berger, Florian/Pogorzhelskiy, Michael/Zhang, Guangtao/Zwick, Carola/Müller-Birn, Claudia (2017): **Toward Cyber-Physical Research Practice based on Mixed Reality.** In: Burghardt, Manuel/Wimmer, Raphael/Wolff, Christian/Womser-Hacker, Christa (Eds.): Mensch und Computer 2017 – Workshopband. Regensburg: Gesellschaft für Informatik e.V., 395–400. DOI: 10.18420/muc2017-ws08-0347

Jayasankar, A./Seidel, R./Guiducci, Lorenzo/Hosny, A.S.F./Fratzl, Peter/Weaver, J. C./Dunlop, John W.C./Dean, M.N. (2017): **Mechanical behavior of idealized, stingray-skeleton-inspired tiled composites as a function of geometry and material properties.** In: Journal of the Mechanical Behavior of Biomedical Materials. DOI: 10.1016/j.jmbbm.2017.02.028

Lauschke, Marion/Schneider, Pablo (Eds.) (2017): **23 Manifeste zu Bildakt und Verkörperung** (Image Word Action, 1). Berlin/Boston: De Gruyter.
Lauschke, Marion/Schiffler, Johanna/Engel, Franz (Eds.) (2017): **Ikonische Formprozesse: Zur Philosophie des Unbestimmten in Bildern** (Image Word Action, 3). Berlin: De Gruyter.

Leinfelder, Reinhold/Hamann, Alexandra/Kirstein, Jens/Schleunitz, Marc (Eds.) (2017): **Science Meets Comics. Proceedings of the Symposium on Communicating and Designing the Future of Food in the Anthropocene**. Berlin: Ch. A. Bachmann Verlag.
DOI: 10.5281/zenodo.556383

Nikolai, Angela/Thümmler, Sabine (Eds.) (2017): **Form Follows Flower. Moritz Meurer, Karl Blossfeldt und Co**. Exh. cat. Kunstgewerbemuseum – Staatliche Museen zu Berlin. Berlin: Deutscher Kunstverlag.

Orliowski, Maike/Lessing, Johanna/Sattler, Felix/Nyakatura, John A. (Eds.) (2017): **Orobates – Nach 300 Jahren reanimiert**. Exh. cat. TAT Berlin/Phyletisches Museum Jena.

Rosenstock, Tizian/Giampiccolo, Davide/Schneider, Heike/Runge, Sophie Jutta/Bährend, Ina/Vajkoczy, Peter/Picht, Thomas (2017): **Specific DTI seeding and diffusivity-analysis improve the quality and prognostic value of TMS-based deterministic DTI of the pyramidal tract**. In: NeuroImage: Clinical, vol. 16, 276–285. DOI: 10.1016/j.nicl.2017.08.010

Rosin, Susann/Nyakatura, John A. (2017): **Hind Limb Extensor Muscle Architecture Reflects Locomotor Specialisations of a Jumping Versus a Striding Quadrupedal Caviomorph Rodent**. In: Zoomorphology. DOI: 10.1007/s00435-017-0349-8

Stuhl, Frauke/Bredekamp, Horst/Schäffner, Wolfgang (Eds.) (2017):
+ultra. gestaltung schafft wissen. Dokumentation der Ausstellung und ihrer partizipativen Vermittlungsformate. Münster: Waxmann.

Scholtz, Gerhard (Ed.) (2017): **Serie und Serialität.** With contributions from Claudia Blümle, Günther Loose, Jonathan Ferracci, Gerhard Scholtz, Sandra Schramke, Richard Weinkamer et al. Berlin: Reimer.

Schulze, Mario (2017): **Wie die Dinge sprechen lernten. Eine Geschichte des Museumsobjektes 1968–2000**. Bielefeld: transcript.

Ukmar-Godec, T./Bertinetti, L./Dunlop, John W.C./Godec, A./Grabiger, M. A./Masic, A./Nguyen, H./Zlotnikov, I./Zaslansky, P./Faivre, D. (2017): **Materials nano-architecturing via cation-mediated protein assembly: making limpet teeth without mineral.** In: Advanced Materials. DOI: 10.1002/adma.201701171

van Dijk, Nathaja/Ergenzinger, Kerstin/Kassung, Christian/Schwesinger, Sebastian (Eds.) (2017): **Navigating Noise**. With a preface by Wolfgang Schäffner. Berlin: Verlag der Buchhandlung Walter König.

Weigel, Sigrid/Deutsches Hygienemuseum Dresden (Eds.) (2017): **Das Gesicht: Bilder – Medien – Formate.** Ausst.-Kat. Deutschen Hygiene-Museum Dresden. Göttingen: Wallstein.

2016

Bauche, Manuela/Vogel, Christian (Eds.) (2016): **Mobile Objekte**. Berichte zur Wissenschaftsgeschichte, vol. 39, no. 4: Special Issue. Weinheim: Wiley. With contributions from Jochen Hennig, Ricarda Musser, Anna Weymann, Barbara Göbel, Anke Te Heesen, Ina Heumann et al.

Beck, Thorsten (2016): **Shaping Images: Scholarly Perspectives on Image Manipulation.** Berlin: De Gruyter.
Blümle, Claudia/Wismer, Beat (Eds.) (2016): **Hinter dem Vorhang. Verhüllung und Enthüllung seit der Renaissance. Von Tizian bis Christo.** Exh. cat. Kunstpalast Düsseldorf. München: Hirmer.

Doll, Nikola/Bredekamp, Horst/Schäffner, Wolfgang für das Interdisziplinäre Labor »Bild Wissen Gestaltung« (eds.) (2016): **+ultra. gestaltung schafft wissen.** Exh cat. Martin-Gropius-Bau, Berlin. Leipzig: E. A. Seemann. With contributions from Claudia Blümle, Angela Bösl, Horst Bredekamp, Matthias Bruhn, Katharina Lee Chichester, Nikola Doll, Peter Fratzl, Kathrin Friedrich, Karin Krauthausen, Claudia Mareis, Moritz Queisner, Patricia Ribault, Reinhard Wendler, Wolfgang Schäffner, Gerhard Scholtz, Lisa Schreiber, Carola Zwick et al.

Engel, Franz/Hadjinicolaou, Yannis (Eds.) (2016): **Formwerdung und Formentzug (Actus et Imago, 16)**. Berlin: De Gruyter.

Friedman, Michael/Schäffner, Wolfgang (Eds.) (2016): **On Folding. Towards a New Field of Interdisciplinary Research**. Bielefeld: transcript.

Friedman, Michael/Tomšič, Samo (Eds.) (2016): **Psychoanalysis: Topological Perspectives. New Conceptions of Geometry and Space in Freud and Lacan**. Bielefeld: transcript.

Friedrich, Kathrin/Queisner, Moritz/Roethe, Anna (Eds.) (2016): Bildwelten des Wissens. Kunsthistorisches Jahrbuch für Bildkritik, vol. 12: **Image Guidance. Bedingungen bildgeführter Operation.** Berlin: De Gruyter.

Grewe, Martin/Zachow, Stefan (2016): **Fully Automated and Highly Accurate Dense Correspondence for Facial Surfaces.** In: Hua, G./Jégou, H. (ed.): Computer Vision – ECCV 2016 Workshops. Lecture Notes in Computer Science 9914, 552–568.
DOI: 10.1007/978-3-319-48881-3_38

Katan-Schmid, Einav (2016): **Embodied Philosophy in Dance. Gaga and Ohad Naharin's Movement Research.** London: Palgrave Macmillan. (PhD thesis, Tel-Aviv University/Humboldt-Universität zu Berlin)

Kesting, Marietta/Kunze, Sophia (Eds.): **Dark Rooms. Räume der Unsichtbarkeit.** Neofelis Verlag.

Klonk, Charlotte (Ed.) (2016): **New Laboratories. Historical and Critical Perspectives on Contemporary Developments**. Berlin/Boston: De Gruyter. With contributions from Ronald Göbel, Sabine Hansmann, Charlotte Klonk, Christina Landbrecht, Henrike Rabe, Jürgen P. Rabe, and Verena Straub et al.

Ladewig, Rebekka (2016): **Schwindel. Eine Epistemologie der Orientierung (Historische Wissensforschung, 6).** Tübingen: Mohr Siebeck.

Leinfelder, Reinhold/Hamann, Alexandra/Kirstein, Jens/Schleunitz, Marc (Eds.) (2016) **Eating Anthropocene. Curd Rice, Bienenstich and a Pinch of Phosphorus – Around the World in Ten Dishes.** Berlin/Heidelberg: Springer.

Loscher, David M./Meyer, Fiete/Kracht, Kerstin/Nyakatura, John A. (2016): **Timing of Head Movements is Consistent with Energy Minimization in Walking Ungulates.** In: Proceedings of the Royal Society B: Biological Sciences, vol. 283, no. 1843. DOI: 10.1098/rspb.2016.1908

Oswalt, Philipp/Barthel, Stephan/Mende, Julia von/Schmidt, Anne (2016): **Von der Welt in die Stadt, ins Haus, in den Kochtopf – und zurück. Eine Spurensuche in der Anthropozänküche.** In: Bauwelt, vol. 107, no. 37 (Special issue). DOI: 10.5281/zenodo.400506
Golsenne, T., Ribault, Patricia (Eds.) (2016): **Essais de Bricologie. Ethnologie de l'art et du design contemporains** (Techniques & Culture, 64). Paris: Ed. EHESS, CNRS.

2015

Bredekamp, Horst/Schäffner, Wolfgang (Eds.) (2015): **Haare hören – Strukturen wissen – Räume agieren. Berichte aus dem Interdisziplinären Labor Bild Wissen Gestaltung**. Bielefeld: transcript.

Buckmann, Marcus/Gaschler, Robert/Höfer, Sebastian/Loeben, Dennis/Frensch, Peter A./Brock, Oliver (2015): **Learning to Explore the Structure of Kinematic Objects in a Virtual Environment.** In: Frontiers in Psychology, vol. 6, no. 374. DOI: 10.3389/fpsyg.2015.00374

Därmann, Iris/Macho, Thomas (Eds.) (2017): **Unter die Haut. Tätowierungen als Logo- und Piktogramme**. München: Wilhelm Fink. With contributions from Iris Därmann, Kai Kappel, Anna L. Roethe et al.

Engel, Franz/Marienberg, Sabine (Eds.) (2015): **Das Entgegenkommende Denken** (Actus et Imago, Bd. 15). Berlin: De Gruyter. With contributions from Horst Bredekamp, Franz Engel, Yannis Hadjinicalaou, Marion Lauschke, Sabine Marienberg, Pablo Schneider, Jürgen Trabant et al.

Grewe, Carl Martin/Schreiber, Lisa/Zachow, Stefan (2015): **Fast and Accurate Digital Morphometry of Facial Expressions.** In: Facial Plastic Surgery, vol. 31, no. 5: The Facial Profile, 431–438. DOI: 10.1055/s-0035-1564720

Guiducci, Lorenzo/Weaver, J.C./Bréchet, Y.J./Fratzl, Peter/Dunlop, John W. (2015): **The Geometric Design and Fabrication of Actuating Cellular Structures**. In: Advanced Materials Interfaces, vol. 2, 1500011.
DOI: 10.1002/admi.201500011

Meer, Julia (2015): **Neuer Blick auf die Neue Typographie – Die Rezeption der Avantgarde in der typografischen Fachwelt der 1920er Jahre***.* Bielefeld: transcript. (PhD thesis, Bergische Universität Wuppertal)

Reindl, Antónia/Strobach, Tilo/Becker, Carola/Scholtz, Gerhard/Schubert, Torsten (2015): **Crab or lobster? Mental principles underlying the categorization of crustaceans by biology experts and non-experts.** In: Zoologischer Anzeiger, vol. 256, 28–35. http://dx.doi.org/10.1016/j.jcz.2015.03.001

Scholtz, Gerhard (Ed.) (2015): **Special issue: The 3rd International Congress on Invertebrate Morphology (ICIM3)**. In: Zoologischer Anzeiger, vol. 256. Amsterdam: Elsevier. Online: https://www.sciencedirect.com/journal/zoologischer-anzeiger/vol/256

te Heesen, Anke/Schulze, Mario/Dold, Vincent (Eds.) (2015): **Museumskrise und Ausstellungserfolg. Die Entwicklung der Geschichtsausstellung in den Siebzigern**. Berlin: Humboldt-Universität zu Berlin.

2014

Gaschler, Robert*/Schwager, Sabine*/Umbach, Valentin J./Frensch, Peter A./Schubert, Torsten (2014): **Expectation mismatch: Differences between self-generated and cue-induced expectations.** In: Neuroscience and Biobehavioral Reviews, vol. 46, 139–157.
DOI: 10.1016/j.neubiorev.2014.06.009

Friedrich, Kathrin/Queisner, Moritz (2014): **Automated killing and mediated caring: How image-guided robotic intervention redefines radiosurgical practice**. In: Proceedings MEMCA-14: Machine Ethics in the Context of Medical and Care Agents, AISB50 Convention. Online: http://doc.gold.ac.uk/aisb50/AISB50- S17/AISB50-S17-Friedrich-Paper.pdf

Balke, Friedrich/Siegert, Bernhard/Vogl, Joseph (Eds.) (2014): **Modelle und Modellierung** (Archiv für Mediengeschichte, 14). Paderborn: Fink. With contributions from Richard Weinkeller, Karin Krauthausen, Reinhard Pendler, Bernd Mahr, Samo Tomšic et al.

2013

Bruhn, Matthias/Scholtz, Gerhard (Eds.) (2013): Bildwelten des Wissens. Kunsthistorisches Jahrbuch für Bildkritik, vol. 9.2: **Morphologien.** Berlin: De Gruyter.

Junge, Barbara/Berzina, Zane/Scheiffele, Walter/Westerveld, Wim/Zwick, Carola (2013) (Eds.): **The Digital Turn. Design in the Era of Interactive Technologies.** Zurich: Park Books.

Kassung, Christian/Macho, Thomas (Eds.) (2013): **Kulturtechniken der Synchronisation.** München: Fink.

Stein, Christian (2013): **Interdisziplinäre Terminologie – Über die Konzeption einer Ontologie für den Exzellenzcluster »Bild Wissen Gestaltung«**. In: eDITion - Fachzeitschrift für Terminologie, no. 2, 15–19.

7.2 Additional achievements

Selected prizes/awards/fellowships

Stefan Zieme	Adler-Mansfield Prize, University of Notre Dame (2019)
Wolfgang Coy	Weizenbaum-Medaille (2018)
Julia Meer	Volkswagen Foundation Postdoctoral Fellowship at MIT (2018)
Carla J. Maier	Marie Curie Fellowship (2018)
Claudia Blümle	Fellowship, International Research Institute for Cultural Techniques and Media Philosophy (Internationales Kolleg für Kulturtechnikforschung und Medienphilosophie IKKM), Bauhaus-Universität Weimar (2017)
Tiago da Costa e Silva	Charles S. Peirce Young Scholar Award (2017)
Horst Bredekamp	Schiller Prize of the city of Marburg am Neckar (2017)
Christian Kassung	Senior Fellowship, Leuphana University of Lüneburg (2016/17)
Horst Bredekamp	Founding Director (with N. MacGregor and H. Parzinger), Humboldt Forum in the Berlin Palace (2015–2018)
Horst Bredekamp	Pour le Mérite (2014)

Selected offered professorships

Matthias Bruhn	Professorship, Karlsruhe University of Arts and Design (HfG) (since 2018)
Sandra Schramke	Professorship, Muthesius University of Fine Arts and Design, Kiel (since 2017)
John A. Nyakatura	Professorship, Humboldt-Universität zu Berlin
Christina Vagt	Assistant Professorship, University of California, Santa Barbara (since 2017)
Margarete Vöhringer	Professorship »Materiality of Knowledge«, Georg-August-Universität Göttingen (since 2017)
Margarete Pratschke	Deputy Professorship, Department of Art and Visual History, Humboldt-Universität zu Berlin (2017–2018)
Petra Löffler	Deputy Professorship, Department of Cultural History and Theory, Humboldt-Universität zu Berlin (since 2017)
Christian Stein	Guest Professorship »Diversity of Knowledge«, Humboldt-Universität zu Berlin (2017)
Britta Lange	Deputy Professorship, Department of Cultural History and Theory, Humboldt-Universität zu Berlin (2016–2017)
Trempler, Jörg	Professorship, Art History and Visual Culture Studies, University of Passau (since 2016)
Marietta Kesting	Junior Professorship, Academy of Fine Arts, Munich (since 2016)
Michael Dürfeld	Guest Professorship »Diversity of Knowledge«, Humboldt-Universität zu Berlin (2013–2014)
Claudia Bruns	Professorship, Historical Anthropology and Gender Research, Humboldt-Universität Berlin (since 2013)

Selected external funding/jointly developed projects

Cluster of Excellence »Matters of Activity« (2019-2025)	Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)
Einstein Circle »Science & Culture« (2017-2019)	Einstein Foundation
Einstein Schering Circle »Life Imaging« (2018-2019)	Einstein Foundation Berlin Schering Stiftung
Scientific Comic »Phosphor und globale Ernährungsmuster« (2015-2016)	Deutsche Bundesstiftung Umwelt
Exhibition »+ultra. knowledge & gestaltung« (2016)	Einstein Foundation Berlin LOTTO Foundation
Kosmos Summer University »Modern Walking. Innovative Urban Mobility« (2013)	Universidade de São Paulo Universidad Nacional de Colombia
Die Thronfolger. Replikenwissen (2016-2017)	German Federal Cultural Foundation
Dinosaurier in Berlin! (2014-2018)	Federal Ministry of Education and Research
Bild und Bildlichkeit (2013-2015)	Fritz Thyssen Foundation

Selected patents

Schmitz, B., Zwick, C., Zwick, R. (2017)	“Mechanical Subassembly for a Chair and Chair Having Such a Mechanical Subassembly” European Patent Office: EP2983561.
Plikat, C., Schmitz, B., Zwick, C., Zwick, R. (2017)	“Piece of Seating Furniture Having a Saddle-Form Seat Surface” USPTO: US9538848.

Gholami, M.F., Severin, N., Rabe, J. P., Scenev, V./HU Berlin (2016)	“Beschichtungsmittel zum Herstellen einer elektrisch leitfähigen Schicht und Verfahren zu dessen Herstellung” Deutsches Patent- und Markenamt: DE102013225904.
Schmitz, B., Zwick, C., Zwick, R. (2016)	“Mechanical Assembly for a Chair and Chair with Such a Mechanical Subassembly” PCT/EP2016/055450.
Plikat, C., Schmitz, B., Zwick, C., Zwick, R. (2016)	“Chair” European Patent Office: EP2582267.
Schmitz, B., Zwick, C., Zwick, R. (2015)	“Wall Element” PCT/EP2014/074305.
Severin, N., Dorn, M., Rabe, J.P./HU Berlin (2014)	“Anordnung mit einem Träger und einer Schicht” Deutsches Patent- und Markenamt: DE102009056052.
Schmitz, B., Zwick, C., Zwick, R. (2014)	“Method for Producing a Lining for a Furniture Piece, and Furniture Piece, in Particular Seating Furniture Piece.” PCT/EP2014/000303.
Kalachev, A., Rabe, J. P., Severin, N./HU Berlin (2013)	“Method of analyzing a substance” United States Patent: US 8,357,896.

Selected exhibitions

Zoologie in Bildern – Die Wandtafeln der Zoologischen Lehrsammlung	Veterinary Anatomy Theater, Humboldt-Universität zu Berlin (2019)
Cube of Physics	Department of Physics, Humboldt-Universität zu Berlin (2018–2019)
Temporäres Objektlabor: Steine – Bilder – Lügendetektoren	Veterinary Anatomy Theater, Humboldt-Universität zu Berlin (2018)
Das Gesicht. Eine Spurensuche	Deutsches Hygiene Museum, Dresden (2017–2018)
REPLIKEN WISSEN – Eine Archäologie vervielfältigter Vergangenheit	Veterinary Anatomy Theater, Humboldt-Universität zu Berlin (2017–2018)
Hinter dem Vorhang	Kunstpalast Düsseldorf (2016–2017)
Form Follows Flower. Moritz Meurer, Karl Blossfeldt & Co.	Kunstgewerbemuseum Berlin (Museum of Decorative Arts, Berlin) (2017–2018)
GRRLT. Abseits der Norm	Veterinary Anatomy Theater, Humboldt-Universität zu Berlin (2016–2018)
OROBATES. Nach 300 Millionen Jahren reanimiert	Veterinary Anatomy Theater, Humboldt-Universität zu Berlin (2016–2017)
+ultra. knowledge & gestaltung	Martin Gropius Bau Berlin (2016–2017)
ON THE EDGE. Artists in Dialogue with Humboldt University Collections	Veterinary Anatomy Theater, Humboldt-Universität zu Berlin (2016)
Acts of Orientation – Navigating Noise	Schering Stiftung (2015)
KlangSehen – Visualisierungsstrategien und Wahrnehmungspraktiken von Klang	Jakob-und-Wilhelm-Grimm-Zentrum (2015)
Copy and Paste oder die Neubelebung einer Lehrsammlung	Berlin University of the Arts (2015)
Portable Media – I carry therefore I produce	Pergamon Palais (2014)
Speaking Images – Speaking of Images	Jakob-und-Wilhelm-Grimm-Zentrum (2013–2014)
Von Innen nach Außen – Die Novemberpogrome 1938 in Diplomatenberichten aus Deutschland	New Synagogue Berlin – Centrum Judaicum (2013–2014)

Selected installations

Mimik-Explorer Interactive user interface providing an experimental, game-based form of testing and deconstructing facial emotional codes. The installation was presented at the exhibitions »+ultra. knowledge & Gestaltung« at Martin-Gropius-Bau Berlin, »Das Gesicht. Eine Spurensuche« at the Deutsche Hygiene Museum, Dresden, and »Faszination Gesicht-Was unsere Mimik alles zeigt« in Vögele Kultur Zentrum, Pfäffikon, Switzerland.	Project »Epistemic Reverse Side of Instrumental Images«
Face to face – Interface A self-feeding facial-expression archive, searchable by face. Installation by Moritz Wehrmann in the context of the exhibition »+ultra. gestaltung schafft wissen« at the Martin-Gropius-Bau in Berlin.	Project »Epistemic Reverse Side of Instrumental Images«
Raummaschine http://mos-raummaschine.com Installation surrounding the subject of space as an agent as well as the interplay between movement and space.	Project »Mobile Structures«

Selected films & videos

TIME Feature film about time theories and their vivid mediation.	Project »Visual Gestaltung of Time«
Sciddle – The Science Riddle https://vimeo.com/177092128 Ludic film project, where basic theoretical concepts are clarified by physicists in a puzzle-like way.	Project »gamelab.berlin«
Bringing a fossil to life: Reverse engineering locomotion https://www.nature.com/articles/d41586-019-00186-x Dynamic simulation using a combination of x-ray video, computer modelling and robotics to reanimate a 280-million-year-old fossil. (Nature highlight)	Project »Morphology and History of Forms«
Culture Collaboratory http://col-laboratory.com Short video that presents the design concept for an interdisciplinary interactive research platform and collections management system aiming at museum professionals.	Project »Culture Collaboratory. Virtual Workspace for Interdisciplinary Collections Research and Management«
Playing with Virtual Realisities http://www.gamelab.berlin/portfolio/playing-with-virtual-realities/ The film explores how VR-technology and the embodied practices of gaming and dancing enact and design imagination and perceptual experience.	Project »gamelab.berlin«
Who we are and what we do https://www.interdisciplinary-laboratory.hu-berlin.de/en/bwg/ueber-uns/ The film explains the structure and work of the Interdisciplinary Laboratory »Image Knowledge Gestaltung«.	Cluster of Excellence »Image Knowledge Gestaltung«
Die menschliche Mimik als Gefühlscode. Verheißungen und Verfehlungen Coproduction with Deutsches Hygiene-Museum Dresden in occasion of the exhibition »Das Gesicht. Eine Spurensuche«.	Project »Epistemic Reverse Side of Instrumental Images«

Selected games & digital tools

Decide & Survive Strategic game that generates new insights for game design research and game development in the context of player behavior and game design.	Project »gamelab.berlin«

game(+ultra) Designed on the occasion of the exhibition »+ultra gestaltung schafft wissen«, the game leads to a more intensive exploration of the exhibits, contributing to the understanding of the complex themes and to the practical experience of the creation of knowledge.	Project »gamelab.berlin«
Singleton – gamificated life Singleplayer game for integrating personal goals into everyday life and individual development based on self-defined priorities.	Project »gamelab.berlin«
PlosOne Metadata Extractor Browser plugin that extracts metadata from lists of PlosOne publications, including abstracts, making them processable and analyzable for text mining.	Project »gamelab.berlin«
iWrite Gamified tool for the improvement of scientific writing processes allowing the user to divide writing processes into concentrated sessions, eliminate distractions, visualize progress and plan writing sessions.	Project »gamelab.berlin«
Reading Revisited VR application that tests reading in Virtual Reality and dynamically integrates various texts into moving landscapes.	Project »gamelab.berlin«
ID+Lab http://www.idpluslab.de/idplusmodel.html Publication platform designed to publish interdisciplinary research work as a network and visualize connections between publications that otherwise remain hidden.	Project »gamelab.berlin«
Bee Virtual Collaborative VR application that examines how objects can be noticed in VR, how virtual spaces can be transferred to physical ones and to what extent communication influences the noticing of environmental properties.	Project »gamelab.berlin«
BWG VR Interactive, stereoscopic 360° experience for virtual reality headsets, which shows the Cluster of Excellence »Image Knowledge Gestaltung« in its various spaces and introduces actors of the Cluster in their working environments.	Project »gamelab.berlin«
Diary Tool for researching digital scientific working methods of different disciplines such as software usage, keystrokes, activity cycles and more.	Project »Architectures of Knowledge«
OncoLogg Novel mobile assistance and navigation system for patients with chronic diseases and prolonged treatment procedures.	Project »Em•pa•thy«
process.annotator http://forschungskreis.com/project/process-annotator/ Annotation of a large object in real space using a VR setup.	Project » Hybrid Knowledge Interactions«
empiric.assemblage Database-based online application designed to facilitate digital ethnographic data collection.	Project »ArchitecturesExperiments«
Culture Collaboratory http://col-laboratory.com A software designed for the research and management of collections of cultural artifacts.	Project »Culture Collaboratory. Virtual Workspace for Interdisciplinary Collections Research and Management«
Historical BioData Explorer Integrative, image-oriented web interface that makes historical, biological research data searchable in digitized texts, images and objects.	Project »Historical Structural Investigations in the Laboratory«

Audiowalks

AudioWalk »Einkaufswelten, Flaneure, Inszenierung« https://www.interdisciplinary-laboratory.hu-berlin.de/de/content/audiowalk-einkaufswelten-flaneure-inszenierung/	Meer, J./Steindorf, J./Lamas Cornejo, C. (conception und coordination) With contributions from Lorenzo Guiducci, Juliane Köhler, Julia Meer, Lisa Schreiber, Christof Windgätter. Sounddesign: Jonas Palzer.

AudioWalk »Körper, Zeit, Bewegung« https://www.interdisciplinary-laboratory.hu-berlin.de/de/content/audiowalk-korper-zeit-bewegung/	Meer, J./Steindorf, J./Lamas Cornejo, C. (conception und coordination) With contributions from Lee Chichester, Till Julian Huss, Einav Katan-Schmid, Maria Keil, John A. Nyakatura, Sandra Schramke, Thomas Stach. Sounddesign: Jonas Palzer.
AudioWalk »Typographie, Ordnung, Orientierung« https://www.interdisciplinary-laboratory.hu-berlin.de/de/content/audiowalk-typografie-ordnung-orientierung/	Meer, J./Steindorf, J./Lamas Cornejo, C. (conception und coordination) With contributions from Juliane Köhler, Tom Lilge, Christian Loeben, Julia Meer, Christine Schmid, Erik Spiekermann, Johanna Steindorf, Katharina Walter. Sounddesign: Jonas Palzer.

Spin-offs

Surfhero UG Game development in the context of science, exhibitions, museums and learning environments.	Founders: Stein, C./Lilge, T., 2014
Playersjourney UG http://playersjourney.de/de/ Specialized on knowledge transfer in museums and exhibitions.	Founder: Stein, C., 2017

Structural achievements

Master Open Design https://master-open-design.org A double degree program offered by HU Berlin in cooperation with the Universidad de Buenos Aires. Students acquire interdisciplinary skills relating to a broad spectrum of empirical methodologies that encompass cultural studies and humanities through analysis and historicizing, scientific experimentalization from the natural sciences, and creative synthesis from the design disciplines.	In cooperation with Universidad de Buenos Aires
Master COOP Design Research https://coopdesignresearch.de/#home The program opens up professional perspectives in the fields of research and teaching, design and cultural studies and curatorial practice.	In cooperation with Anhalt University of Applied Sciences and Bauhaus Dessau Foundation
Accredited structured PhD program *Image Knowledge Gestaltung* Support and mentoring of disciplinary doctoral students with additional training in interdisciplinarity	Strengthening disciplinary training through interdisciplinarity
International Society for Model Research Fostering debates on the role of models and modeling, while at the same time strengthening the network of projects related to the cultural technique of modeling.	The society was established at the Hermann von Helmholtz Center for Cultural Techniques.

7.3 PIs and other participating researchers

Table 7: PIs and other participating researchers

First name Surname	Position	Institute
Claudia Blümle *	Principal Investigator	Department of Art and Visual Studies, HU Berlin
Horst Bredekamp	Director, Principal Investigator	Department of Art and Visual Studies, HU Berlin
Matthias Bruhn #	Principal Investigator	Department for Art Research and Media Philosophy, Karlsruhe University of Arts and Design
Jochen Brüning	Principal Investigator	Department of Mathematics, HU Berlin
Wolfgang Coy	Principal Investigator	Department of Computer Science, HU Berlin
Peter Fratzl	Director, Principal Investigator	Department of Biomaterials, Max Planck Institute of Colloids and Interfaces, Potsdam
Peter Frensch	Principal Investigator	Department of Psychology, HU Berlin
Finn Geipel	Principal Investigator	Department of Architecture, TU Berlin
Barbara Göbel	Principal Investigator	Ibero-American Institute, Prussian Cultural Heritage Foundation, Berlin
Stefan Gradmann #	Principal Investigator	Literary Studies Research Unit, University of Leuven, Netherlands
Anke te Heesen	Principal Investigator	Department of History, HU Berlin
Regine Hengge	Principal Investigator	Department of Biology, HU Berlin
Christian Kassung	Principal Investigator	Institute of Cultural History and Theory, HU Berlin
Charlotte Klonk	Principal Investigator	Department of Art and Visual Studies, HU Berlin
Norbert Koch	Principal Investigator	Department of Physics, HU Berlin
Reinhold Leinfelder #	Principal Investigator	Department of Earth Sciences, FU Berlin
Anne Letsch	Principal Investigator	Department of Hematology, Oncology and Palliative Care, Charité, Berlin
Thomas Macho #	Principal Investigator	International Research Center for Cultural Studies (IFK), University of Art and Design Linz, Austria
Bernd Mahr †	Principal Investigator	Department of Electrical Engineering and Computer Science, TU Berlin
Claudia Mareis	Principal Investigator	Institute of Experimental Design and Media Cultures, FHNW Academy of Art and Design, Basel, Switzerland

Claudia Müller-Birn	Principal Investigator	Institute of Computer Science, FU Berlin
Susanne Muth	Principal Investigator	Institute of Archeology, HU Berlin
John A. Nyakatura *	Principal Investigator	Department of Biology, HU Berlin
Thomas Picht	Principal Investigator	Department of Neurosurgery, Charité, Berlin
Jürgen P. Rabe	Principal Investigator	Department of Physics, HU Berlin
Patricia Ribault *	Principal Investigator	Institute of Cultural History and Theory, HU Berlin
Wolfgang Schäffner	Director, Principal Investigator	Institute of Cultural History and Theory, HU Berlin
Gerhard Scholtz	Principal Investigator	Department of Biology, HU Berlin
Robin Schuldenfrei #	Principal Investigator	The Courtauld Institute of Art London, United Kingdom
Michael Seadle	Principal Investigator	Berlin School of Library and Information Science, HU Berlin
Jürgen Sieck	Principal Investigator	School of Computing, Communication and Business, HTW University of Applied Sciences, Berlin
Thomas Stach	Principal Investigator	Department of Biology, HU Berlin
Helmut Staubach †	Principal Investigator	Weißensee Academy of Art Berlin
Matthias Staudacher	Principal Investigator	Departments of Physics and Mathematics, HU Berlin
Sabine Thümmler	Principal Investigator	Kunstgewerbemuseum Berlin (Museum of Decorative Arts), Staatliche Museen zu Berlin, Prussian Cultural Heritage Foundation
Christina Vagt *	Principal Investigator	Institute of Cultural History and Theory, HU Berlin
Joseph Vogl	Principal Investigator	Department of German Literature, HU Berlin
Sigrid Weigel	Principal Investigator	Center for Literary and Cultural Research (ZfL), Berlin
Christof Windgätter	Principal Investigator	University of Applied Sciences Europe, Berlin
Moritz Wullen	Principal Investigator	Kunstbibliothek, Staatliche Museen zu Berlin, Prussian Cultural Heritage Foundation
Carola Zwick	Principal Investigator	Department of Product Design, Weißensee Academy of Art Berlin
Claudia Bruns	Associated Investigator	Institute of Cultural History and Theory, HU Berlin

Peter Deuflhard †	Associated Investigator	Institute for Mathematics, FU Berlin
John Dunlop	Associated Investigator	Department of Biomaterials, Max Planck Institute of Colloids and Interfaces, Potsdam
Iris Därmann	Associated Investigator	Institute of Cultural History and Theory, HU Berlin
Klaus Eder	Associated Investigator	Department of Social Sciences, HU Berlin
Oliver Hahn	Associated Investigator	Division of Analysis of Artefacts and Cultural Assets, BAM Federal Institute for Materials Research and Teaching, Berlin
Alfred Jacoby	Associated Investigator	Dessau Institute of Architecture, Anhalt University of Applied Sciences, Dessau
Joachim Krausse	Associated Investigator	Design Department, Anhalt University of Applied Sciences, Dessau
Philipp Oswalt #	Associated Investigator	Department of Architecture, University of Kassel
Hans-Jörg Rheinberger	Associated Investigator	Max Planck Institute for the History of Science, Berlin
Helmar Schramm †	Associated Investigator	Institute of Theater Studies, FU Berlin
Holger Schulze #	Associated Investigator	Department of Arts and Cultural Studies, University of Copenhagen, Denmark
Bettina Uppenkamp #	Associated Investigator	Department of Theory and History, University of Fine Arts Hamburg
Richard Weinkamer	Associated Investigator	Department of Biomaterials, Max Planck Institute of Colloids and Interfaces, Potsdam
Stefan Weinzierl	Associated Investigator	Institute for Language and Communication, TU Berlin

* Researchers marked with an asterisk were hired by the Cluster.
# Researchers marked with a # have left the host university or other participating institution, but have kept their position within the Cluster.

The institutes listed above represent the situation as at December 2018.

7.4 Participating institutions and cooperation partners

Table 8: Detailed list of the participating institutions and the most important cooperation partners

Institutes of the host university/ universities	Location
Department of Archaeology	Berlin
Department of Art and Visual History	Berlin

Department of Biology	Berlin
Department of Chemistry	Berlin
Department of Computer Science	Berlin
Department of Cultural History and Theory	Berlin
Department of European Ethnology	Berlin
Department of German Literature	Berlin
Department of Library and Information Science	Berlin
Department of Mathematics	Berlin
Department of Physics	Berlin
Department of Psychology	Berlin
Department of Social Sciences	Berlin
Hermann von Helmholtz Center for Cultural Techniques (HZK)	Berlin
Institutes of the participating universities [1)] (if applicable)	Location
Charité – Universitätsmedizin, Neurosurgical Clinic	Berlin
Charité – Universitätsmedizin, Medical Clinic for Hematology and Oncology	Berlin
Freie Universität Berlin, Institute of Geological Sciences	Berlin
Freie Universität Berlin, Institute of Theater Studies	Berlin
Freie Universität Berlin, Department of Mathematics and Computer Science	Berlin
HTW University of Applied Sciences, Faculty 4: School of Computing, Communication and Business (HTW Berlin)	Berlin
Technische Universität Berlin, Laboratory for Integrative Architecture	Berlin
Weißensee Academy of Art Berlin, Product Design	Berlin
Non-university institutions [1)] (if applicable)	Location
BAM Federal Institute for Materials Research and Testing, Department of Art and Cultural Property Analysis	Berlin
Ibero-American Institute, Prussian Cultural Heritage Foundation	Berlin
Kunstbibliothek, Staatliche Museen zu Berlin, Prussian Cultural Heritage Foundation (SPK)	Berlin
Kunstgewerbemuseum (Museum of Decorative Arts), Staatliche Museen zu Berlin, Prussian Cultural Heritage Foundation (SPK)	Berlin
Leibniz Center for Literary and Cultural Research (ZfL)	Berlin
Max Planck Institute of Colloids and Interfaces, Department of Biomaterials (MPIKG)	Potsdam
Museum für Naturkunde - Department "History of Science & Museum Studies"	Berlin
Zuse Institute Berlin – Department of Visual Data Analysis	Berlin
Most important cooperation partners [2)] (if applicable)	Location
Bard College, Bard Graduate Center	New York, USA
Bauhaus Dessau Foundation	Dessau
Centre for Contemporary History	Potsdam
Centro Internacional de Diseño del Conocimiento “Tomas Maldonado”	Buenos Aires, Argentina
Deutsches Hygiene-Museum Dresden	Dresden
École Nationale Supérieure des Arts Décoratifs (EnsAD)	Paris, France

École Nationale Supérieure des Beaux-Arts (ENSBA)	Paris, France
Filmuniversität Babelsberg	Potsdam
FHNW Academy of Art and Design	Basel, Switzerland
Haus der Kulturen der Welt (HKW)	Berlin
Humboldt Forum Kultur GmbH	Berlin
University of Art and Design Linz, International Research Center for Cultural Studies (IFK)	Linz/Vienna, Austria
Max Planck Institute for the History of Science	Berlin
Prussian Cultural Heritage Foundation (SPK)	Berlin
Universidad de Buenos Aires	Buenos Aires, Argentina
Universidade de São Paulo	São Paulo, Brazil
Universität Kassel, Architectural Theory and Design	Kassel

1) Institutions that were funded by the Cluster.
2) Institutions that were not funded by the Cluster but contributed their own resources to the Cluster (e.g. research partners, industrial cooperation partners, or other service providers, museums, cultural institutions, applications partners, etc.)

7.5 Doctoral researchers

Table 9: Doctoral researchers – completed and ongoing theses

	Doctoral theses completed within the Cluster [1)]	Thereof: (partially [≥ 50 %]) financed by the Cluster	Ongoing doctoral theses after expiry of Cluster's funding
Total (number)	23	21	37*
Thereof: Female researchers (%)	52%	57%	57%
Origin [2)]			
Number and %			
Germany	23 (100%)	21 (100%)	37 (100%)
World region or country			
…			
…			

1) Completed during the Cluster's total funding duration; completion is defined as the date of the final doctoral exam, e.g. "Disputatio" or "Rigorosum".
2) Refers to the location of the last position held prior to joining the Cluster.
* The reasons for ongoing dissertations after the end of the Cluster's funding period are the staggered recruitment of PhD candidates in different years and many parental leaves. Of the 37 ongoing doctoral dissertations, more than half are expected to be completed within the course of 2020.

Deutsche
Forschungsgemeinschaft
German Research Foundation

Humboldt-Universität zu Berlin, Unter den Linden 6, D-10099 Berlin