BuildDigiCraft

New Mindset for High-quality Baukultur in Europe:

Bridging Craft and Digital

Annette Bögle, Emiliya Popova (eds.)

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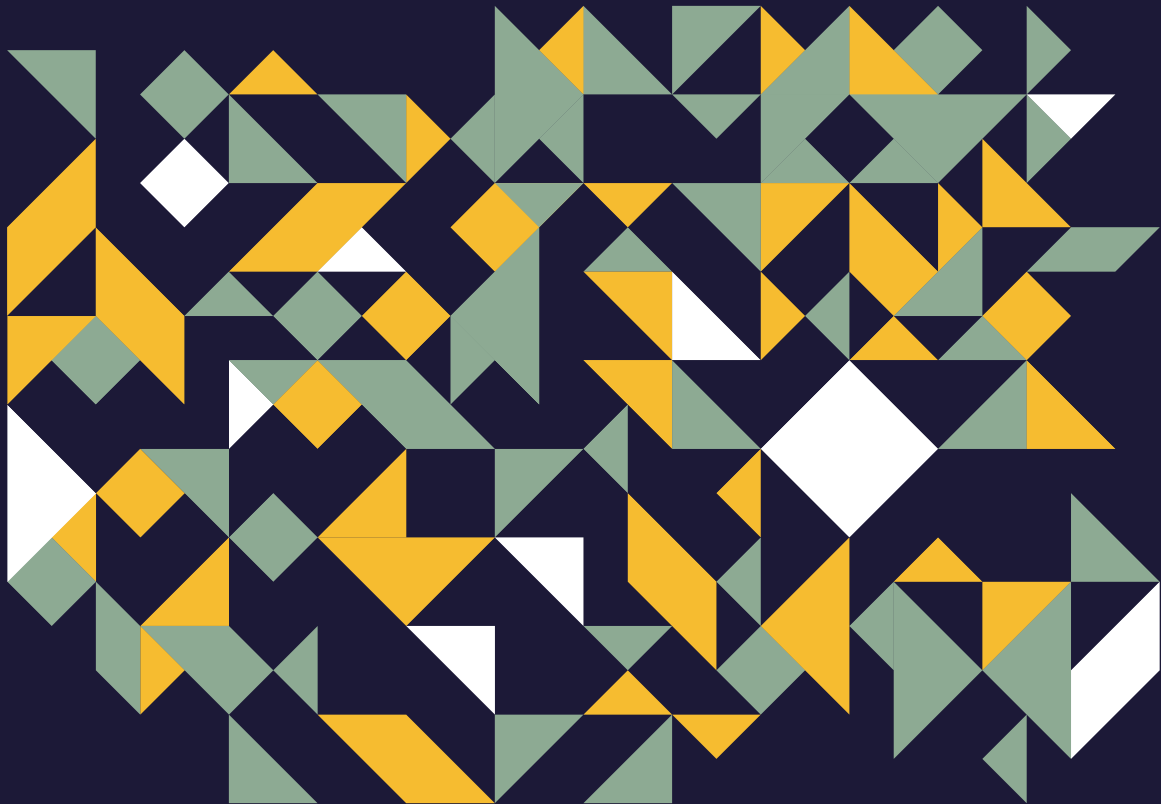
1.0 Introduction



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1.0 Background

The core of the **BuildDigiCraft** project was the development and implementation of an innovative teaching and training module for young scientists, PhD candidates and advanced Master's level students. It allowed for a joint exploration of the questions of how the ongoing digital revolution is affecting the work of designers, architects, engineers, urban planners and other professionals responsible for the shaping of the built environment and of what new opportunities arise from the available digital and data-processing technologies for creating innovative solutions for the design, construction, maintenance and management of buildings and cities. At the same time the hypothesis was provided that the values and leading principles of traditional craftsmanship, such as dedication, pride in one own's work, and the mindful and sustainable dealing with the building material, need to be re-introduced and validated in the context of the new digitally-driven work environment.

Set in a larger perspective, the training program was part of a long-term cooperation, strategy between eight universities in the Baltic Sea region which in addition to their geographic proximity to the Baltic Sea also share common historic developments, climatic conditions, landscape correlations as well as lots of similarities in the development of handicrafts and the culture of building and construction over the centuries. Despite the similarities, each of these places has its own special and unique character just as each of the represented universities has its own established culture of professional and higher academic education. At an earlier cooperation stage, several years prior to this publication, teachers and research experts from these eight universities were able to exchange initial knowledge and experience on the different teaching approaches, methods and tools used in higher education at their institutes in the disciplines of architecture, structural engineering, urban planning, urban design, environmental engineering as well as art and related artistic studies. This was achieved within the BeInterBaltic project, a forerunner project of the **BuildDigiCraft** project. The **BeInterBaltic**[1] project paved the way for the introduction of a new educational framework to implement joint interdisciplinary teaching workshops between several universities, all situated in cities around the Baltic Sea: Hamburg, Copenhagen, Gothenburg, Gdańsk, Riga, Tallinn and Helsinki. Every year between 2015 and 2018, the ten-day Baltic International Summer School took place in August in Hamburg. Teachers and students from around the Baltic Sea as well as invited experts from across Europe and the rest of the world came together to test and share their knowledge, working methods and latest experience with each other. The educational focus was on the study program of Master's-level students. The supervision of the interdisciplinary and internationally mixed student groups was provided by young scientists and early-stage PhD candidates as well as by regular feedback sessions with senior scientists and guest experts. This first initiative for sharing teaching experience in an interdisciplinary context helped the participating universities to initiate common ground for future interdisciplinary research collaboration. At the same time the need for further development of the joint interdisciplinary teaching formats on a higher doctoral training level was recognized within the cooperation network. **A natural continuation of the Baltic International Summer School on a PhD research level was set as a priority for the future development of the network.**

[1] **BeInterBaltic**

Full title: Intersections in built environment: promoting interdisciplinary higher education in the Baltic Sea Region

Co-funding: Erasmus+ Strategic Partnerships for Higher Education

Duration: September 2015–August 2018

Motivation — interdisciplinary approach

The BeInterBaltic project focused on the complexity of current urban conditions, actual chances and challenges in the built environment. The traditional division of disciplines is no longer adequate: complexity requires cooperation and understanding between the disciplines of the built environment, especially regarding the design process. However, it is not sufficient only to promote the dialog at the intersections of the disciplines, the impacts on the disciplines themselves must be illuminated, too. For the intersections between architecture and engineering as well as other related disciplines of built environment, this has practical consequences concerning the contents, topics and methods behind the design process.

Baltic International Summer School

Baltic International Summer School (B.I.S.S.)

Within the BeInterBaltic project it was possible to develop and test new teaching methods, formats and instruments in the education of the built environment. This was achieved by the organization, implementation and evaluation of the Baltic International Summer School (B.I.S.S.), which took place in all the three years of the project. The B.I.S.S. brought together more than 60 students from the Baltic Sea region representing various disciplines of built environment and offered them the opportunity to work together in international and interdisciplinary mixed project groups. Input and expert consultations were offered by the involved academic teaching staff, PhD candidates in the role of student group mentors as well as by invited renowned practitioners as keynote speakers. The pilot edition of the B.I.S.S. took place already in 2015 and served as testing ground for the concept outline of the BeInterBaltic project.

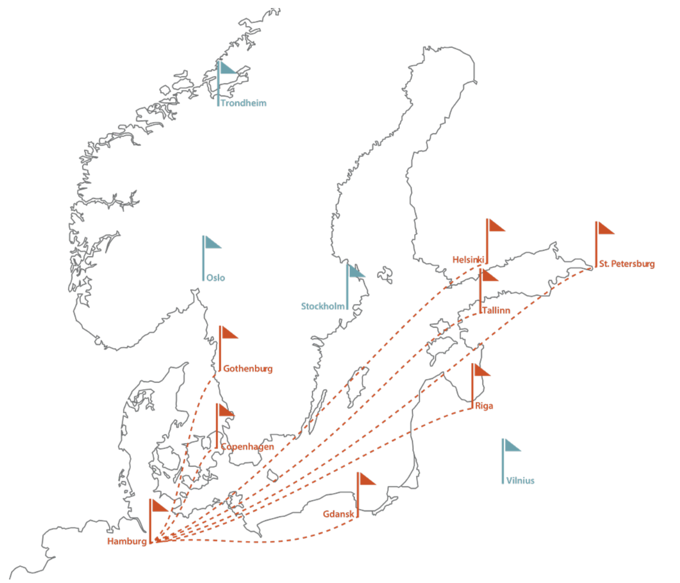
- **B.I.S.S. 2015**
  "at — over — on the water"
  Documentation: https://repos.hcu-hamburg.de/handle/hcu/443
- **B.I.S.S. 2016**
  "Hamburg 2030 — Urban Futures"
  Documentation: https://repos.hcu-hamburg.de/handle/hcu/477
- **B.I.S.S. 2017**
  "City Elements — Infrastructure and Networks Shaping Harbor Areas"
  Documentation: https://repos.hcu-hamburg.de/handle/hcu/491
- **B.I.S.S. 2018**
  "Beyond Urban Flows — Architecture and Engineering for Transition Places"

Project aims

- Develop and test new teaching methods, formats and instruments in the education of built environment
- Adapt current curricula to contemporary and emerging labor market needs
- Equip students with interdisciplinary and intercultural competences and skills needed to deal with complex problems in multicultural societies
- Promote, increase and make full use of the cooperation between the universities across the Baltic Sea region, supporting its sustainable development

BeInterBaltic consortium – Baltic Sea region

- HafenCity University Hamburg, (Lead partner)
- Gdańsk University of Technology
- Tallinn University of Technology
- Royal Danish Academy of Fine Arts
- Technical University of Denmark
- Chalmers University of Technology
- Aalto University



2.0 Topic and starting point

The introduction of innovative projects for interdisciplinary teaching in the field of the built environment represents the understanding that generally there is a need for more cooperation and understanding between the disciplines of the built environment themselves, such as architecture, structural and civil engineering, urban planning and design as well as artistic and philosophical studies related to space. In the context of the envisaged further research collaboration, the shaping of the built environment is understood within the established network as a collaborative creative process, which aims at improving and further thinking about the social, technical and aesthetic quality of the built urban environment in order to answer the current societal needs by using diverse and interdisciplinarily-oriented methodological approaches.[2]

[2] Interfaces in the Built Environment. Bridging Technology and Culture in the Baltic Sea Region (Proceedings PhD Symposium), file:///C:/Users/hhz856/Downloads/PhD_Proceedings_Interfaces_final.pdf https://repos.hcu-hamburg.de/handle/hcu/500

As in any interdisciplinary context, the main challenge in bringing together so many different academic and disciplinary as well as professional and cultural backgrounds and experiences was the setting up of a common framework for knowledge integration. It was important that this would allow for different topics, methodologies, design principles and theories as well as for the different scales of the built environment – from the structural and architectural detail through the building to the urban level – to find common ground to mutually benefit each other.

In the concept phase of the **BuildDigiCraft** project, a natural continuation of the BeInterBaltic project, the main challenge was to identify the shared goal and the means for its final achievement. The main questions were: what is the future built environment that we would like to frame together, and what binds us all together?

The group gravitated toward the idea – simple as it may sound – that ideally in every piece of work that designers, engineers and planners create, there should always be an inner striving to achieve higher quality in the surrounding built and natural environment. But then the question arises as to what it is that the high quality of the built environment is comprised of. And how do we measure the perception of this quality? In 2018, the same question gained importance and was introduced for discussion on a higher political level in Europe. In January 2018 the European Ministers of Culture came together for **the Davos Conference on High-quality Baukultur in Europe**. It was agreed that the overall concept of high-quality Baukultur should be embedded in Europe on a political and strategic level. Baukultur is understood within the context of the Davos Declaration through the following three central aspects:

[3] Davos Declaration, 2018, https://baukultur--production--storage.s3.amazonaws.com/baukultur/2022-06-09-075742--context-document-en.pdf

1. The existing construction, including cultural heritage assets, and contemporary creation must be understood as a single entity. The existing construction provides an important Baukultur reference for the future design of our built environment.
2. All activities with an impact on the built environment, from detailed craftsmanship to the planning and execution of infrastructure projects that have an impact on the landscape, are expressions of Baukultur.
3. Baukultur not only refers to the built environment but also to the processes involved in its creation.[3]

Most importantly, a new term in the professional language of the specialists of the built environment was put forward on an official political level – the German term Baukultur was introduced to underpin the understanding that the built environment is not only the collection of the existing and contemporary building stock and infrastructure, but also involves all the processes and activities required for its creation. Based on such an understanding, the Davos Declaration gives further incentives to society, politics and science to rethink the current situation which is marked through disciplinary blinkers, ephemeral profit maximization or digital automation, as well as confronted by major ecological and climatic challenges putting at risk the future of our planet.

Baukultur encompasses all activities with spatial impact, from craftsmanship details to large-scale urban planning and development of landscapes. Baukultur refers to all activities with spatial impact of all actors involved over time.[4]

Next to the term Baukultur, the Davos Declaration has inspired the development of clearly defined criteria for the definition of a high-quality Baukultur. The **Davos Baukultur**

[4] The Davos Baukultur Quality Assessment System. Davos Declaration: Towards a High-quality Baukultur for Europe, 2018.

Quality System consists of eight major criteria that help to define the high-quality Baukultur level of places. These are Governance, Functionality, Environment, Economy, Diversity, Context, Sense of Place, and Beauty (Fig[●1]).

The concept of high-quality Baukultur is essential for the formulation of the aim of the **BuildDigiCraft** project. It offers a holistic framework for bringing together a wide range of diverse research topics and methodological

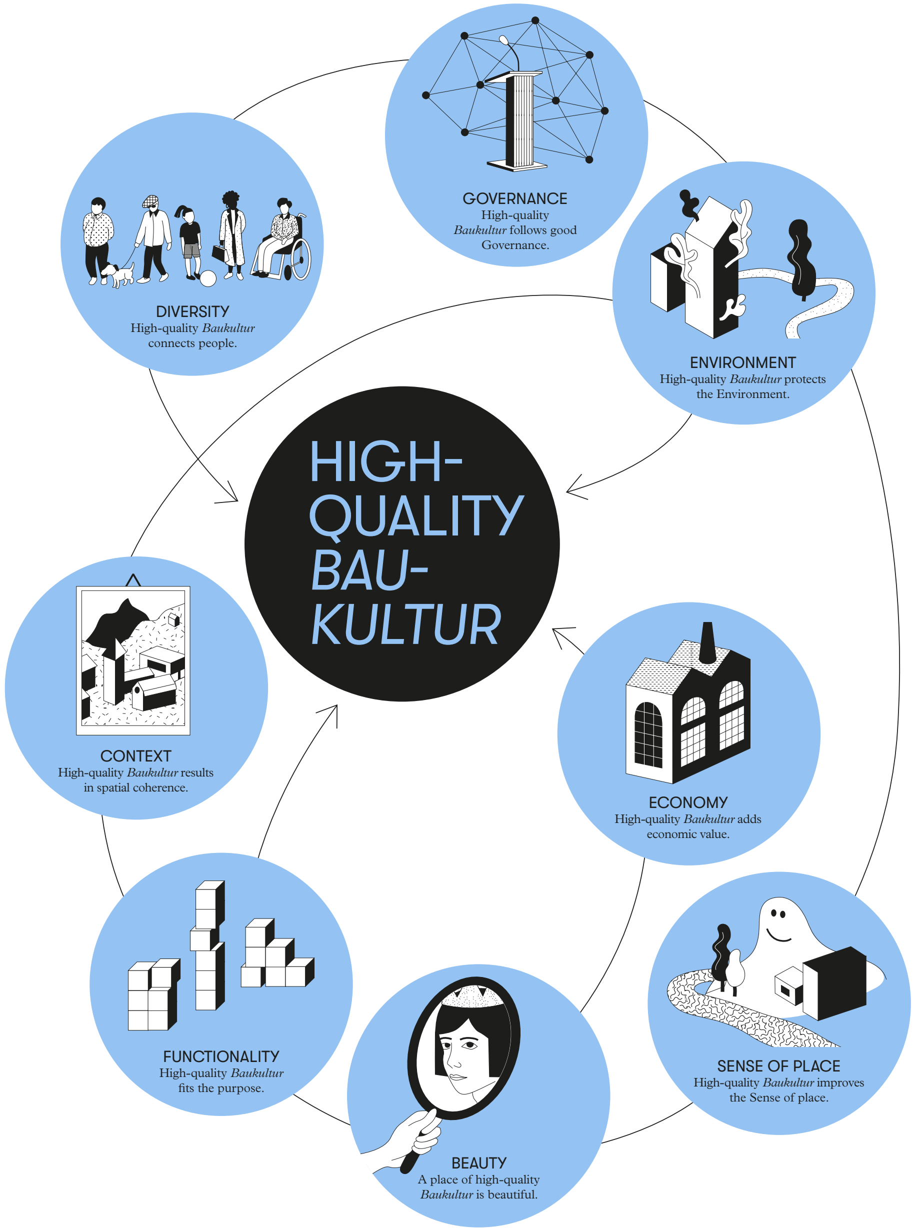


Fig [●1] Eight criteria for a high-quality Baukultur — the Davos Baukultur Quality System © Swiss Federal Office of Culture / Illustration: Heyday

approaches related to future shaping of the built environment. Two years after the Davos Declaration, in 2020, another major political initiative within the European Union built on the concept of Baukultur and the **Davos Declaration** from 2018 – the **New European Bauhaus (NEB)**. NEB calls for the formation of a new movement of citizens, experts, designers, professionals, businesses, and institutions engaged in the shaping of the built environment. It advocates a joint reimagination of "sustainable living in Europe and beyond,"[5] including the creation of a common platform for experimentation and connection leading to the realization of more beautiful, sustainable and inclusive projects. With the Davos Declaration 2018 and the NEB Initiative, two major political milestones, a very clear message was sent throughout Europe – an open invitation to reflect together on the need for a crucial change in the mindset of the professionals responsible for the built environment as well as of society as a whole and to look at how we want to address and shape the built environment of the future in the context of global societal and climatic challenges.

The building and construction sectors are known for being **very conservative when it comes to risks and changes**, and at the same time not flexible enough to manage to adapt quickly to the changed circumstances. Therefore, it is not surprising that exactly this sector meets most challenges in its reorganization and reaction to current climatic, societal and technological challenges. There is **an urgent need for a change of mindset** in the design and management approach of the issues of the built environment.

One of the main outcomes of the BeInterBaltic project and the Baltic International Summer School was the recognition that **interdisciplinary teaching and research in the disciplines of the built environment use new digital tools as a common language**. Current advancements in information technology such as the use of AI and machine-learning algorithms, online real-time networked platforms, parametric design, BIM and GIS applications, VR and AR technologies as well as the use of new digital

5 New European Bauhaus Initiative, main web page, https://new-european-bauhaus.europa.eu/about/about-initiative_en

manufacturing technologies for rapid prototyping, digital fabrication and generative component design have already entered the professional and educational field of architects, structural and civil engineers, urban planners and product designers. Students and young researchers use the advantages of these technologies in their projects and practice and are not afraid to test them in the context of new design and planning tasks. While there is an open-minded and predominantly advantage-oriented approach toward the use of new technologies by the young generation, this is still not generally the case among professionals in the planning and construction industry. This industry sector still struggles to adapt its rules and regulations as well as its business policies and logic to the ongoing digitally-driven transformation. **There is a need for a fundamental change in the way "we are doing things" and the way "we communicate and collaborate with each other" and digital technologies play a major role in this transformation process**. This refers not only to the field of the built environment but to almost every field of occupation.

Next to the numerous opportunities arising from the new technological approaches available for data leverage, processing and monitoring, there are also **a lot of uncertainties and fundamental fears to be observed in society**. First of all, there is the fear of the ability to adapt to the new working conditions and the fear of losing jobs. A large number of society members do not feel prepared for the new market requirements. Besides that, there is a general distrust towards the reliability of digital infrastructures as well as toward data privacy policies regarding the collection, storage and processing of vulnerable personal data. Another major uncertainty regarding the integration of purely digitally-driven work processes refers to the achieved quality of the final product (services or goods) and the ability of these processes to serve individual or specific boundary conditions. This brings along the fear of overdone standardization and simplification, which is seen as a major issue in the for the built environment so relevant field of design and aesthetics.

In searching for an answer on how we can overcome these deeply anchored fears and uncertainties in both society and among professionals when it comes to solving questions related to the way we shape and maintain the built environment, the **BuildDigiCraft** network recognized the importance of **highlighting the values and knowledge of traditional craftsmanship accumulated** over the centuries. Craftsmanship addresses in its essence quality, beauty and resource efficiency; it promotes a relation to sustainable material and techniques and offers tangible experiences through synergies of mind and hand while intimating satisfaction in achieving a level of mastery and highest quality. Craft entails implicit and tacit knowledge and is passed on between craftspeople. Craft values are deeply sustainable as their core value is quality and reducing wasteful approaches. The craftsmanship ethos in design and building projects is essential for strengthening the sense of belonging and commitment to the surrounding space because it gives meaning to the process and because through craftsmanship the process can be identified with the material and the physical outcome of the project.

Considered in the context of the **BuildDigiCraft** network, handicraft traditions and craftsmanship knowledge in the Baltic Sea region were already acknowledged early on as a common factor in the development and realization of building projects throughout the region. The professional guilds of craftspeople in the Hanseatic and Nordic cities around the Baltic Sea have exchanged skills and knowledge throughout the centuries mainly thanks to the short maritime distances and established commercial relations. Today, this is still valid, and this exchange holds not only for the Baltic countries but for almost every region populated by humans on earth. Identifying and introducing **craftsmanship as a main guiding principle in the context of the ongoing digital transformation of the design and construction sector** was therefore essential for setting up the framework for designing a new path leading to a high-quality Baukultur in the digital age.

3.0 Motivation and mission

BuildDigiCraft builds on the holistic concept of Baukultur and seeks to explore opportunities to further develop it in the context of a highly-digitalized world.

The German Federal Foundation Baukultur gives the following definition for Baukultur:

*"Baukultur aims at good planning and building. It combines a **high design standard** with a **holistic view of social, economic,** and **environmental aspects**, and thus has an **emotional and aesthetic dimension**. Baukultur is essential to produce an environment that is perceived as **liveable**. It serves to secure and develop the **social and economic values** thus created. Producing Baukultur is **a social process** based on a broad understanding of **qualitative values and goals** and their implementation with high levels of **interdisciplinary expertise**. Baukultur is the **positive result of a good process culture**."* [6]

One of the main current challenges identified by the Federal Foundation Baukultur is the changing values and technical innovation regarding the question of how we will live in future.

BuildDigiCraft aims to embrace the huge opportunities arising from digitalization while at the same time reconnect the actors (e.g., designers, builders, and users) and the projects (e.g., the built environment) with the work qualities of craftsmanship.

The mission of **BuildDigiCraft** is:

- to raise awareness on the overreaching concept of Baukultur
- to raise awareness on the need of cultural change in the building sector through digital advancements in technology and science
- to bring in the qualities of craftsmanship in a digitally-driven environment

[6] German Federal Foundation Baukultur (Bundesstiftung Baukultur), BAUKULTUR REPORT "Built Living Spaces of the Future – Focus City" 2014/15, English version, https://www.bundesstiftung-baukultur.de/fileadmin/files/medien/78/downloads/baukultur-bericht-e.pdf

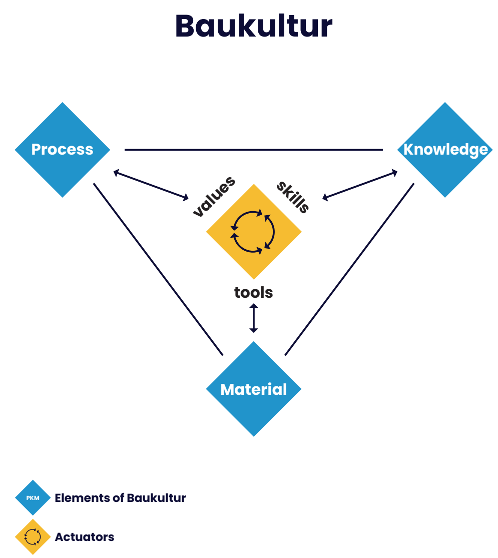
4.0 Aims

The main aim of the **BuildDigiCraft** project is to establish a European training network for young researchers, teachers and practitioners that promotes **innovative teaching approaches** for shaping the built environment based on the imminent and highly necessary culture change in the building sector caused by the rapid advances of digitalization.

The BuildDigiCraft project deconstructs Baukultur down to its core elements, i.e., Processes, Knowledge, and Material (Fig [● 2]). Shaping and maintaining of the built environment results in complex and diverse processes and includes design, planning, construction, maintenance, and as well as end of use phase. In broader terms, these Processes are influenced by the available Knowledge and understanding of Material. The **values, skills and tools** serve to actuate the developments and to carry out the Process.

The project raises awareness on the current relevance of the topic regarding the ongoing cultural transformation in the building and planning sector. With the introduction of the **BuildDigiCraft** model for scientific reflection, a holistic framework for interdisciplinary exchange is offered to a broader research community. Within the training program participants are equipped with new skills and competences, which help them to prepare for the future labor market requirements.

Fig [● 2] **BuildDigiCraft** model for scientific reflection.



5.0 Concept and method

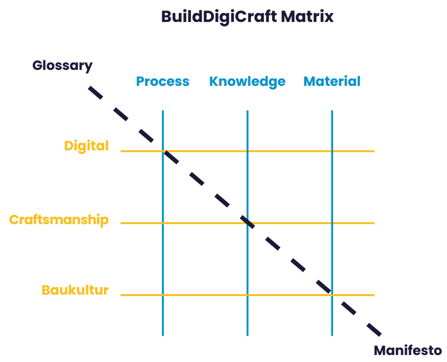


Fig [● 3] Matrix-based conceptual and methodological approach of the training program.

The conceptual and methodological approach of the training program is framed within the matrix-based intersection of the pillar concepts of the **BuildDigiCraft** project. The three major thematic concepts Baukultur, Craftsmanship and Digitalization are aligned on the vertical axis; horizontally, they intersect with the three constructive elements of Baukultur: Process, Knowledge, and Material. This grid is the foundational framework for the directions that are explored within the training program.

As in every interdisciplinarily run project, at the beginning there is a need to identify and contextualize the language used, the methods, and the boundary objects to thereby enable a better understanding among the participants of the training network. This usually requires the introduction of a project-based or context-oriented glossary. Next to the standard understanding of a glossary, which usually offers definitions of jointly used terminology, the **BuildDigiCraft** introduces an extended version of the standard glossary concept. The Glossary in the **BuildDigiCraft** training program is understood much more as a method for contextual reflection on the used terminology than simply offering static definitions. It allows for a temporal as well as scale-oriented exploration of the terms used in the project concepts and ideas (see Fig [● 3]). The **BuildDigiCraft** Glossary thus helps build a common foundation for shared understanding of the main concepts in the project as well as of the context-specific input shared by the training participants. The Glossary plays an essential role in the development of the methodological approach of the training program because it is used as a method for reflection on complex research questions. The **BuildDigiCraft** explorative matrix as well as the complementary Glossary methodology help develop the content of the intellectual outputs of both the project and the training program. Within a final, post-training reflection phase about the program, the essence and major statements of the project are brought together in a **BuildDigiCraft** Manifesto, which, unlike the Glossary, offers precisely defined statements and recommendations for the role of higher education training for the formation of a new professional mindset leading to high-quality Baukultur in the digital age.

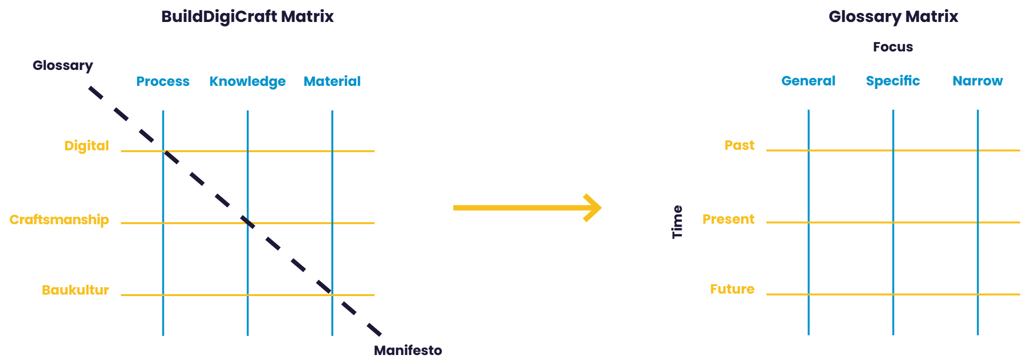


Fig [● 4] Matrix-based method for contextual reflection on the used terminology: vertically temporal and horizontally scale-oriented exploration.

Structurally, the training program is one of the main working packages within the **BuildDigiCraft** project. It is the backbone of the whole project, offering a well-framed platform for an extensive intellectual discourse between all project participants: advanced Master's-level students, early stage researchers and experienced scientists. The material generated within the **BuildDigiCraft** training program was evaluated as research material within the rest of the working packages, which at the same time corresponds to the intellectual outputs of the project.

Working package		Intellectual output
WP1: Glossary	→	Glossary as a method for reflection on complex research questions
WP2: Process	→	Guidelines for a design process leading to a high-quality Baukultur in the digital age
WP3: Knowledge	→	Toward guidelines for the development of a higher education curriculum: bridging craft and digital for a high-quality Baukultur
WP4: Material	→	The meaning of Material, Materiality, and the Digital for Baukultur
WP5: Manifesto	→	Manifesto for High-Quality Baukultur in the Digital Age
WP6: New teaching and training module	→	Interdisciplinary Doctoral Training Course
WP7: Digital platform	→	Digital exhibition space and cloud-based exchange platform

2.1 Training program
Intellectual Output 6

Interdisciplinary Doctoral Training Course

Authors
Emiliya Popova, Annette Bögle

Contents

1.0 Structure

1.1 Formal structure

The **BuildDigiCraft** training program consists of four consecutive five-day long Intensive Study Programs, referred to as ISPs in short. They can be taken within one calendar year, within an interval of three or four months. For instance, the pilot issue of the **BuildDigiCraft** training program started in October 2020 and ended in December 2021, with ISP1 taking place in October 2020, ISP2 in February 2021, ISP3 in June and ISP4 in December 2021. This training course is open to advanced Master's-level students and PhD students who are working on their individual projects where the role and impact of the digital technologies on issues related to the shaping of the built environment is being explored. **The program is interdisciplinary and open to young professionals from the field of studies of design and architecture, structural and civil engineering, urban planning but also to any field of studies with a certain focus on spatial planning and the transformation of the built environment**.

1.1.1 Application for the ISPs

The general organizational structure of the ISPs is the same for each ISP. The programs are launched with an **application phase** and an open call for participation that is distributed throughout the teaching and doctoral networks of the teaching and expert staff involved. The call describes the focus, scope and contents of the program, the higher educational institutions involved, the work formats during the intensive course as well as the selection criteria for the participants. The formal selection criteria focus on the academic and disciplinary background (PhD/Master's level, field of studies), whereas the thematic criteria help to find participants who are interested in research projects related to one of the following topics:

- Digital transformation in the planning and building industry
- Cultural transformation of the professions of the built environment
- Future of craftsmanship, digital craftsmanship
- Formation of new cultural and aesthetic values in the built environment of the digital age

1.1.2 Preparation for the ISPs

Selected candidates receive prior to the start of the training program a set of preparatory task assignments, which are related to the content of the specific ISP. The preparatory tasks help participants present themselves at the beginning of the course, and at the same time they offer guidelines for setting the individual research work within the scope of the **BuildDigiCraft** training program. The number of the preparatory task varies for each ISP, in the first two ISPs the number of preparatory tasks is aligned with the number of training days – there is a preparatory task for each day. In the last two ISPs the number of tasks is reduced to one or two, but then the task assignment requires a more focused and in-depth reflection on the individual research project.

1.1.3 Input during the ISPs

There are **three major sources of input** during the training program: **individual input by the participants, input from the scientific team organizing the training program** (in the form of supervision of the group work as well as contribution to the joint discussion rounds after each group work presentations) and **external input** coming from invited experts and renowned keynote speakers. The invited experts bring in the latest know-how and cutting-edge ideas regarding the selected thematic focus of the specific ISP. There is an invited expert for each day of the training program, in some cases even two speakers per day. Each ISP day ideally starts with the input of the invited expert offering a major intellectual impulse for the following group work tasks and discussions.

1.1.4 Work formats during the ISPs

The work format during an ISP consists of **individual presentations, supervised group work formats and intermediate and final group presentations**. The individual presentation is usually based on a preparatory task, it can take place either in the larger round or in smaller breakout groups of four to six people, depending on the total number of participants. The **individual task or presentation**, respectively, allows each participant to introduce to the rest of the group their current research context as well as individual and research background. After the "presentation round," the actual ISP group work starts. **Group work tasks** are introduced as "mapping guidelines for group work" and are mainly based on the preparatory task assignments. Within the group work, in small breakout sessions of four to six members, participants present their individual findings to each other, discuss them and follow the mapping guidelines to try to find a common way to organize and classify information, so that they can later transfer the results to the joint discussion rounds or to the group task assignments of the next days. The assignments of the group work tasks during the ISP is carefully prepared by the supervising scientific staff. The selected exercises help participants and the scientific supervising team to gain a shared understanding of the dimensions and impact of the ongoing cultural change in the building and planning sector. They also build up the foundation for the **joint discussion rounds** during and after the final group work presentations. **During the group work**, each group is fully or partially supervised by at least one member of the teaching staff. Ideally, group work is always supervised by two teaching members. In some cases, groups can be given first some unsupervised group work time, while supervisors' input is collected only in the final stage of the daily group work period. The character of the group work during the four ISPs changes gradually, allowing for the testing of different group work formats.

ISP1: Group work task assignments and group members change every day

ISP2: Group work task assignments and group members change every day

ISP3: Group work is arranged around certain topics (two to four in total), group members remain the same throughout the ISP, ideally four participants per group

ISP4: Group work is arranged only around one topic, participants are separated in groups of five to six people, group members remain the same throughout the ISP

The gradually changing character of the group work reflects the depth of the concepts explored within the **BuildDigiCraft** project. In order to cover as many aspects as possible at the beginning during ISP1 and ISP2, it is recommendable to create as many explorative group tasks as possible, ideally one per day, so that all participants can get a better overview of the thematic scope, the concepts and ideas introduced by the different participants and members of the scientific team. At the same time, in terms of interdisciplinarity, it is important at the beginning of the training program to give participants the opportunity to interact with as many participants as possible. Therefore, the **BuildDigiCraft** team recommends a regular change of group work assignments and group members within the first two stages of the training program. In the second stage of the program, ISP3 and ISP4, it becomes necessary to create a more focused and concentrated work environment in order to achieve a higher level of scientific reflection among the participants. While in ISP3 the organization team can choose to have two to four main topics to organize the group work around, in the last ISP the topic can remain the same for all group members. Thus, group members have the opportunity for a more intensive exchange by interacting with the same group members throughout the whole ISP. In the last stage of the training program all group members work on the same topic, trying to address it from their individual perspective but at the same time to reach a new level of shared understanding about the cultural change within the built environment of the digital age. An interdisciplinary work language is created at this level, in which Baukultur, Craftsmanship and Digital are used synergetically.

1.1.5 Digital tools for the group work during the ISP

The training program can be carried out both in physical and digital format. Whereas there was enough experience and knowledge accumulated for the organization and implementation of training workshops in physical presence, there had not been much experience in carrying through a training program in an entirely digital mode until the beginning of the coronavirus crisis. The **BuildDigiCraft** program was therefore the first training program of the organizing scientific team that took place in a completely digital format. The new digital tools that are available allow for new modes of collaboration. The experience made within the **BuildDigiCraft** training program shows that there are **two major communication tools absolutely necessary for the realization of group work and discussions in the digital format**. The first one refers to the digital conference tools used for enabling real-time communication mainly via camera and microphone, and in a highly extended version within a game-engines reality allowing for an avatar embodiment of the participants. The second major worktool is the interactive whiteboard, allowing for an immediate and simultaneous visualization of ideas and thoughts within a team. The latter enables an immediate and machine-readable visual documentation of group work and discussions.

1.1.6 Documentation

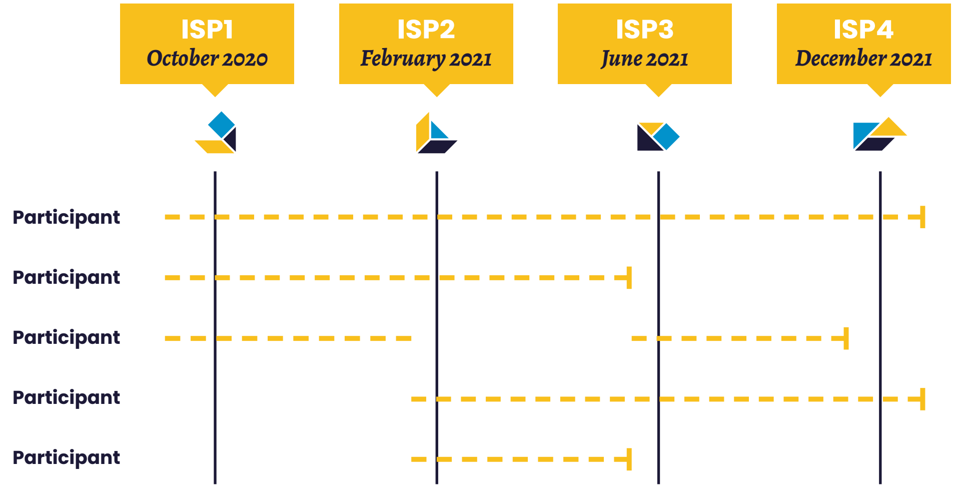
All input and outcome of the training program needs to be carefully documented. Thus, the collected material during the ISPs remains available in a well-structured manner for later evaluation and post-processing. All external input is video-recorded and uploaded on a popular and widely accessible video platform such as the YouTube[1] channel of the project. The input of the individual participants in the form of submitted pre-tasks and visual outcomes from the group work assignment (saved on an interactive white board) is organized in a digital documentation format. The closing discussion rounds during the training program can be recorded and used in a follow-up evaluation. In a next phase, the fully documented insights of the training program are processed through the prism of the **BuildDigiCraft** model (see [Chapter 1.0 | "Introduction" | Fig[●2]]), allowing for the creation of well-structured guidelines and strategies for the Process, Knowledge, and Material necessary for achieving high-quality Baukultur in the digital age.

1 https://www.youtube.com/channel/UC8bIdsOCxTQCwF2Xu1H3_rA/videos

1.1.7 Participation in the ISPs: number and consecutiveness

An ISP from the **BuildDigiCraft** training program can be open to a different number of participants. However, it is recommended to have no less than ten participants and a maximum of 25. A smaller number of participants would mean a significant narrowing of the spectrum of explored topics, a larger number would lead to a lower quality of interaction between the participants, thus depriving some of them of the opportunity to actively engage in discussions in a bigger round.

Fig[●1] Participation form.
Option 1: consecutive
Option 2: non-consecutive



The **BuildDigiCraft** program with its four ISPs is planned as a consecutive study program. However, it allows for non-consecutive participation and integration of new participants at any stage of the program. At the same time, it is highly recommended to ensure that there is a small number of "regular participants," who have attended at least two of the ISPs. This allows for a continuous transfer of knowledge between the "old" and "new" participants. It is the members of the scientific team, organizers of the training, who remain constant throughout the training program. They supervise the PhD and Master's students throughout the group work and joint discussions as well as make sure that the workshop outcomes flow in the project outputs (Fig[●1]).

1.1.8 Scientific supervision during the ISPs

The **BuildDigiCraft** scientific team is responsible for both the concept of the **BuildDigiCraft** training program and the supervision of the participants' work during the ISPs. Group work and group discussions foresee the involvement of experienced researchers to guide the participants, the early-stage researchers, through the conceptual framework of the **BuildDigiCraft** project as well as to equip them with the necessary skills and competences for a future career in research and academia. Group supervisors during the group work exercises have two main tasks. First, they make sure that the group follows the assigned mapping guidelines for the group work. Secondly, they supervise the quality of the discussion rounds within the group, while at the same time actively contributing to it by bringing in disciplinary insights from their own field of expertise. In the final discussion rounds after the group presentations, usually at the end of each working day, all group supervisors come together and take part in a bigger joint discussion round with all participants (see Fig[• 2] as an example of the program).

Fig[• 2] Example of an ISP program.

TOPIC (DAY)

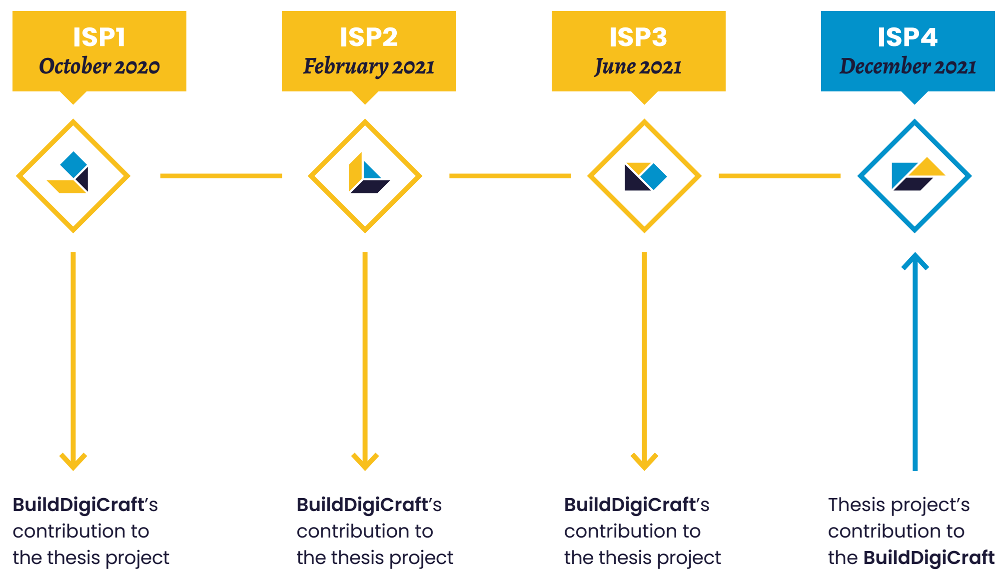
9:00—9:15, 9:15—9:30, 9:30—9:45, 9:45—10:00, 10:00—10:15, 10:15—10:30, 10:30—10:45, 10:45—11:00, 11:00—11:15, 11:15—11:30, 11:30—11:45, 11:45—12:00, 12:00—12:15, 12:15—12:30, 12:30—12:45, 12:45—13:00, 13:00—13:15, 13:15—13:30, 13:30—13:45, 13:45—14:00, 14:00, ..., 15:00, ..., 16:00, ..., 17:00, ..., 18:00

15.02.2021 Monday — Day 1: Introduction	16.02.2021 Tuesday — Day 2: Process	17.02.2021 Wednesday — Day 3: Material	18.02.2021 Thursday — Day 4: Knowledge	19.02.2021 Friday — Day 5: Roundup
KEYNOTE Mette Ramsgaard Thomsen Centre for IT and Architecture Research Group (CITA) *Assoc. Prof., Royal Danish Academy*	KEYNOTE Mark Burry, AO Founder of Swinburne University of Technology's Smart Cities Research Institute *former Prof. of Urban Futures, University of Melbourne*	KEYNOTE 1 Vicki Thake Material and Spatial Design ... *Assoc. Prof., Royal Danish Academy*	KEYNOTE Helle Rootzen Professor in Learning Technology and Digitalization LearnT DTU - Center for Digital Learning Technology. *CEO Andhero*	KEYNOTE Lars Botin Values and social responsibility in technology development *Assoc. Prof., Aalborg University,*
Coffee Break (15 min)	*Coffee Break (15 min)*	*Coffee Break (15 min)*	*Coffee Break (15 min)*	*Coffee Break (15 min)*
OFFICIAL WELCOMING	GROUP WORK 1 *(Pre-Task 2)*	KEYNOTE 2 Anton Kuzyk Professor in DNA Nanotechnology – Department of Neuroscience and Biomedical Engineering *Aalto University*	GROUP WORK 1+ PANEL DISCUSSION KEYNOTE SPEAKER *(Pre-Task 4)*	INPUT TALK Vincent Kuo, *VXT Research*
GROUP WORK 1 *(Pre-Task 1)*	*Break (15 min)*	*Break (15 min)*	*Break (15 min)*	GROUP WORK 1 *(Pre-Task 5)*
Break (15 min)	GROUP WORK 2	GROUP WORK 1 + 2 *(Pre-Task 3)*	GROUP WORK 2	*Break (15 min)*
GROUP WORK 2	*Break (120 min)*	*Break (120 min)*	*Break (90 min)*	GROUP WORK 2 + PANEL DISCUSSION WITH LARS BOTIN
	OPTIONAL WORKSHOP PARAMETRIC DESIGN WITH RHINO/GRASSHOPPER Part 1 *Kacper Radziszewski* *15:30—18:00*	OPTIONAL WORKSHOP PARAMETRIC DESIGN WITH RHINO/GRASSHOPPER Part 2 *Kacper Radziszewski* *15:30—17:30*	OPTIONAL WORKSHOP PARAMETRIC STRUCTURAL DESIGN WITH KARAMBA3D *Clemens Preisinger* *15:00—17:00*	OFFICIAL CLOSING

1.1.9 Relation between the training program and the individual project

The training program brings together an interdisciplinary team of researchers at different levels of their research careers to offer them a holistic framework and exchange platform for their research projects. During the first three ISPs the scientific team behind the program provides the input and guidelines for the intensive group work, helping participating researchers to set their research projects in the holistic framework of the **BuildDigiCraft** project. In the last ISP it is the participants who are asked in their group work projects to deliver a joint outcome, their own Group Manifesto, which can then be used for the further development of the project's final Manifesto. Thus, the project framework is developed within an active exchange of ideas between the participants, the scientific team and the invited experts (see Fig[• 3]).

Fig[• 3] Relation between the training program and the individual project.



1.1.10 Formal recognition of participation

The participation at the **BuildDigiCraft** training program can be formally awarded with credit points for the transfer of knowledge in higher education. The participation at each ISP, including the fulfillment of the preparatory tasks, allows for the acquisition of 2 to 2.5 ECTS[2] which corresponds to 60 to 75 working hours. The exact number of the credit points depends on the academic award system at each university. The **BuildDigiCraft** training program can be basically integrated as an official doctoral study course in the doctoral education program of European higher education institutions.

2 **ECTS** = European Credit Transfer and Accumulation System: the European Credit Transfer and Accumulation System (ECTS) is a tool of the European Higher Education Area for making studies and courses more transparent.

1.2 Contents structure

The **BuildDigiCraft** training program was implemented as a one-year online training program which consisted of four consecutive five-day long[3] intensive training courses – called "Intensive Study Programs" (ISPs). Each of these four ISPs was dedicated to a specific topic, which in turn reflected a certain aspect to be explored within the **BuildDigiCraft** project.

ISP1
October 2020
Concepts and Fundamentals

ISP2
February 2021
Digital Futures

ISP3
June 2021
Craft and Craftsmanship

ISP4
December 2021
Rethinking Baukultur in the Digital Age
From Bauhaus to the New European Bauhaus

3 Exception ISP1 "Concepts and Fundamentals" – duration was only four days instead of five. A minimum of five consecutive days for an intensive study program is required according to the Erasmus+ Strategic Partnerships program requirements.

To follow, the detailed day-by-day content program of each of the four ISP is presented. First, the thematic focus of the training with the leading discussion questions is outlined, then the input lectures are listed (a detailed description is available in the Catalog [Chapter 4.0 | "Catalog of Video Lectures"] of the **BuildDigiCraft** Input Lectures) and finally, the format of the group work during the training with a full description of the specific task and project assignments is looked at.

ISP1 Concepts and Fundamentals

Thematic scope

ISP1 is the first of four consecutive training events organized between 2020 and 2021 within the thematic framework of the **BuildDigiCraft** project. ISP1 is dedicated to setting out the common ground for the joint work within the doctoral teaching program. It builds up the fundamentals and introduces the main concepts of the **BuildDigiCraft** project: future projections, Baukultur in Europe, craft and craftsmanship and digital explorations.

Leading discussion questions:

- *What is Baukultur in the digital age?*
- *What is craft and craftsmanship?*
- *How can crafting techniques and materiality be transferred to the digital world?*
- *What is the essence of the digital revolution in respect to shaping the built environment?*

Fig[● 4] Full program ISP1 "Concepts and Fundamentals."

DAY COORDINATOR	19.10.2020 Day 1: **Introduction** HCU, RTU	20.10.2020 Day 2: **Baukultur** GUT, HCU	21.10.2020 Day 3: **Craft** KADK, Aalto, Chalmers	22.10.2020 Day 4: **Digital** DTU, Chalmers
9:00—9:15	INTRO PROJECT "**Build Digi Craft**" *(in Zoom Meeting)*	INTRO GLOSSARY *(in Zoom Meeting)*	DRAWING EXERCISE Helle Mie Helleson (Royal Danish Academy) *(in Zoom Meeting)*	KEYNOTE *Digital Craftsmanship (title TBC)* **Kristoffer Negendahl** (Denmark University of Technology) *(in Zoom **Webinar**)*
9:15—9:30				
9:30—9:45	KEYNOTE *How are you imagining [y]our future?* **Chris Luebkeman** (ETH Zürich, Strategic Foresight Hub) *(in Zoom **Webinar**)*	KEYNOTE *What is Baukultur and Baukultur in the Digital Age?* **Inga Glander** (German Federal Foundation Baukulur) *(in Zoom **Webinar**)*		
9:45—10:00				
10:00—10:15			KEYNOTE *Craft in a Digital era. A Search for Earthly Paradise?* **Claes Caldenby** (Chalmers University of Technology) *(in Zoom **Webinar**)*	*Coffee Break (15 min)*
10:15—10:30				GROUP WORK Pre-Task: Digital (Built) Environment *(in Zoom Meeting)*
10:30—10:45	*Coffee Break (15 min)*	*Coffee Break (15 min)*		
10:45—11:00	INTRODUCTION: 3D-AVATAR EXPERIENCE *(Zoom M)*	GROUP WORK Pre-Task: Case Study Baukultur *(in Zoom Meeting)*		
11:00—11:15	EXPLORATION 3D-CONGRESS SPACE *(TriCAT Spaces)*		*Coffee Break (15 min)*	
11:15—11:30			GROUP WORK Pre-Task: (1) Semantics of Craft Pre-Task: (2) Why Material Matters *(in Zoom Meeting)*	
11:30—11:45	GET-TO-KNOW THE GROUP 1			
11:45—12:00				*Lunch Break (30 min)*
12:00—12:15	*Avatar Coffee Break (15 min)*			
12:15—12:30	GET TO KNOW THE GROUP 2 Individual Presentations, Pre-Task 1 *(sub-groups)*	*Lunch Break (30 min)*		REFLECTION *(individually)*
12:30—12:45				GLOSSARY Group Presentations + Discussion
12:45—13:00		REFLECTION *(individually)*	*Lunch Break (30 min)*	
13:00—13:15	*Avatar Coffee Break (15 min)*	GLOSSARY Group Presentations + Discussion		
13:15—13:30	GET BACK TO STAGE "What comes next?" & Feedback		REFLECTION *(individually)*	MANIFESTO Group Presentations + Discussion *(all in Zoom M)*
13:30—13:45			GLOSSARY Group Presentations + Discussion	
13:45—14:00		MANIFESTO Group Presentations + Discussion *(all in Zoom Meeting)*		*Coffee Break (15 min)*
14:00—14:15	FACE-TO-FACE *(in Zoom Meeting)*		MANIFESTO Group Presentations + Discussion *(all in Zoom M)*	OFFICIAL CLOSING
14:15—14:30				
DIGITAL TOOL OF THE DAY	Avatar Conference Tool	Interactive White Board	Interactive White Board	Interactive White Board

Day 1: Introduction

Initial input

- Introduction to the project and the teaching program
- Dr. Chris Luebkemann, *ETH Zurich*, Strategic Foresight Hub
  Lecture title: ***How are you imagining [y]our future?***

Group work

- **Get-to-know-the-group activity:** carried out first as an avatar meeting in a 3D conference space. Participants enter the training program directly in a 3D game-engine environment, without having the opportunity for a face-to-face exchange based on their real-faced, selves. Within this environment they first have no opportunity for a one-to-one voice exchange. Instead, they can test different options to transform the digital space by adding new forms and furniture, can move around freely and look at the other avatars. Next, in order for them to get first impressions of the group and the team constellation, they are asked to group according to various indicators (i.e., student status, home university, discipline, etc.). After this explorative phase, half of the participants are asked to present their Preparatory task 1 to the rest of the group. For this activity they meet in four separate breakout sessions called "private zones" in the avatar environment. The experience within the 3D meeting environment ends with a plenary session in a classic stage-audience setting, where the participants are officially welcomed and the **BuildDigiCraft** project and the training program are presented (Fig[● 5]). After that everybody leaves the avatar meeting and the ISP participants meet again in a camera-based 2D standard online conference environment, where the other half of the participants who have not yet presented their preparatory task can introduce themselves in an environment they now know.
- Preparatory task 1: ***"Personal presentation and relevance to the BuildDigiCraft project including five keywords"*** (both in the 2D and 3D conference space)

Fig[● 5] Screenshots from the avatar meeting ISP1, Day 1.

Pre-task 1: Assignment

Reflect on your individual project (PhD project / Master's thesis or any project of personal interest) in respect to the following three concepts: Baukultur, Craft(smanship) and Digital(ization).

Prepare a presentation with four to six slides, addressing the following issues:

1. Personal profile/introduction – who you are?
2. Baukultur – does the term Baukultur play any role in your work?
3. Craft & Craftsmanship – how do you see these in your work?
4. Digital & Digitalization – what dimensions and representations does the Digital have in your work?
5. Share with the audience your personal statement/choice/interest (Joker slide).
6. Suggest your own five keywords in relation to Baukultur, Digital, and Craft, and please add/share (your own) short definition of these words.

Fig[● 6] Collected keywords in Pre-task 1, ISP1.

- 3D-SCANNING
- ADAPTABILITY
- AESTHETIC
- AGILE
- ALGORITHMIC
- DESIGN
- ALIVE
- ARCHITECTURE
- BAUKULTUR
- BUILDING NDUSTRY
- BUILT and UNBUILT
- BUILT ENVIRONMENT
- CARE
- CHANGE
- CIRCULAR
- CIRCULAR ECONOMY
- COLLABORATION
- COMMUNICATION TOOLS
- CONNECTION
- CRAFT
- CRAFT TECHNOLOGY
- CRAFTSMANSHIP
- DATA-AVAILABILITY
- DATA-INTEGRATION
- DETAIL
- DEVELOPMENT
- DIGITAL
- DIGITAL FABRICATION
- DIGITAL TOOLS
- DIGITALISATION
- EMOTIONAL
- ENVIRONMENT
- FUTURE-ORIENTED
- GENERATIVE DESIGN
- HERITAGE
- IDENTITY
- INFORMED PROCESS
- INTEGRATION
- INTEGRITY
- INTERACTIVE DESIGN
- INVOLVEMENT
- LEARN
- LIFE-CYCLE
- LIFESTYLE
- MACHINE LEARNING
- MANAGEMENT/ ECONOMIC SYSTEMS
- MATERIAL
- MATERIAL COMPUTATION
- MATERIAL REUSE/ RECYCLE/UPCYCLING
- MATERIALITY
- MATERIALITY & DIGITAL
- MEGASCANS
- OPEN BUILDINGS
- OPTIMISATION
- OWNERSHIP
- PARTICIPATORY
- PEOPLE
- PHOTOGRAMMETRY
- POLICIES
- PRESERVE
- PROJECT
- REFLECTION
- RESILIENCE
- RESISTANCE
- RESPONSIBILITY
- REUSE
- REVITALISATION
- SAVE
- SCALE
- SHAPE
- SOCIAL
- SOCIAL ISSUES
- SOCIAL PARTICIPATION
- STRUCTURAL ART
- STRUCTURES and ARCHITECTURE
- SUSTAINABILITY
- SYSTEM
- TACIT KNOWLEDGE
- TACTILE
- THINK OUTSIDE THE BOX
- TIMBER-ONLY STRUCTURES
- TIME
- TRANSFORM
- UNIQUE
- UNREAL ENGINE
- URBAN PLANNING
- VR HDM MODELING
- WELL-BEING

Day 2: Baukultur

Initial input

- Glossary introduction (Glossary Matrix) see [Chapter 2.2 | IO1 "Glossary"]
- Inga Glander, German Federal Foundation Baukultur
  Lecture title: ***What is Baukultur in general and Baukultur in the digital age?***

Group work

- Presentation Preparatory task 2 ***"Case Study Baukultur"*** in supervised breakout groups of four to seven people
- Group presentations and joint discussion in the larger round

Pre-task 2: Assignment

Think of a concrete case of practiced Baukultur that you would like to present and justify your choice by answering the question: *Why is this case a good or bad example of practiced Baukultur (in your opinion)?*
There are no thematic or format restrictions. You can use the suggested literature references.

Literature references:

1. **ECAP Vienna 2018 – Documentation**
   European Conference for Architectural Policies "*High Quality Building for Everyone. Baukultur and the Common Good in Europe*"
   https://www.ace-cae.eu/uploads/tx_jidocumentsview/ECAP_Vienna_2018.pdf

2. **Davos Declaration 2018** https://davosdeclaration2018.ch
   + Conference "*Getting the measure of Baukultur*" 2019
   https://davosdeclaration2018.ch/conference-2019-geneva/
   Context document:
   https://davosdeclaration2018.ch/media/Context-document-en.pdf

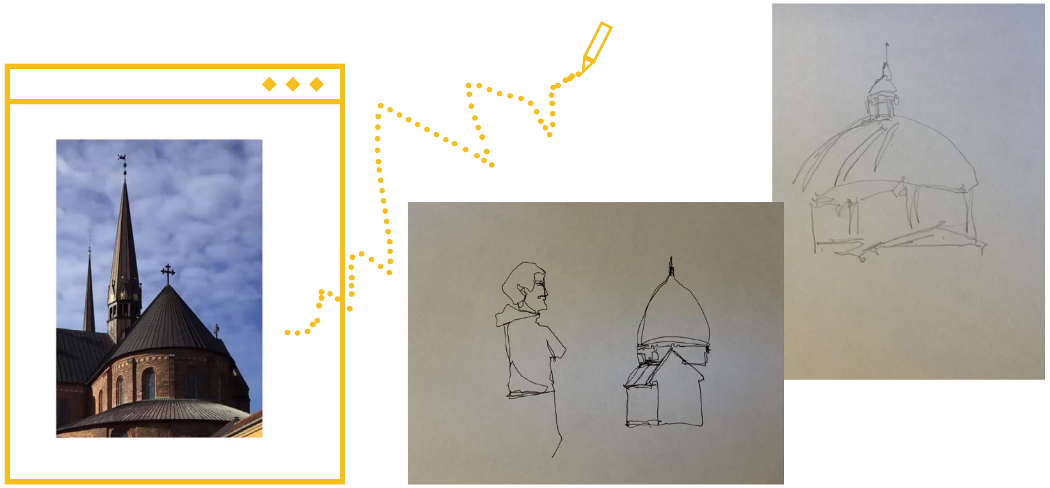
3. **German Federal Foundation Baukultur** (English version)
   https://www.bundesstiftung-baukultur.de/en

Day 3: Craft and Craftsmanship

Initial input

- Real-time online "**Drawing exercise**" by Helle Mie Helleson (Assoc. Prof.), *Royal Danish Academy*
  Aim of the exercise: activation of the connection between the mind and the hand at an online meeting
- Claes Caldenby, Prof. em., *Chalmers University of Technology*
  Lecture title: ***Craft in a digital era. A search for earthly paradise?***

Fig[● 7] Drawing sketches by Faezeh Sadeghi, drawing exercise, ISP3, Day 3.



Group work

- Presentation Preparatory task 3 ***"Craft & Craftsmanship: Semantics of Craft(smanship) and Material Matters"*** in supervised groups of four to seven people
- Group presentations and joint discussion in the larger round (see Fig[● 8–11]).

Pre-task 3: Assignment

a) Semantics and Etymology of Craft & Craftsmanship
Present and discuss the semantics and etymology of the words "*Craft*" / "*Craftsmanship*" in your native language or any language of personal choice.

b) Why does material matter? How to digitize material and skill?
Find and present examples (one or two) on how materials or skills can be (re)presented in a digital environment, how we can approach Craft/Craftsmanship and the material dimension in the digital environment.

There are no thematic or format restrictions. You can use the suggested literature references.

1. ***The Craftsman***, Richard Sennett, 2008
2. **Richard Sennett: *Craftsmanship*** at MAK, Museum für Angewandte Kunst, Vienna, October 9, 2016, https://www.youtube.com/watch?v=nIq4w9brxTk
3. ***The Good Craftsman***, Richard Sennett, ACT Cube, Nov. 13, 2018, Part of the Fall 2018 Lecture Series: Vibrant Signs and Indeterminant Matter(s), MIT program in art, culture and technology, https://vimeo.com/320539053
4. ***Richard Sennett on Art and Craft***, Getty Museum, December 3, 2009, https://www.youtube.com/watch?v=LH1aX_6-xkY
5. **Richard Sennett: *The Decline of the Skills Society***, UC Berkeley Events, Oct.25, 2011
   1) reality of the prospect – high-skilled society; **2)** what do we mean by skills (capacities for symbolic interpretation)? **3)** how we deal with skills that involve new technologies, https://www.youtube.com/watch?v=mjd5iM42APA
6. **Richard Sennett: *Und wo bleibt der Mensch?***,
   SRF Sternstunde Philosophie (English version), December 7, 2018.
   https://www.youtube.com/watch?v=rNzX4Ou3FvQ
7. **Bauhaus-Archiv: *Museum für Gestaltung***, Berlin,
   https://www.bauhaus.de/en/ (Arts & Crafts)

Fig[● 8] Outcomes of the Pre-task 3 group work – Group 1.

Group 1

Country	Craft definition in ~ 6 words please. Long one in the yellow box :)	Craftsmanship definition in ~ 6 words please. Long one in the yellow box :)
Matijs Babris **Latvia 1**	2 words **Position** (post office) **+** **Nonsense** (futility, vanity)	The same
Ilirjana Haxhiaj- **Albania**	**Daily Skill** The skill that one exercises daily, usually working by hand or with simple tools, having special habits and skills, gained from experience; -Profession	; the **totality of crafts**; ex:Blacksmith craftsmanship
Szymon Kowalski - **Poland**	craft/craftsmanship (same translation) **1. «small scale manufacturing including making and repairing utility items by hand or with simple tools»** 2. "ability to do such subjects" 3. "with reference to the fields of art: mastery of technique, creative workshop" *4. formerly. "Profession, occupation"*	craft/craftsmanship (same translation) 1. «small scale manufacturing including making and repairing utility items by hand or with simple tools» **2. "ability to do such subjects"** **3. "with reference to the fields of art: mastery of technique, creative workshop"** *4. formerly. "Profession, occupation"*
Asad Fallah-**Iran**	**industry**, Crafts, Profession,Art **Skill: Something fulfilled by practice**	Handmade, Handwork
Egīls Markus - **Latvia 2**	**Activity/Skill** that one possess/does in **creation of something by hand**	Similar

craftsmanship
= Two Parts
1-industry, Crafts,
Profession,Art
2- Handmade,
Handwork

Craftsmanship *Rzemiosło* (Polish)	General	Specific	Related to (PhD) thesis
Past	Small-scale manufacturing including making and repairing utility items by hand or with simple tools	Carpentry works (show of skills and abilities)	Object with its **orginal function** (in this particular church)
Present	With reference to the fields of art: mastery of technique, creative workshop (in retreat)	Object of preservation (a great carrier of skills and abilities from past)	**Object** of interest as a great **specimen** of knowledge
Future	Automatization, Digitalization of crafts (algorithms, computer-aided crafts: 3D prints)	Hopefully still existing object (still as a great carrier of skills and abilities from past)	**Digital reconstruction** of piece of architecture (with possibility to share the knowledge and show former ways of constructing buildings)

Craftsmanship Matijs	General	Specific	
Past	Necessity	Part of trade. One of main providers of income	Technique
Present	Relic?	**Conservation** of existing buildings mostly?	**3D scanning**
Future	Luxury	**Informational bandwidth extension** – digitalization drawing, hand–eye coordination	**Virtual planning?**

Craftsmanship Egils	General	Specific	Related to (PhD) thesis
Past	Everything is handmade	Scale models, architectural details, construction work	Manually doing things, data gathering, a lot of labor needed
Present	High-quality work involves manual labor in combination with technologies	Scale models, architectural details, prefab, digital data, CNC, laser cutters	Looking into solution on how to work smarter and more efficiently while not losing quality
Future	Technologies take over manual labor, fully automatized solutions with some human supervision	Robotized solutions, higher educated people needed with know-how	Working smart, data-based solution not professional guessing

Craftsmanship Ilirjana Haxhiaj	General	Specific	Related to (PhD) thesis
Past	The activity/profession that one performed daily by hand	Limited materials/ constructions	DIY buildings/ application of material found in vicinity
Present	The skills/knowledge required to perform and manipulate materials	To offer a qualitative space and adaptable one through the application of special structures, etc	New building structures/ more morphological shapes/ replace easily and fix any damage through minimal intervention
Future	Preserving traditional skills	To offer a qualitative space and adaptable one through the application of special structures, etc	Sustainable buildings/ spaces/ reducing carbon footprint of building materials

Asad Craftsmanship	General	Specific	Related to (PhD) thesis
Past	It was a collective act within society	Craftsmen working habitually, internalized skill, open source	**Evolution of skills and construction**
Present	There is an artisan's perspective of the issue	Closed system, lack of narrative	Possibility of integration of skills and construction as one entity
Future	**Bringing back the quality to objectification**	**Work is the extension of identity in society**	Skilled confidence + skilled cooperation + quality

Fig[● 9] Outcomes of the Pre-task 3 group work – Group 2.

Group 2

What are the most important group statements for you in the discussion?

Digital can be a new form of Craftsmanship by the integration of the material system based on material characteristics, constructional principles, and the development of new construction methods.

Integration of the knowledge/experience from past and the innovative application at the present

Digital technology can also be a tool for promoting democratic participation.If we make the technology and the skill open-source, the popularization of design tools & processes can lower the entry barriers to the world of making things.

biometric investigation	General	Specific	Related to Phd. Ms.
Past	Traditional experimental	Structures and products were designed and created through materiality strength and behavioural principles which was mostly gained experimentally	
Present	Analysing, scanning, and testing	Designing and construction development is based on material principles and differentiation	Material Programming
Future	DNA Testing		

Craftsmanship	General	Specific	Related to Phd. Ms.
Past	Objectification creating accompanied by quality		
Present	Handmade, Digital, and visual fabricating	Use of robotic, 3D printing, and all digital tools in fabrication and assembly	
Future			

Craft	General	Specific	Related to Phd. Ms.
Past	Manual/hand work	Drawing, sculpturing, modeling by physical product	**Skills Knowldege Experience**
Present	Integration of manual and automated process	3D representation with inputs from manual experiences	Integration of knowledge and experiences
Future	Precise and accureate design with automated process	Understanding product behaviour with technical analysis applying the different algorithms and the AI technology	Development of digital craft

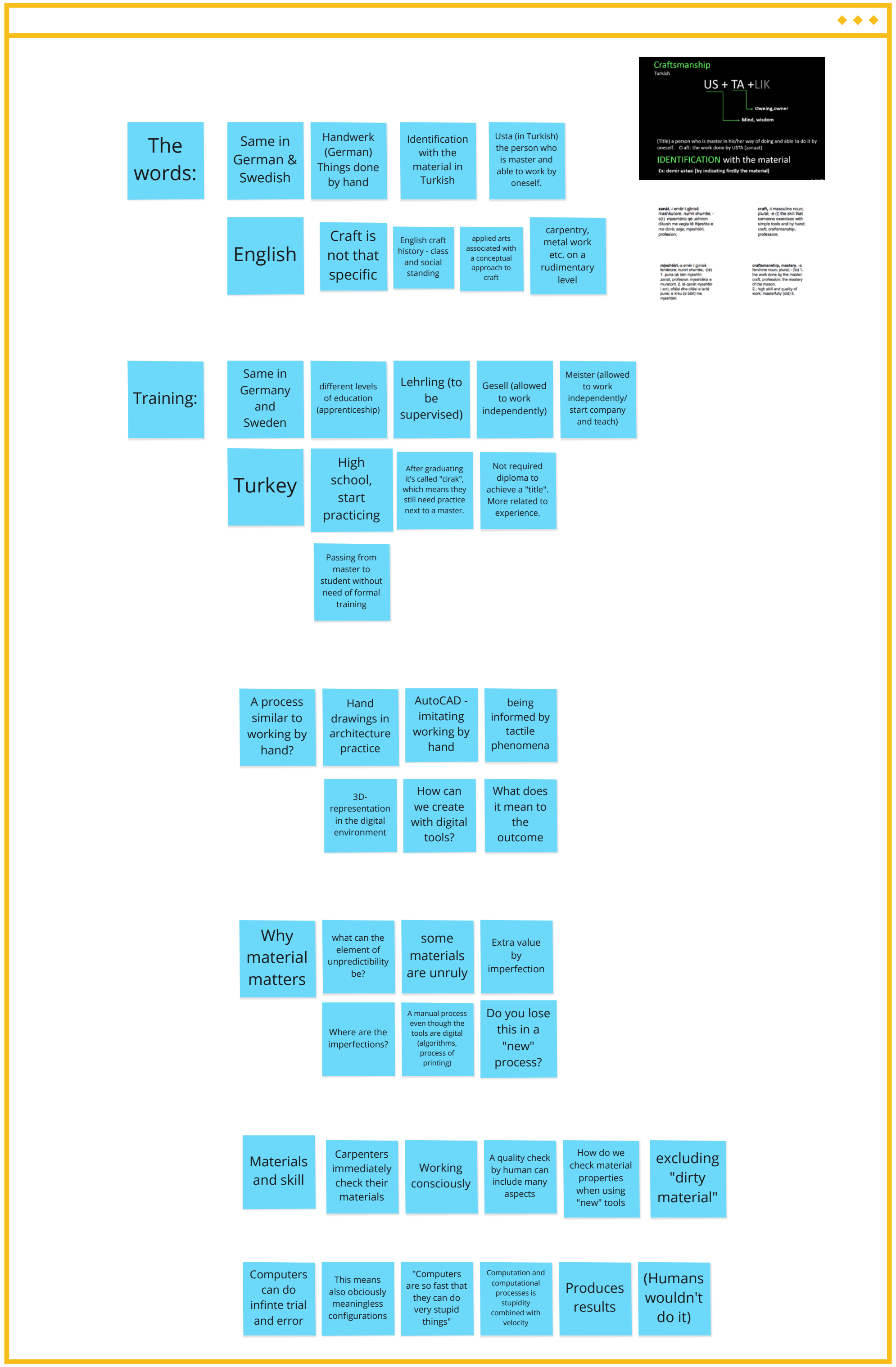
Material Resistance	General	Specific	Related to Phd. Ms.
Past	Intuitive understanding of material behavior.	How to process the material using the proper tools. Reading/Scanning, choosing the proper specimen. Choosing the proper tool.	How did they read, evaluate materials in the past
Present	"Material resistance is something one should avoid"	Material properties from tables ,Mechanical stresses, Test data from few experiments. Theoretical understanding of material resistance.	How to work with the resistance rather than against it?
Future	Choose the right material for the proper purpose	Incorporating the physical behavior and properties in digital tools. Combine theory and intuition.	

Digital Involvement	General	Specific	Related to Phd. Ms.
Past		Public participation	Participatory methods
Present	Use digital technology to involve more people in design process	3D printing photogrammetry	translation in the representation of an object
Future	Involvement in both physical and virtual world.	open-source digital democracy	

Hantverk	General	Specific	Related to Phd. Ms.
Past	People working the knowledge and skills of their hand.	Profession related to guilds. Knowledge about the material and tools, depending on guild. Working with your hands. Brunelleschi was a goldsmith. Such as mason, brickmaker, carpenter, smith.	Understanding of old building techniques, how did they work. Transfer skills and knowledge to a contemporary context in a format that could be understood today. What sources of knowledge and tools did they have?
Present	Beginning of automation of hand and machine integration. New digital technologies.	Automation or replacement of manual labour. At the present, ,or the near history, things automation have made things less advanced, prefabricated concrete elements. Still it is mechanical process that are designed by people. Programming as a new craft/craftmanship. Going from hand-drawings to BIM and parametric design. We still not use these technologies to the full potential.	Transfer the knowledge into available contemporary technologies, theory and methods. Could be digital design tools as well as digital fabrication.
Future	Incorporating the different separate technologies through more developed interfaces. Full integration between man and machine. Homo Deus - Yuval Noah Harari?	Figure out how utilize the computer and digital tools to the fullest. Incorporating the different separate technologies or production techniques into an interface where a person can interact and be in control of the outcome. Two possible tracks: 1. Assisting of people in- such as work(such as fologram). Cheap technologies that everyone can use(democratic aspect). 2. Digital fabrication - Going from mass produced elements to a more unique process for each project within budget. Utilizing the material to the fullest(function), aesthetics	How to democratize digital tools and digital fabrication?

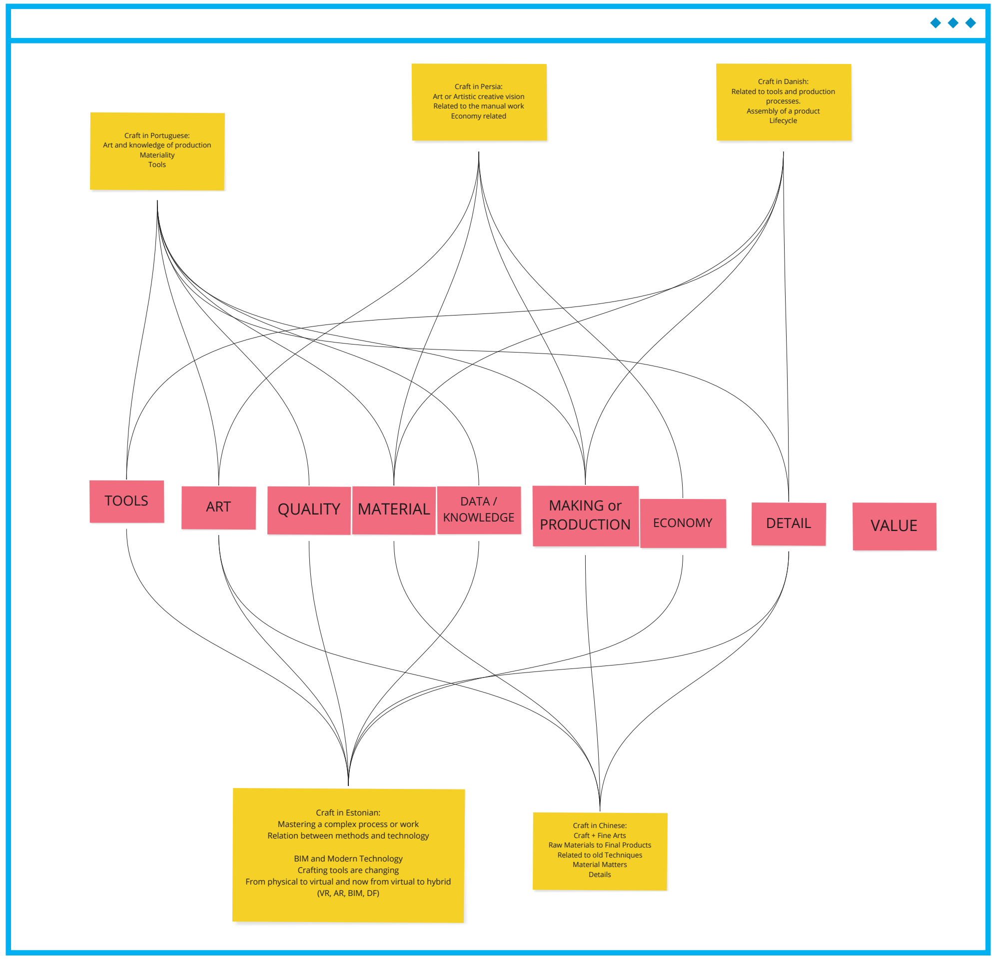
Fig[•10] Outcomes of the Pre-task 3 group work – Group 3.

Group 3



Fig[•11] Outcomes of the Pre-task 3 group work – Group 4.

Group 4



Day 4: Digital (Built) Environment

Initial input

- Kristoffer Negendahl, Assoc. Prof., *Denmark University of Technology*
  Lecture title: ***Engineering architectural arguments – systematic and practical approaches for multivariate optimization***

Group work

- Presentation Preparatory task 4 ***"Digital (Built) Environment"*** in supervised groups of four to seven people
- Group presentations (see Fig[● 13–15])
- Final discussion and closing of the ISP1
  - Joint reflection on the ISP1
  - Observations and statements from the teaching staff
  - Question to participants: Findings for the future work?
  - Free space for a final word by the participants on the three main topics: "*Baukultur*," "*Craft and Craftsmanship*" and "*Digital(ization)*", Fig[● 12]

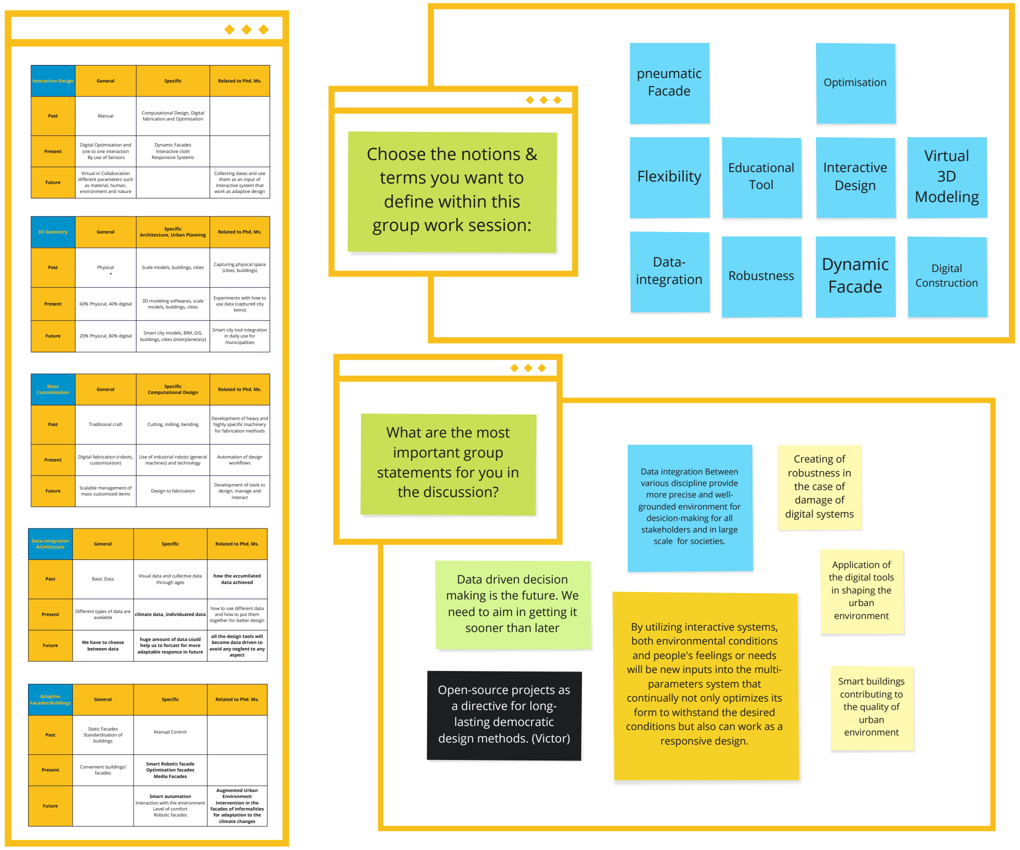
Pre-task 4: Assignment

Think of and present case examples (1 or 2) where the "digital" had and will have impact on the processes of design, the making and society (not necessarily only in the context of the built environment, any context of interest is welcome). Present the ones which have impressed you the most (positively or negatively)!

Fig[● 12] Outcomes ISP1, Day 4, Closing – Final words by the ISP participants.

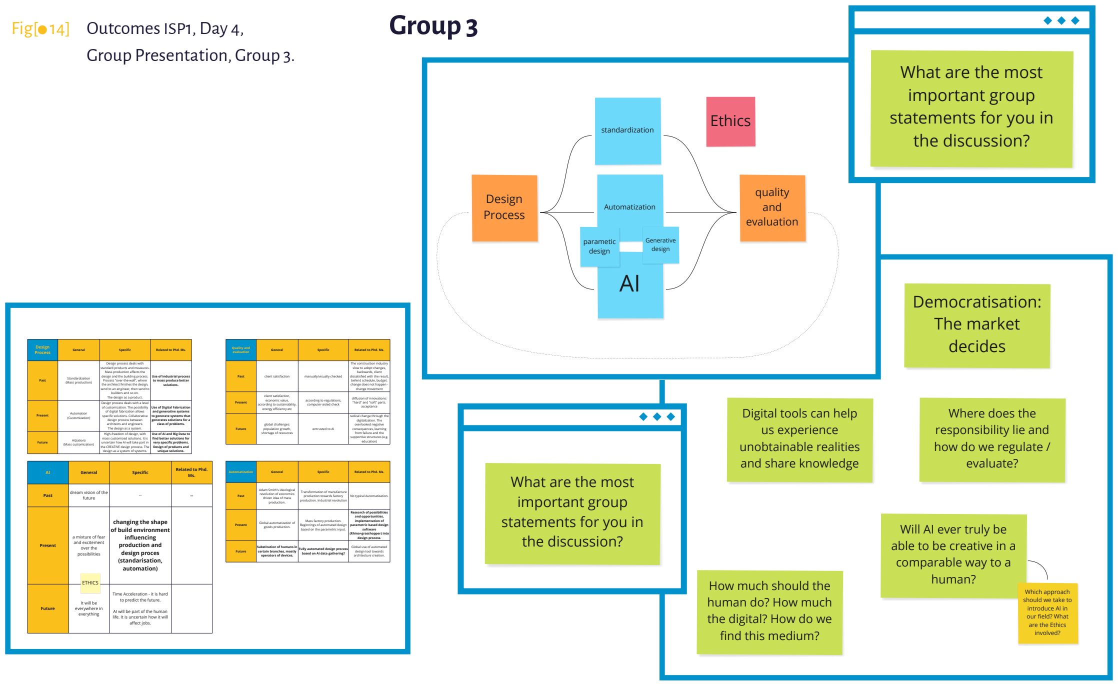
Fig[●13] Outcomes ISP1, Day 4, Group Presentation, Group 1.

Group 1



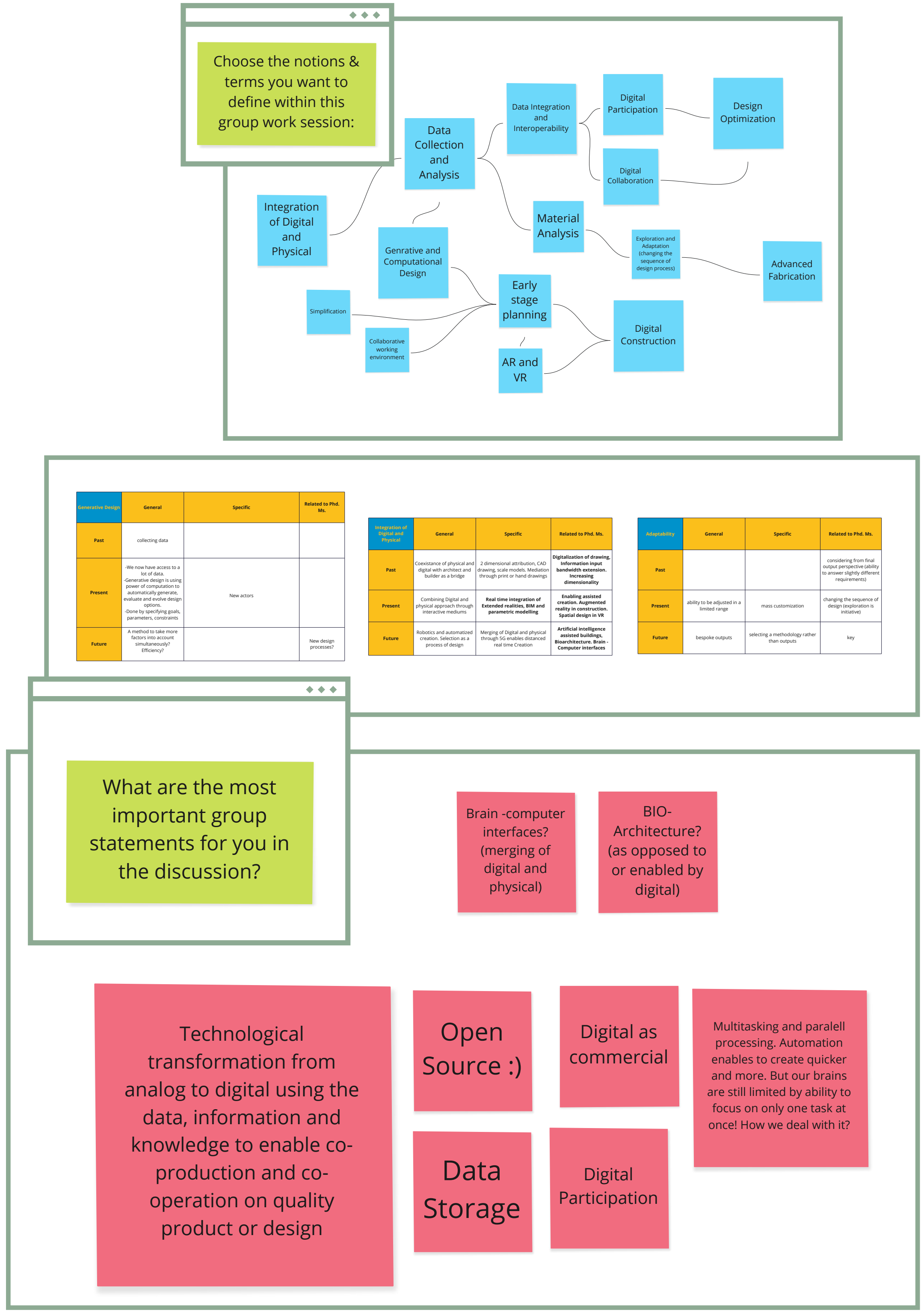
Fig[●14] Outcomes ISP1, Day 4, Group Presentation, Group 3.

Group 3



Fig[●15] Outcomes ISP1, Day 4, Group Presentation, Group 4.

Group 4



ISP2 Digital Futures

Thematic scope

ISP2 "Digital Futures" is the second of four consecutive training events that was organized between 2020 and 2021 within the thematic framework of the **BuildDigiCraft** project. In ISP2 participants are asked to reflect on the role of advanced digital technologies and the available digital tools on their research work as well as to think together of possible digital future projections of and for the built environment. The thematic focus is set on the following topics: digital urban futures and data-driven decisions, parametric and generative design, artificial intelligence, digital fabrication and digital material transformation. Structurally, the focus of each of the three middle days of the training is set on one of the three main Baukultur elements of the **BuildDigiCraft** project: Process, Knowledge, and Material. The ISP2 is rounded up with a reflection on the intrinsic relationship between humans and technology, as well as on the question of whether "*humans are exclusive carriers of moral and political values*" in a joint discussion with the invited speaker of the day (in this case, Lars Botin).

Leading discussion questions

- *What is Baukultur in the digital age?*
- *What is the essence of the digital revolution in respect to the shaping of the built environment?*
- *How do we design, build and maintain the built environment based on craftsmanship, data and algorithms?*

In addition, further skill training in parametric design is offered in three afternoon sessions. Participants of the ISP2 could optionally join **a workshop on "*Parametric design with Rhino/Grasshopper*" and "*Parametric Structural Design with Karamba3D.*"** (for full description of the workshops see [Chapter 4.0 | "Catalog of Video Lectures"])

Fig[● 16] Full program ISP2 "Digital Futures."

General rules of the group work during ISP2

- Every day new composition of the working groups
- Please choose one speaker every day for each working group
- Present to each other the preparatory tasks
- Compare your individual outcomes with the input in the morning (input lecture)
- Collect your vision(s) for the topic of the day (input for the **BuildDigiCraft** Manifesto)
- Add your contribution to the Glossary

Day 1: Introduction

Initial input

- Prof. Mette Ramsgaard Thomsen,
  Centre for IT and Architecture Research Group (CITA)
  Lecture Title: ***Digital Craft in a Bio-based Material Paradigm***
- Welcome and introduction to the project and the teaching program
- Updated presentation **“Glossary introduction (Glossary Matrix)”** – instructions for further use during the ISP2 (see Intellectual Output [Chapter 2.2 | IO1 “Glossary”]

Group work

- Presentation Preparatory task 1 ***“Personal presentation and relevance to the BuildDigiCraft project including five keywords”*** in supervised groups of four to five (same Task as in ISP1, Day 1)

  Mapping guidelines for the group work during Day 1 (ISP2):

  1. Present to each other your Preparatory task 1
  2. Get to know your group better
  3. New joint group work task assignment: Map [y]our digital tools
     - What are the digital tools that you are using in your project/for your work?
     - Make a collection and cluster them so that you can present them to the rest of the audience in the next session.

     Think also of the following issues while clustering:
     Why and what do you use them for?
     What are the challenges in using them?
     What do we gain/lose by applying them: pros and cons

- Group presentations and joint discussion in the larger round

Day 2: Process

Initial input

- Prof. Marc Burry, AO, *Founder of Swinburne University of technology’s Smart Cities Research Institute*
  Lecture Title: ***Urban futures and designing the digitalized city: from parametric design to parametric urbanism***

Group work

- Presentation Preparatory task 2 ***“Digital Process Modeling”*** in supervised groups of four to five

Pre-task 2: Assignment

Identify a question related to your (PhD) project that you would like to find the answer to/a solution for by applying a conceptual digital workflow or process model. Try to make a preliminary outline of such an imaginary workflow/process. Think digitally and visually, sketch your thoughts. The selected question does not necessarily have to be the main research question of your (PhD) project – it can also be a sub-question related to a specific issue of interest.

This pre-task will be the basis for the group work during the training session.

Mapping guidelines for the group work during Day 2 (ISP2):

1. Present to each other your Preparatory task 2 on Digital Process Modeling
2. Glossary task: according to step-by-step instructions in the Glossary presentation (see Intellectual Output 1)
3. New joint group work task assignment: Digital Process Modeling
   Find a way to map your imaginary workflows by relating them to the:
   a) Glossary Matrix
   b) Digital tools you gathered on Day 1
4. Identify the new and important questions/processes that we need for our future work as professionals responsible for the built environment

- Group presentations and joint discussion in the larger round (for results see [Chapter 2.2 | IO1 “Glossary”] and [Chapter 2.3 | IO2 “Process”])

Day 3: Material

Initial input

- Vicky Thake, PhD, Assistant Prof., *Royal Danish Academy*
  Lecture Title: ***Fiber-reinforced Polymer Composites in an Architectural Context***
- Anton Kuzyk, Assoc. Prof., *Aalto University*, Department of Neuroscience and Biomedical Engineering
  Lecture title: ***DNA-based nanoscale architectures***

Group work

- Presentation Preparatory task 3 ***"Living vs. Non-living Material"*** in supervised groups of four to five

Pre-task 3: Assignment

1. What is the material/materiality in the context of your (PhD) project?
   How do you approach/interpret it through the digital? Can you influence the material/materiality in your project by applying digital processes?
2. Look at the "living world" for further inspiration(s).
   Look for good examples of material/materiality in the living world, which potentially could be transferred back to the context of your own PhD/project, especially in terms of design and construction.
   - *What kind of new materiality can we create in the future?*
   - *What is the role of responsive materials/responsiveness for the future built environment?*
   - *How can we apply the concept of self-organization/self-organizing processes, inspired by the living world in our professional future?*

Mapping guidelines for the group work during Day 3 (ISP2):

1. Present to each other your Preparatory task "*Material: living vs. non-living*."
2. Group work: summarize the variety of material/materiality within your projects in order to present it in the next session to the other groups.
3. Contribution to the Glossary: focus on the concepts of *Material*, *Materiality*, and *Digital Material*.
4. The group speakers present the outcomes of the group work task to the audience.

- Group presentations and joint discussion in the larger round (for results see [Chapter 2.2 | IO1 "Glossary"] and [Chapter 2.5 | IO4 "Material"])

Day 4: Knowledge

Initial input

- Helle Rootzen, *LearnT DTU – Center for Digital Learning Tech*, CEO of andhero
  Lecture Title: ***Big or small data for big and small problems?***

Group work

- Presentation Preparatory task 4 ***"Knowledge Transfer and Data Analysis"*** in supervised groups of four to five

Pre-task 4: Assignment

The task assignment is related to the keynote lecture of the day: Big or small data for big and small problems? (Helle Rootzen, andhero)

1. Think on a situation where you were aware of how data analysis made a project better. Why was it better? Please look at different sources like papers, books, and the Internet to find a good example.
2. In the context of your own projects: what is the data you use? How do you identify and acquire this data? How do you use it? How do you (plan to) interpret/evaluate it?
3. During Helle Rootzen's keynote lecture, keep in mind the following question:
   How can you see that the principles and ideas that Helle talks about can be used in your own project and what would be the benefits?

Mapping guidelines for the group work during Day 4 (ISP2):

1. Present to each other your Preparatory task "*Knowledge Transfer and Data Analysis*."
2. Group work: collect and categorize together as a group the advantages and disadvantages identified by your examples on how data analysis made a project better.
3. Contribution to the Glossary: focus on the concepts of *Knowledge*, *Data*, and *Data Analysis*.
4. The group speakers present the outcomes of the group work task to the audience.

- Group presentations and joint discussion in the larger round (for results see [Chapter 2.2 | IO1 "Glossary"] and [Chapter 2.5 | IO4 "Material"])

Day 5: Roundup – Social Context

Initial input

- Lars Botin, Assoc. Prof., *Aalborg University*
  Lecture Title: ***Do Digits Have Morality?***
- Vincent Kuo, *CEO VXT Research*
  Lecture Title: ***"Baukultur"– actionable insights with natural language processing*** (input for the development of IO1 Glossary)

Group work

- Discussion and work in breakout sessions
  Mapping guidelines for the group work during Day 5 (ISP2):

  1. Present to each other your Preparatory task 5 ***"Individual SWOT Analysis."***
  2. Group work: try to sum up as a group the outcomes of your individual presentations and the group discussion. Discussion topic: intrinsic relationship between human–technology–physical world (built environment) Provocative question: ***Are humans the exclusive carriers of moral, political, and ethical values?***
  3. Contribution to the Glossary: focus on the concepts of *Values* and *Ethics* in relation to the built environment and your research specifically.
  4. The group speakers present the outcomes of the group work task to the audience.

- Group presentations and joint discussion in the larger round (for results see Intellectual Outputs [Chapter 2.2 | IO1 "Glossary"], [Chapter 2.3 | IO2 "Proess"], and [Chapter 2.4 | IO3 "Knowledge"])

Task V: Individual SWOT-Analysis

Perform an individual SWOT-Analysis of your thesis project seen from the perspective of the prior four training days of the ISP2. Sum up what you have learned during the ISP2.

Take in consideration the aspects of ethics and morality within the „digital world" of your own project/thesis. Present the outcome of the reflection in statements:

E.g., "Engineers will not be able to evaluate the output of the software I am using for data processing in my PhD."
"The data I need is currently not available as open source. If we make it open source, then __________ problem/solution/opportuinity/threat."

ISP3 Craft and craftsmanship

Thematic scope

ISP3 "Craft and Craftsmanship" is the third of four consecutive training events organized between 2020 and 2021 within the thematic framework of the **BuildDigiCraft** project. This ISP is dedicated to the exploration of the role of craft and craftsmanship in the current and future professional digital practice of the experts of the built environment such as designers, structural and environmental engineers and urban planners. Input on a wide range of topics in relation to the concept of craftsmanship in the digital age is introduced throughout the training, covering topics from digital disruption and the digital twin, through construction value chains and masonry mechanics, to the right to design, the link to heritage, and the fine fusion of art and crafts. Structurally, the focus of each of the three middle days of the training is based on one of the three main Baukultur elements of the **BuildDigiCraft** project: Process, Knowledge, and Material. Within these, ISP group work is fixed and focused on three pre-selected areas of exploration where craftsmanship interacts with the digital twin, the processes behind shaping the city and the design process. The ISP3 is rounded up with the final project presentations of the three working groups as well as with a presentation of participants' attempt to "physically craft their own PhD."

Leading discussion questions

- *What is Baukultur in the digital age?*
- *How do we design, build and maintain the built environment based on craftsmanship, data and algorithms?*
- *What are the qualities of craftsmanship, what is the essence of craft and craft-based production that we would like to transfer to the future digital shaping of the built environment?*

In the afternoon, additional training through practical workshops is offered to gain knowledge and skills in the three topics of the group work: **digital twin**, **digital urban participation platforms**, and **design process via 3D modeling with "3D Blender."**

Fig[● 17] Full program ISP3 "Craft and Craftsmanship."

DAY TOPIC / TIME ZONE: CEST	14.06.2021	15.06.2021	16.06.2021	17.06.2021	18.06.2021
	Qualities of Craftsmanship	**Material**	**Process**	**Knowledge**	**Arts & Crafts**
9:00—9:15, 9:15—9:30, 9:30—9:45, 9:45—10:00	KEYNOTE Prof. Jüri Soolep *Estonian Art Academy, Estonia*	KEYNOTE Prof. Jörg Noennig *HCU CityScience Lab, Germany*	KEYNOTE Lauri Tuulberg *Welement, Estonia*	KEYNOTE Henric Benesch *University of Gothenburg, Sweden*	KEYNOTE Didzis Jaunzems *Didzis Jaunzems Architecture, Latvia*
10:00—10:15	*Coffee Break (15 min)*	*Coffee Break (15 min)*	*Coffee Break (15 min)*	*Coffee Break (15 min)*	*Coffee Break (15 min)*
10:15—10:30, 10:30—10:45	INTRODUCTION *(Workshop + Group Topics)*	POST-KEYNOTE DISCUSSION + INSIGHTS FOR THE GROUP WORK	POST-KEYNOTE DISCUSSION + INSIGHTS FOR THE GROUP WORK	POST-KEYNOTE DISCUSSION + INSIGHTS FOR THE GROUP WORK	POST-KEYNOTE DISCUSSION *(also John Ochsendorf)*
10:45—11:00, 11:00—11:15, 11:15—11:30, 11:30—11:45	PRE-TASK 1 PRESENTATION	GROUP 1 *Craftsmanship & Digital Twin* GROUP 2 *Craftsmanship & Shaping the City* GROUP 3 *Craftsmanship & Design Process*	CONTINUE GROUP WORK • *3 fixed groups* • *fixed participants* EXPLORATION & STRUCTURE	CONTINUE GROUP WORK • *3 fixed groups* • *fixed participants* FINALISATION	FINAL GROUP PRESENTATIONS • *Group 1* • *Group 2* • *Group 3* + ROUNDUP DISCUSSION
11:45—12:00, 12:00—12:15, 12:15—12:30, 12:30—12:45, 12:45—13:00	GROUP WORK *Process, Knowledge, Material*				
13:00—13:15	*Break (15 min)*	*Break (15 min)*	*Break (15 min)*	*Break (15 min)*	*Break (15 min)*
13:15—13:30, 13:30—13:45, 13:45—14:00	GROUP PRESENTATIONS *Group Work Outcomes*	SUPERVISION / CRITIQUE CONSULTATION BDC Team	SUPERVISION / CRITIQUE CONSULTATION BDC Team	SUPERVISION / CRITIQUE CONSULTATION BDC Team	EXHIBITION PRE-TASK 2 "Build a Physical Model of your (PhD) project" *Try to physically Craft your (PhD) project* + FAREWELL
14:00—14:15, 14:15—14:30, 14:30—14:45, 14:45—15:00	GROUP FINDING			KEYNOTE John Ochsendorf *MIT Architecture*	
AFTERNOON PRACTICAL WORKSHOPS		WORKSHOP "How 2 Digital Twin?" Milos Mikasinovic *NUCE Consulting GmbH, Germany* 15:15—18:30 (3 h)	WORKSHOP DiPa – Digital Urban Participation Platform J. Noennig, M.Niggemann, A. Sliusarenko *HCU Digital City Science, Germany* 16:00—18:30 (2,5 h)	WORKSHOP Blender 3D Eliass Valters *Latvia* 16:00—19:00 (3 h)	

Day 1: Introduction

Initial input

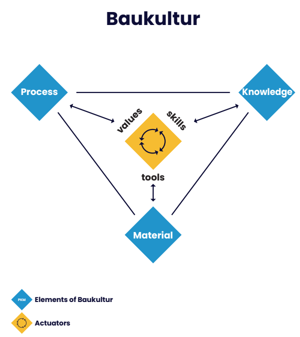
- Prof. Jüri Soolep, *Estonian Academy of Arts*
  Lecture Title: ***Digital Disturbing Delight***
- Welcoming and introduction to the project and the teaching program. Presentation of the three fixed topics for group work: "*Craftsmanship and the digital twin*," "*Craftsmanship and shaping the city*" and "*Craftsmanship and design process*"
- Brief input on craft and craftsmanship: values, principles and qualities, Prof. Annette Bögle, HafenCity University Hamburg

Group work

- Presentation Preparatory task 1 ***"Process–Knowledge–Material–Reflection"*** in supervised randomly selected groups of four to five

Pre-task 1: Assignment

Reflect on your individual project (PhD project/Master's thesis/project of personal interest) in respect to the **BuildDigiCraft** graph model (Fig[● 18]).
Analyze and reflect on your individual project by answering the following questions:



Fig[● 18] **BuildDigiCraft** graph model.

1. What is the Process, what is the Material and what is the Knowledge that you are addressing and using in your (PhD) project, and what is the Process, Knowledge, and Material that you would like to derive from it?
2. How do you see the relation between the Process, Knowledge, and Material in the context of your work?
3. What are the values you are following/addressing in your project?
4. Which skills are you applying and which are the new skills that you are developing within your project?
5. What tools do you use and plan to use?
6. Try to define the term Baukultur in your own words and in respect to your individual project.

Submission format: prepare a five-minute slide presentation (no specific layout requirements. Please add an initial slide to shortly present yourself: professional experience, background, interests, and expectations.

Mapping guidelines for the group work during Day 1 (ISP3):
As a group try to derive the "*Qualities of Craftsmanship*" within the context of the "*Process–Knowledge–Material*" graph.
For the "*Qualities of Craftsmanship*" use the input below:

Qualities of Craftsmanship:
Some keywords
... Identity
... Quality
... Material
... Tool
... Profession
... Art
... Skills
... Talent
... Experience
...

Values of Craftsmanship
... pride in achieving a level of mastery and highest quality
... skill level developed through implicit and tacit knowledge
... passed on within the craftsman community
... deeply sustainable

Values of Digital Craftsmanship
... **Re-interpretation** of the relationship between the work of the mind and the work of the hand
... new-age **digital craftsman** works within the continuously changing environment of the rapidly developing tools and new materiality
... Challenges are **multi-dimensional** and encompassing, relating huge number of inter-related values and relationships
... **Digital tools** offer an unseen level of handling of complexity

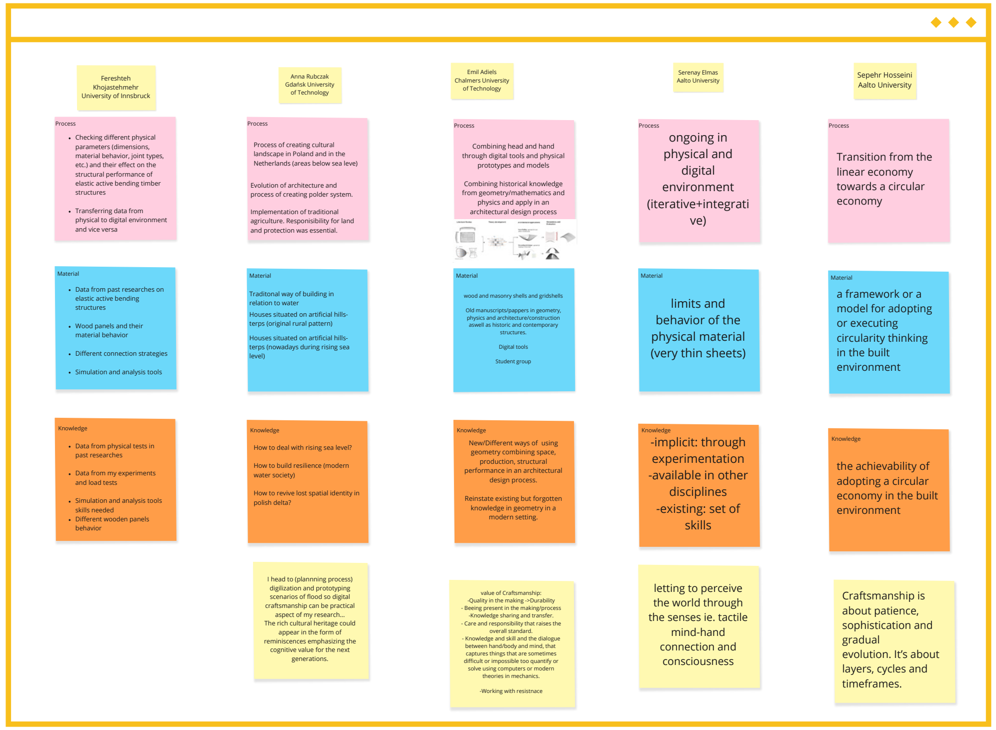
- Group findings for the three fixed topics:
  - Craftsmanship and the digital twin
  - Craftsmanship and shaping the city
  - Craftsmanship and design process
- Group-based supervision and feedback session offered by the expert team of the **BuildDigiCraft** project

Fig[● 19] Outcomes of the group work during Day 1, ISP3 – Group 1.

Group 1

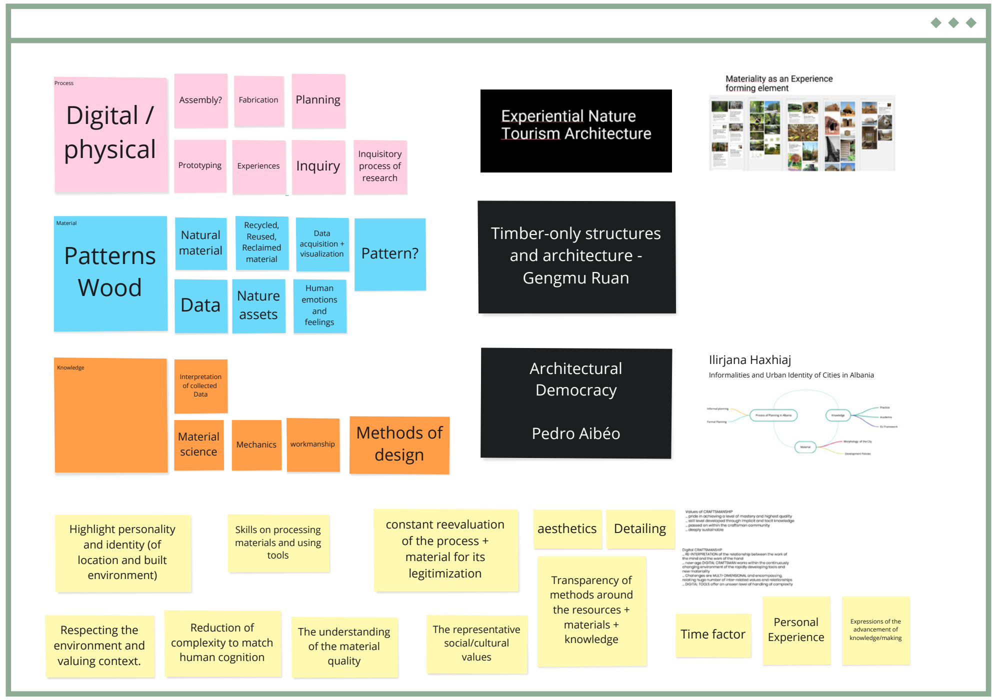
Fig[● 20] Outcomes of the group work during Day 1, ISP3 – Group 2.

Group 2



Fig[● 21] Outcomes of the group work during Day 1, ISP3 – Group 3.

Group 3



Day 2: Material

Initial input

- Prof. Jörg Noennig, *HafenCity University Hamburg*
  Lecture Title: ***Digital City Twins: Urban Analysis and Anticipation***

Joint discussion and group work

- Joint post-keynote discussion in the larger round (participants and **BuildDigiCraft** team)
- Unsupervised project-based group work (three topics)

Project assignment for the group work

1. Which qualities of craftsmanship can be transferred to your group project topic (digital twin, shaping the city, design process), and why are they important?
2. [and vice versa] What part of your (PhD) projects can be related to the qualities of craftsmanship and to the group project assignment?
3. As a group find a way to address the topic in a digital format or even in an analog/a physical manner despite the digital format of the event. Make a group project out of it. Use the facilities you have at hand, use them as a joint group resource (i.e., 3D printing, paper model, video of the surrounding physical environment, city exploratory walks, etc.).
4. Address the Process, Knowledge, and Material in your group project.
5. As a group find a way to present your group project to all workshop participants – presentation on Friday.
6. Create your own project glossary (no specific format restrictions or requirements).
7. Create a Group READER – collect relevant literature references.

- Group-based supervision and feedback session offered by the expert team of the **BuildDigiCraft** project

Day 3: Process

Initial input

- Lauri Tuulberg, *CEO Welement*, Estonia
  Lecture Title: ***Prefabricated Craftsmanship***

Joint discussion and group work

- Joint post-keynote discussion in the larger round (participants and **BuildDigiCraft** team)
- Unsupervised group work (three breakout rooms)
- Group-based supervision and feedback session offered by the expert team of the **BuildDigiCraft** project

Day 4: Knowledge

Initial input

- Henric Benesh, *University of Gothenburg*, Sweden
  Lecture Title: ***On situated knowing, digitalization and two burning buildings***
- Prof. John Ochsendorf, *MIT Architecture*
  Lecture Title: ***Building from History for a Low-Carbon Future***

Joint discussion and group work

- Joint post-keynote discussion in the larger round (participants and **BuildDigiCraft** team)
- Unsupervised group work (three breakout rooms)
- Group-based supervision and feedback session offered by the expert team of the **BuildDigiCraft** project

Day 5: Art and Crafts

Initial input

- Didzis Jaunzems, *Didzis Jaunzems Architecture*, Latvia
  Lecture title: ***Symbiosis of the past and the future***
- Group presentations and joint discussion

Group presentations and joint discussion

- Joint post-keynote discussion in the larger round (participants and **BuildDigiCraft** team)
- Final group presentations
  - Craftsmanship and the digital twin
  - Craftsmanship and shaping the city (Fig|● 22|)
  - Craftsmanship and design process (Fig|● 23|)
- Critical joint discussion round
- Closing exhibition based on the Preparatory task 2 ***"Craft your (PhD) project"***

Pre-task 2: Assignment

Build a physical model of your (PhD) project. Try to approach your research question(s)/ your research topic unconventionally by representing them in a two- or three-dimensional physical model. You can use any physical material you have at hand (no special requirements or restrictions). Be creative!

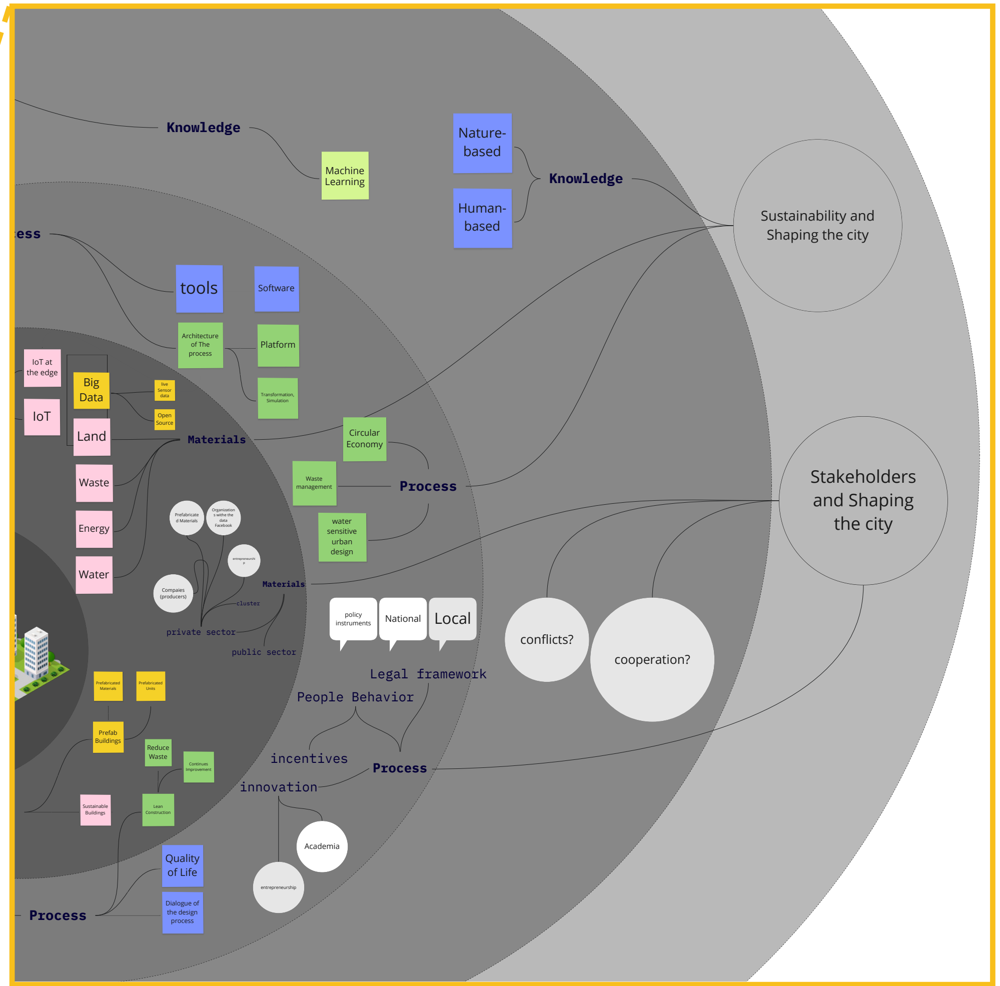
Use this exercise to come away from the words and language as a presentation medium.

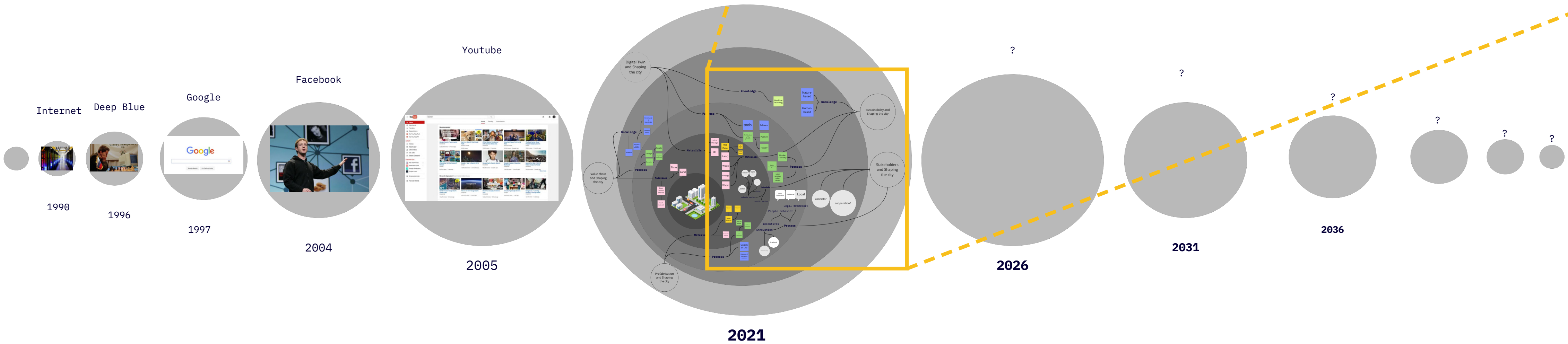
Think of an appropriate way of documenting and presenting your crafted model in the digital conference environment of the workshop – on Day 5. Be ready to explain your approach and choice of representation mode.

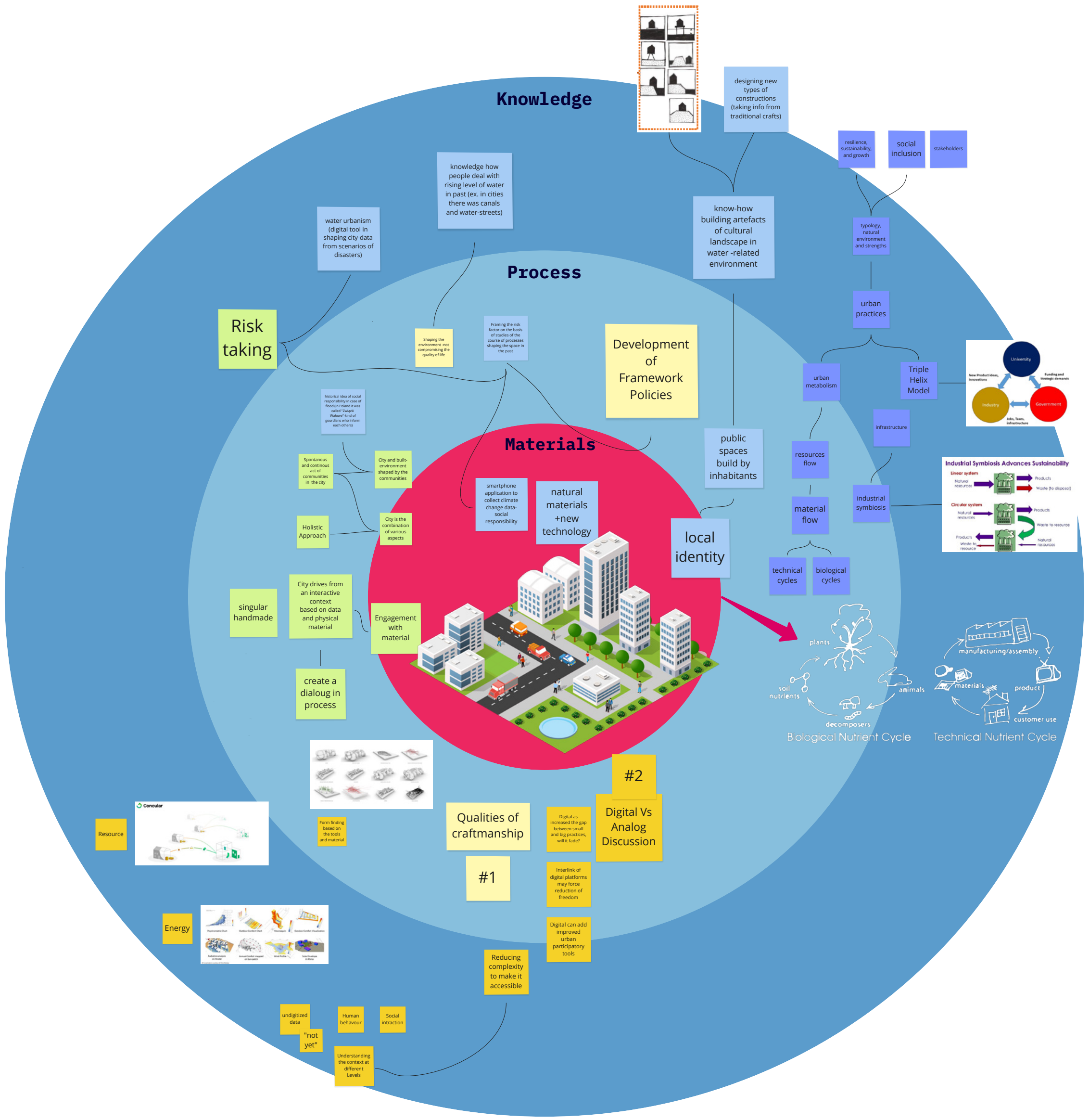
We are very much looking forward to [y]our joint exhibitions on Day 5!

Fig[● 22] Final presentation of the "Shaping the City" Group. "Isometric City" Picture credits: Vecteezy.com

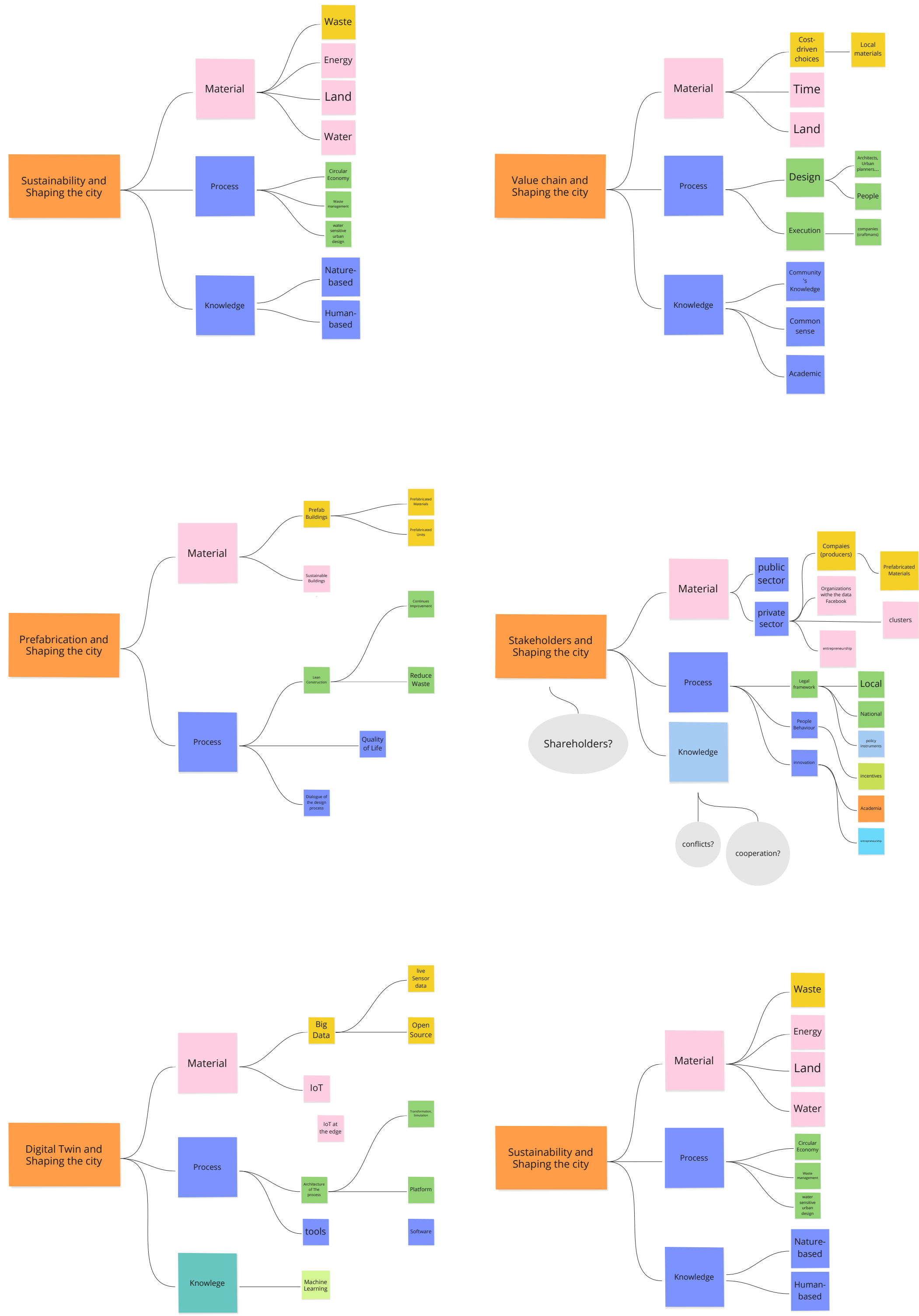
Shaping the City Group







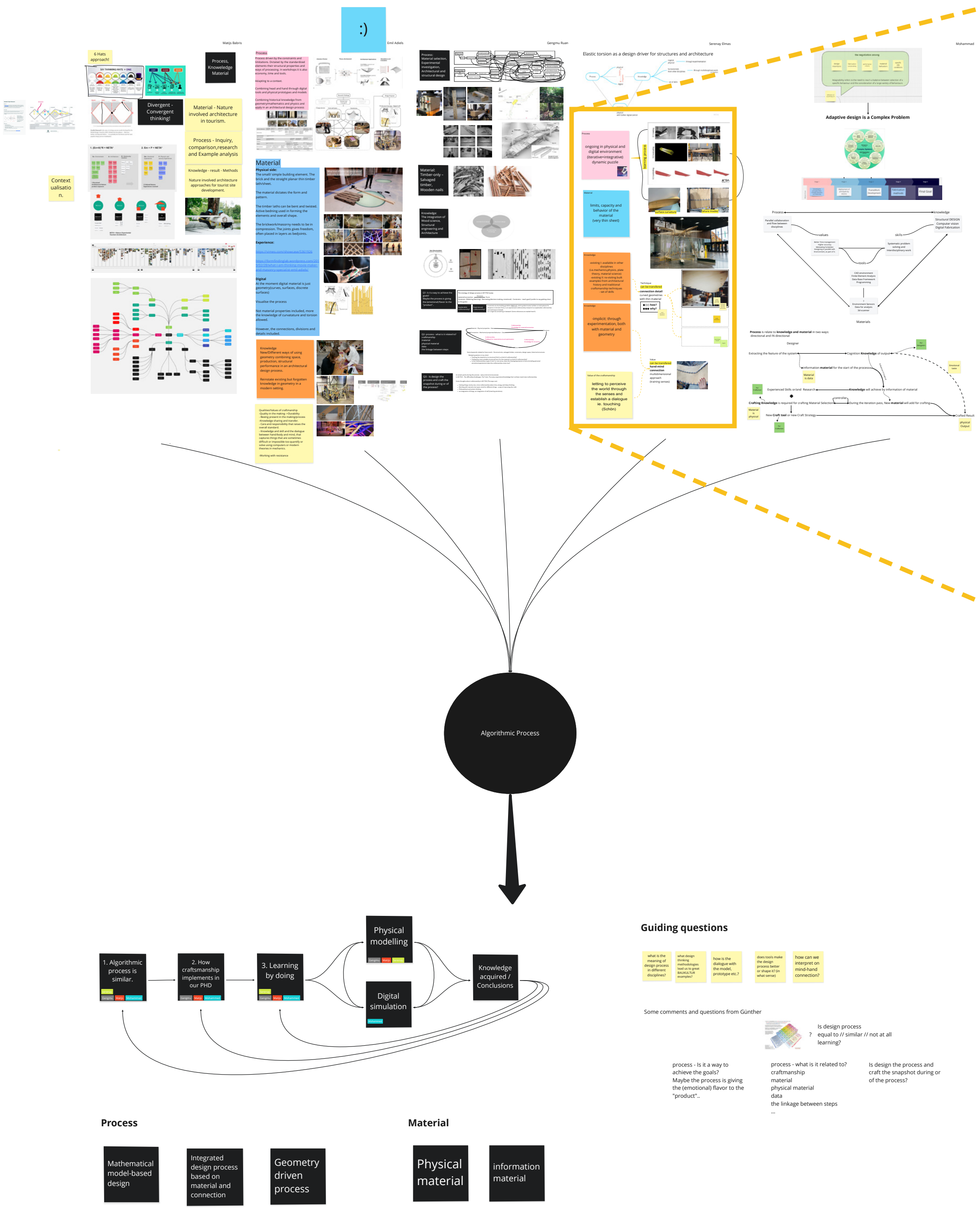
Knowledge
Process
Materials
Risk taking
Development of Framework Policies
public spaces build by inhabitants
local identity
natural materials +new technology
know-how building artefacts of cultural landscape in water-related environment
designing new types of constructions (taking info from traditional crafts)
knowledge how people deal with rising level of water in past (ex. in cities there was canals and water-streets)
water urbanism (digital tool in shaping city-data from scenarios of disasters)
singular handmade
create a dialoug in process
Engagement with material
Qualities of craftmanship
#1
#2
Digital Vs Analog Discussion
urban practices
urban metabolism
Triple Helix Model
resources flow
material flow
industrial symbiosis
technical cycles
biological cycles
Biological Nutrient Cycle
Technical Nutrient Cycle
Resource
Energy
Reducing complexity to make it accessible

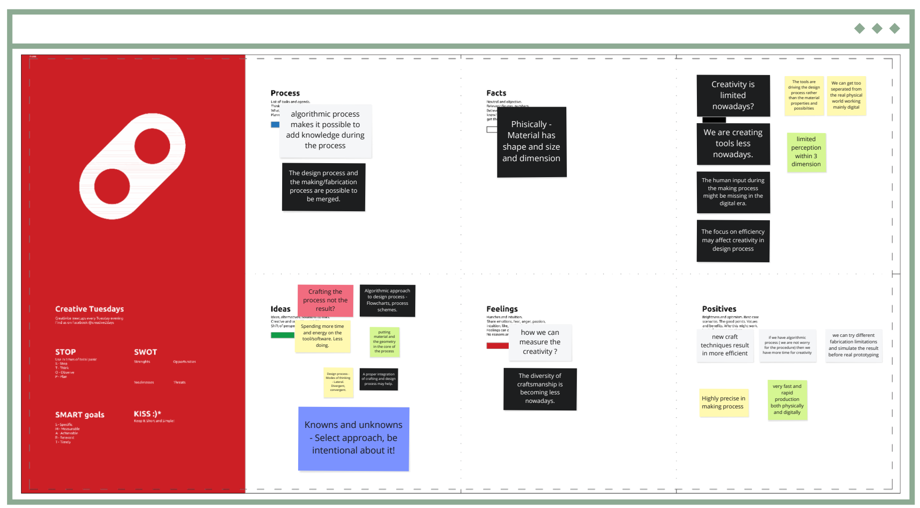


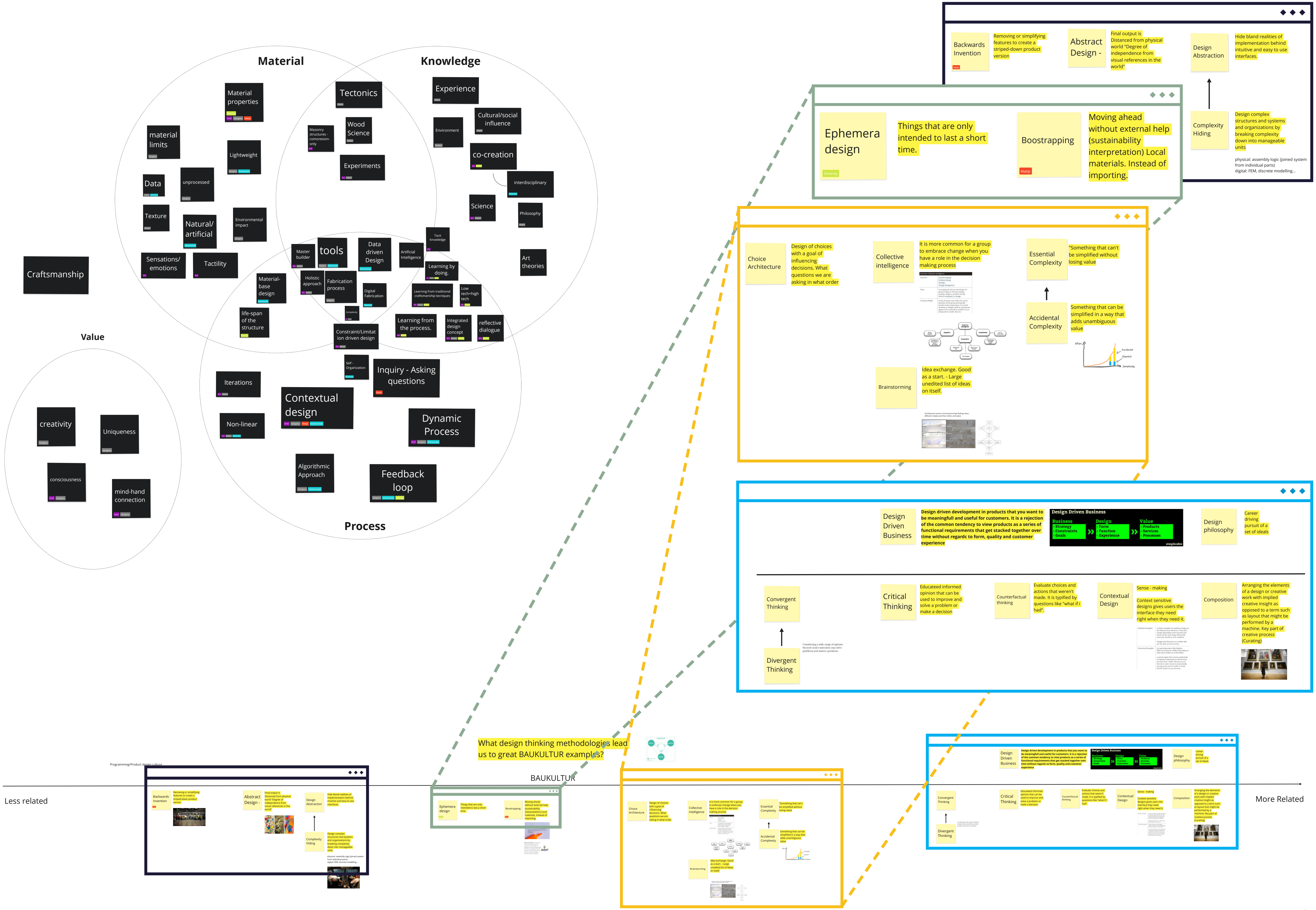
Sustainability and Shaping the city
Material
Waste
Energy
Land
Water
Process
Knowledge
Nature-based
Human-based
Value chain and Shaping the city
Time
Design
People
Execution
Common sense
Academic
Prefabrication and Shaping the city
Quality of Life
Stakeholders and Shaping the city
public sector
private sector
clusters
Local
Shareholders?
conflicts?
cooperation?
Digital Twin and Shaping the city
Big Data
Open Source
IoT
tools
Knowlege
Platform
Software
Machine Learning

Fig[● 23] Final presentation of the "Design Process" Group. *(Some images removed due to copyright issues).*

Design Process Group






Material
Knowledge
Value
Process
Material properties
material limits
Lightweight
Data
unprocessed
Texture
Natural/ artificial
Environmental impact
Sensations/ emotions
Tactility
Craftsmanship
Tectonics
Wood Science
Masonry structures - compression-only
Experiments
Experience
Cultural/social influence
Environment
co-creation
interdisciplinary
Science
Philosophy
Art theories
Tacit knowledge
Master builder
tools
Data driven Design
Artificial Intelligence
Learning by doing.
Material-base design
Holistic approach
Fabrication process
Digital Fabrication
Learning from traditional craftsmanship tecniques
Low tech+high tech
life-span of the structure
Complexity
Constraint/Limitation driven design
Learning from the process.
Integrated design concept
reflective dialogue
Self-Organization
Iterations
Inquiry - Asking questions
Contextual design
Non-linear
Dynamic Process
Algorithmic Approach
Feedback loop
creativity
Uniqueness
consciousness
mind-hand connection
Backwards Invention
Removing or simplifying features to create a striped-down product version
Abstract Design -
Final output is Distanced from physical world "Degree of independence from visual references in the world"
Design Abstraction
Hide bland realities of implementation behind intuitive and easy to use interfaces.
Complexity Hiding
Design complex structures and systems and organizations by breaking complexity down into manageable units
physical: assembly logic (joined system from individual parts)
digital: FEM, discrete modelling...
Ephemera design
Things that are only intended to last a short time.
Boostrapping
Moving ahead without external help (sustainability interpretation) Local materials. Instead of importing.
Choice Architecture
Design of choices with a goal of influencing decisions. What questions we are asking in what order
Collective intelligence
It is more common for a group to embrace change when you have a role in the decision making process
Essential Complexity
"Something that can't be simplified without losing value
Accidental Complexity
Something that can be simplified in a way that adds unambiguous value
Brainstorming
Idea exchange. Good as a start. - Large unedited list of ideas on itself.
Design Driven Business
Design driven development in products that you want to be meaningfull and useful for customers. It is a rejection of the common tendency to view products as a series of functional requirements that get stacked together over time without regardc to form, quality and customer experience
Design Driven Business
Business - Strategy - Constraints - Goals
Design - Form - Function - Experience
Value - Products - Services - Processes
Design philosophy
Career driving pursuit of a set of ideals
Convergent Thinking
Divergent Thinking
Critical Thinking
Educated informed opinion that can be used to improve and solve a problem or make a decision
Counterfactual thinking
Evaluate choices and actions that weren't made. It is typified by questions like "what if i had".
Contextual Design
Sense - making
Context sensitive designs gives users the interface they need right when they need it.
Composition
Arranging the elements of a design or creative work with implied creative insight as opposed to a term such as layout that might be performed by a machine. Key part of creative process (Curating)
What design thinking methodologies lead us to great BAUKULTUR examples?
Programming/Product design culture
BAUKULTUR
Less related
More Related

ISP4 Rethinking Baukultur in the Digital Age

Thematic scope

ISP4 "Rethinking Baukultur in the Digital Age" is the last of four consecutive training events organized between 2020 and 2021 within the thematic framework of the **BuildDigiCraft** project. Next to the Davos Declaration on Baukultur, this ISP also addresses the New European Bauhaus Initiative of the European Union by introducing a subtopic "From Bauhaus to the New European Bauhaus." Participants' attention is thus brought to two important political initiatives both aiming at high-quality Baukultur. This ISP brings insights on several historic, social, and artistic topics regarding the need for radical and revolutionary transformation of society as well as of the role of education in the disciplines of the building sector. The knowledge input within the ISP starts with a historic perspective on the Bauhaus movement, which with its radical approach to design introduced at the beginning of the 20th century the idea of the new society and new man in the built environment. It then focuses on the integration of art and technology and ends with the transformative role of teaching and education in design and constructions. Within interdisciplinarily organized teams for group work, participants receive one final joint task. They have to build up their own Manifesto for high-quality Baukultur in the digital age based on the values and principles of craftsmanship – a **BuildDigiCraft** contribution to the New European Bauhaus initiative.

Leading discussion questions

- *What is Baukultur in the digital age?*
- *What is the essence of the digital revolution in respect to the shaping of the built environment?*
- *How do we design, build and maintain the built environment based on craftsmanship, data and algorithms?*
- *What is the historic role of the Bauhaus movement and which Bauhaus values do we want to transfer to the Baukultur of the digital age and to the New European Bauhaus?*

The main questions raised during the ISP4 as well as throughout the whole **BuildDigiCraft** training program, are further discussed in **a publicly open professional debate** with invited guests from policy-making and the professional fields of architecture, design, engineering, and urban planning. It takes place subsequent to the ISP4. (Online Multiplier Event)

Fig[● 24] Full program ISP4 "Rethinking Baukultur in the Digital Age."

DAY TOPIC (TIME ZONE: CET)	29-11-2021 Intro: Bauhaus	30-11-2021 Integration of Art & Technology	01-12-2021 New Society, New Man in the Built Environment	02-12-2021 Innovative Revolutionary Education	03-12-2021 Closing: New European Bauhaus
9:00—9:15 9:15—9:30 9:30—9:45 9:45—10:00	KEYNOTE Prof. Jacek Friedrich "Title" *Gdańsk University of Technology, Poland*	KEYNOTE Person "Title" *Institution, Country*	KEYNOTE Person "Title" *Institution, Country*	KEYNOTE Person "Title" *Institution, Country*	FINAL GROUP PRESENTATIONS • *Group 1* • *Group 2* • *Group 3* + ROUNDUP DISCUSSION
10:00—10:15 10:15—10:30 10:30—10:45	POST-KEYNOTE DISCUSSION + INSIGHTS FOR THE GROUP WORK	POST-KEYNOTE DISCUSSION + INSIGHTS FOR THE GROUP WORK	POST-KEYNOTE DISCUSSION + INSIGHTS FOR THE GROUP WORK	KEYNOTE Person "Title" *Institution, Country*	
10:45—11:00	*Coffee Break (15 min)*	*Coffee Break (15 min)*	*Coffee Break (15 min)*		
11:00—11:15	INTRODUCTION *(Workshop + Group Work)*	1ST ASPECT *Integration of Art & Technology*	2ND ASPECT *New Society, New Man in the Build Environment*	3RD ASPECT *Innovative Revolutionary Education*	*Coffee Break (15 min)*
11:15—11:30 11:30—11:45	KUMU + MPE	GROUP 1 *Same topic + supervisors for the whole sesison* GROUP 2 *Same topic + supervisors for the whole sesison* GROUP 3 *Same topic + supervisors for the whole sesison*	GROUP 1 *New Day Supervisors* GROUP 2 *New Day Supervisors* GROUP 3 *New Day Supervisors*	GROUP 1 *New Day Supervisors* GROUP 2 *New Day Supervisors* GROUP 3 *New Day Supervisors*	KEYNOTE Person "Title" *Institution, Country*
11:45—12:00 12:00—12:15	PRESENTATION PRE-TASK *(all together or in groups)*				CLOSING DISCUSSION
12:15—12:30 12:30—12:45		*Lunch Break (30 min)*	*Lunch Break (30 min)*	*Lunch Break (30 min)*	
12:45—13:00 13:00—13:15 13:15—13:30	GROUP DIVISION				
13:30—13:45 13:45—14:00	WONDER.ME	GROUP PRESENTATION & BIG ROUND DISCUSSION *(Supervisors remain + new ones for the next day)*	GROUP PRESENTATION & BIG ROUND PRESENTATION	GROUP PRESENTATION TO THE OTHER PARTICIPANTS	

TIME ZONE: CET	07-12-2021 Multiplier Event (MPE 1)
14:00 14:30 15:00 15:30 16:00	Gdańsk Public Debate (ENGLISH) 14:00–16:00 CET **BuildDigiCraft** *meets the* **New European Bauhuas** *Matti Kuittinen, Piotr Lorens, Pietro Elisei, Annette Bögle*

Day 1: Introduction to Bauhaus

Initial input

- Prof. Jadwiga Urbanik, *Wroclaw University of Science and Technology*
Lecture Title: ***History of architectural revolution of the first half of the 20th century – waste of time or useful knowledge?***
- Introduction to the **BuildDigiCraft** Network Participant Map (enabled by the open access data visualization tool "Kumu")

The **BuildDigiCraft** network participant map is an interactive visual database map. Participants, teachers and experts can be filtered by type as well as by ISP participation using interactive buttons. Participants can be grouped by their university, or by their shared interests, again with the help of interactive buttons. See static screenshots in Fig[● 25–26].

The map can be accessed for interactive use via the project webpage – www.builddigicraft.eu – following the menu "Exhibition".[4]

[4] In case the map does not work, please try to open it using a different Internet browser or check the property settings of the current browser.

Personal data, except for the names of the invited input speakers, is anonymized. Speakers have agreed to share their data and video recording of the lecture publicly.

About Kumu:[5] Kumu is an online tool for visual databases, offering free open access for publicly used data. It allows for the creation of interactive multicriteria-databased network maps, with the help of which complex relationships can quickly be visualized, clustered or systematized.

[5] Kumu Inc. – online interactive visual database tool: https://kumu.io/

Group work

Presentation Preparatory task 1 "Bauhaus Reflection" in supervised randomly selected groups of four to five

Pre-task 1: Assignment

Use one of the following aspects of the Bauhaus Movement to reflect on your PhD thesis/individual thesis project:

1. The integration of art and technology
2. The new society and new mankind within their environments
3. Innovative, revolutionary methods of education

(Or choose another Bauhaus-related aspect that you believe deserves to be addressed with your work.)

How do you think your PhD/thesis project does/might address the principles of the New European Bauhaus?

- Group finding for the project assignment ***"Build up Manifesto"*** (two to three groups working on the same topic)

ISP4 Project assignment

What is the **BuildDigiCraft** contribution to the New European Bauhaus to Baukultur in the digital age? **Build a Manifesto.**

Within the first three ISPs the following aspects have been addressed so far:

1. Baukultur, Digitalization, Craftsmanship – thematic approach
2. Process, Knowledge, Material – methodological approach
3. Values, skills, tools – actuators within the method

During the ISP4 we will address the Bauhaus/New European Bauhaus principles and ideas in order to together rethink the Baukultur in the digital age, focusing on the following three aspects:

1. Integration of art and technology
2. The new society and the new man in their environments
3. Innovative revolutionary education

Task: As an interdisciplinary group try to build a Manifesto that helps us to express our network statement.

"We want to have a high-quality Baukultur in the digital age. Using the values and principles of craftsmanship is essential for reaching that goal."

Try to refer to the six elements of the **BuildDigiCraft** model based on the input of the keynote lectures and post keynote discussions during ISP4. Also use the collected material project material bank as well as your experiences from the previous ISPs.

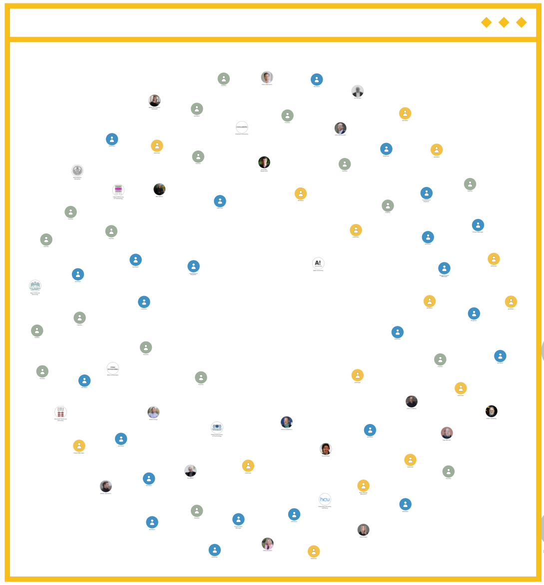
Guiding questions:

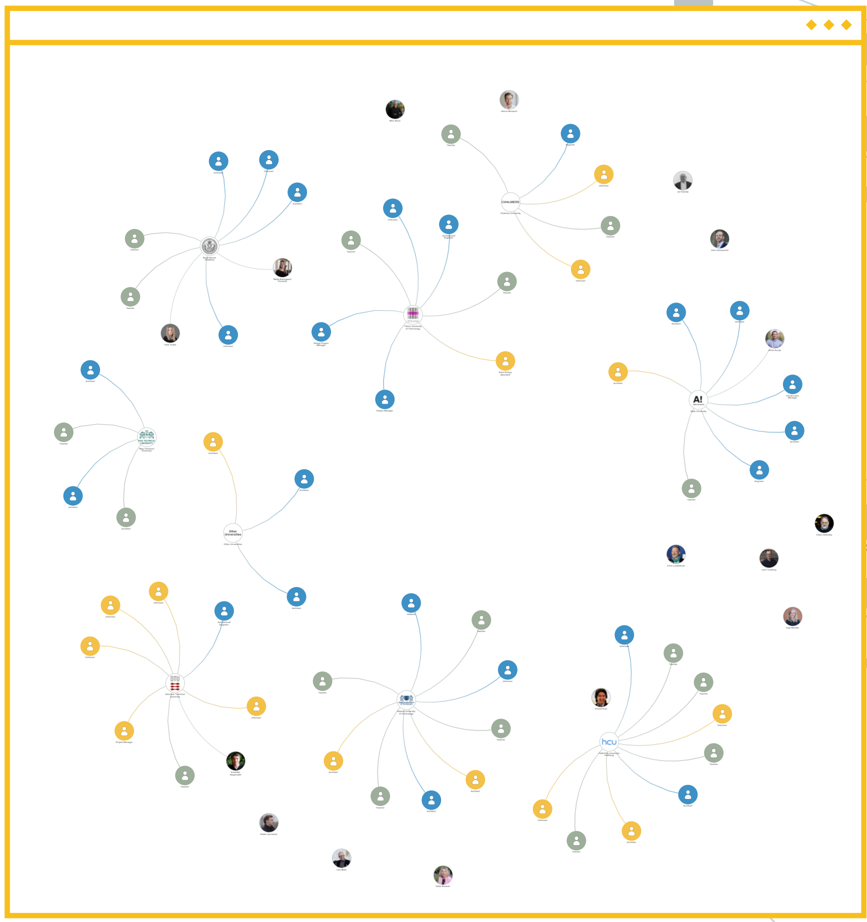
- *What qualitative framework do we need for the new design and planning process in order to reach the goals of the New European Bauhaus and thus manifest Baukultur in the digital age?*
- *How do we gain, define, and structure new knowledge within the new processes?*
- *What is the new material and new materiality of the New European Bauhaus and the Baukultur in the digital age and how do we use it?*

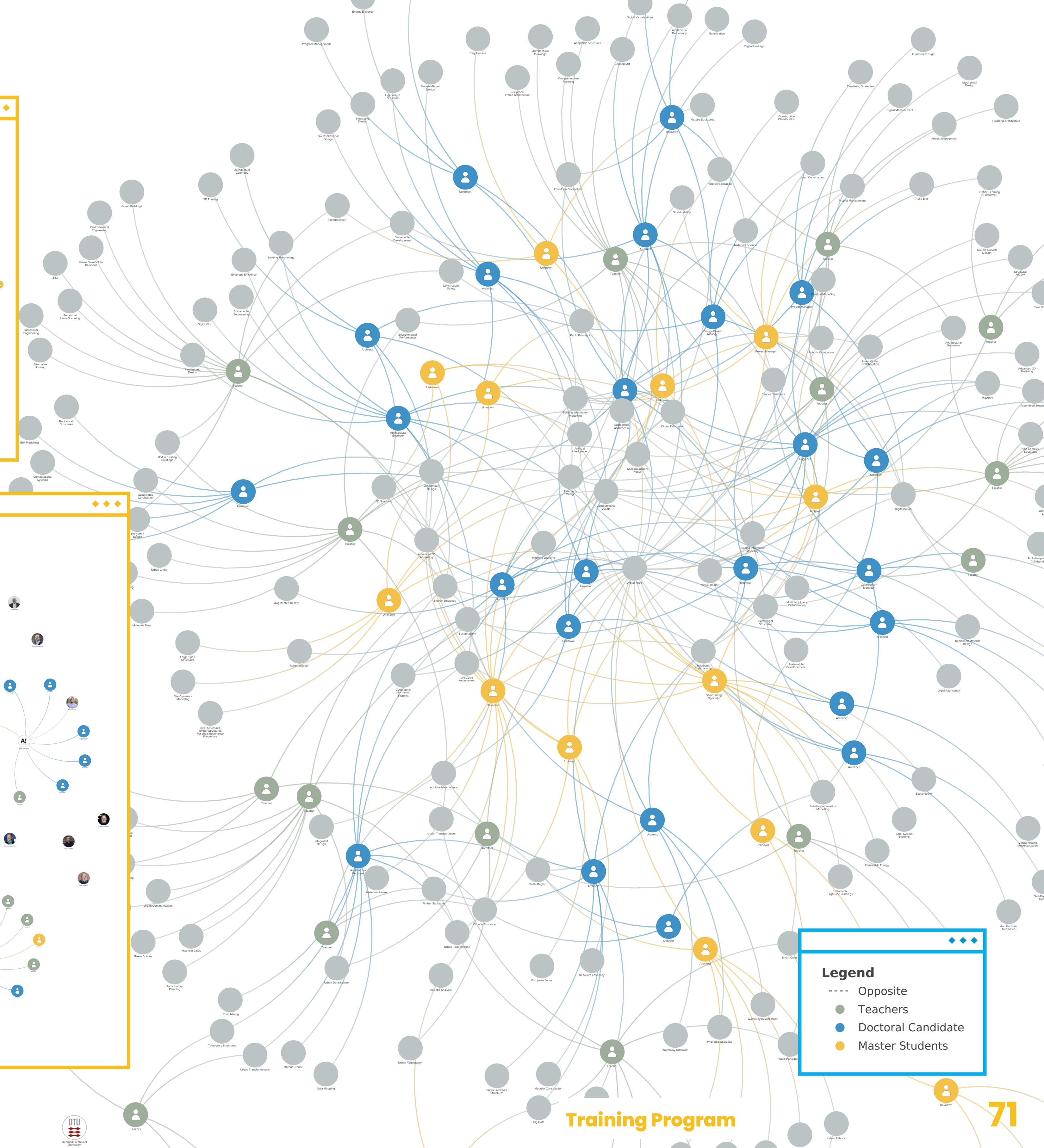
Use your individual PhD/thesis project as a starting point and main source of information.

New tool: try to build a visual DATABASE MODEL as the basis of your joint Group Manifesto – test and use the Kumu tool.

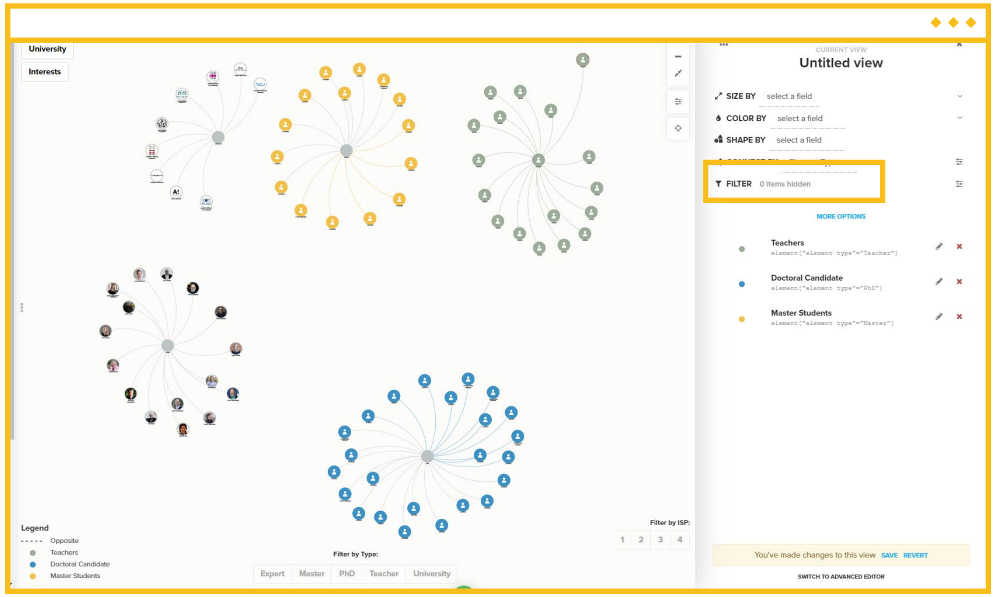
Fig[● 25] **BuildDigiCraft** Participant Network Map – participants' clustering by "Type", "University", and "Topic of Interest."

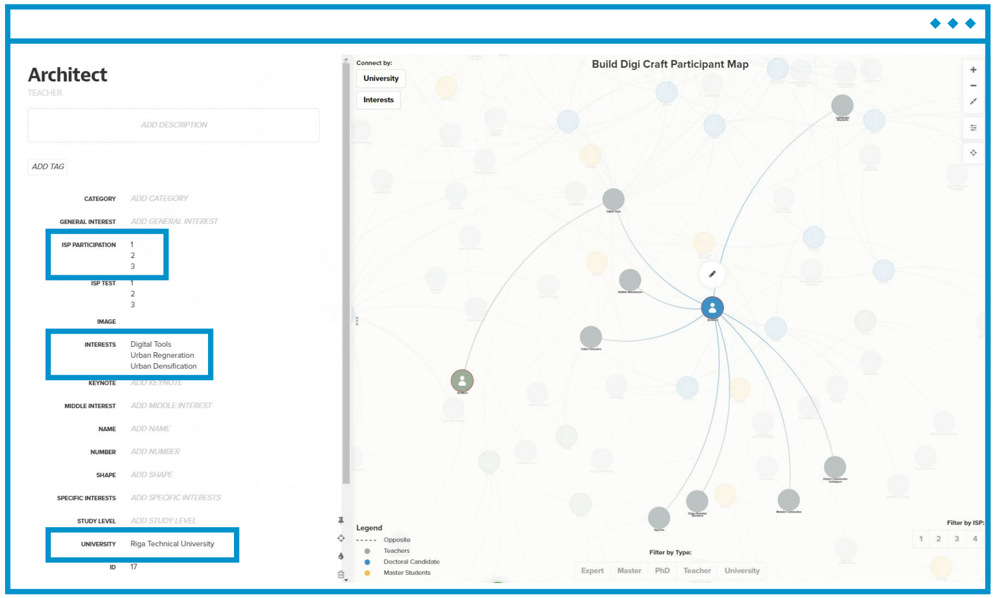


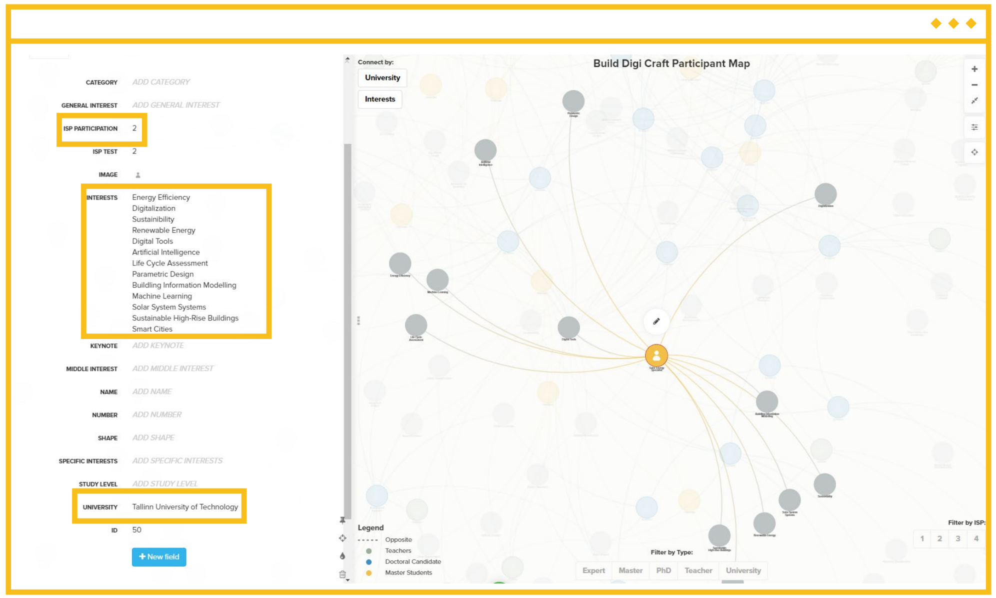




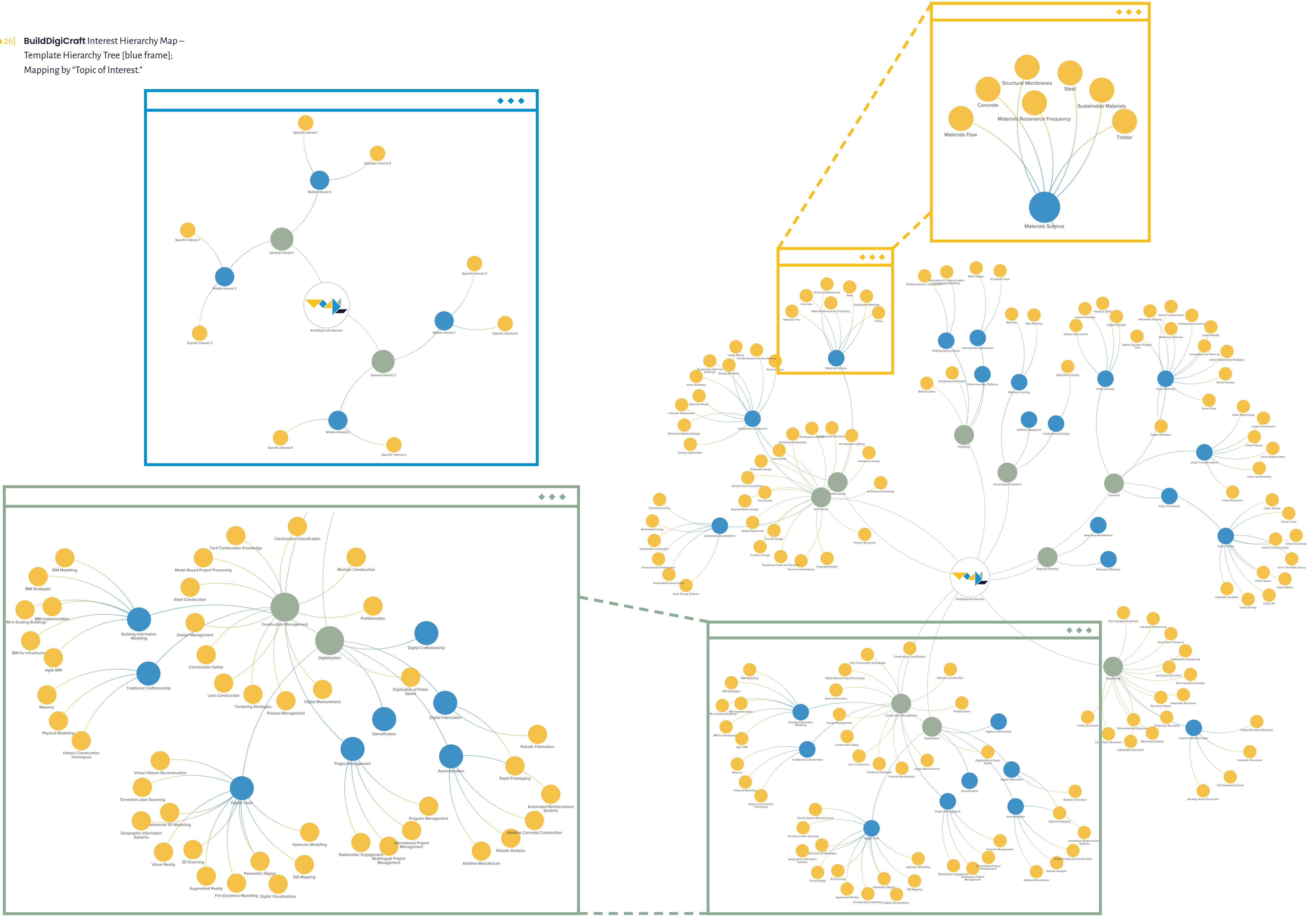
Fig[● 25] **BuildDigiCraft** Participant Network Map –
screenshots illustrating interactive clustering options
(Connection by Element Type [top left];
Zoom-in "Topic of Interest" [top right];
Zoom-in "Participant's Topics of Interest"[bottom left and right]).







Fig[● 26] **BuildDigiCraft** Interest Hierarchy Map – Template Hierarchy Tree [blue frame]; Mapping by "Topic of Interest."



Day 2: Integration of Art and Technology

Initial input

- Robert Sochacki, *Wroclaw Art Academy*, Poland
  Lecture Title: ***The Integration of Art and Technology***

Joint discussion and group work

- Joint post-keynote discussion in the larger round (participants and **BuildDigiCraft** team)
- Unsupervised group work (two to three breakout rooms)
- Group-based supervision and feedback session offered by the expert team of the **BuildDigiCraft** project

Day 3: The New Society and the New Man in Their Environments

Initial input

- Leif Høgfeldt Hansen, *Aarhus School of Architecture*, Denmark
  Lecture title: ***The New Society and the New Man in Their Environments***

Joint discussion and group work

- Joint post-keynote discussion in the larger round (participants and **BuildDigiCraft** team)
- Unsupervised group work (two to three breakout rooms)
- Group-based supervision and feedback session offered by the expert team of the **BuildDigiCraft** project

Day 4: Innovative Revolutionary Education

Initial input

- Olga Ludyga, *WSB University Gdańsk*, Poland
  Lecture title: ***Teacher – the Architect of Learning Process***
- Fernando Manuel Alonso Pedrero, *University of Navarra*, Spain
  Lecture title: ***New Degree in Design ETSAUN – Winner of the New European Bauhaus Prize 2021***

Joint discussion and group work

- Joint post-keynote discussion in the larger round (participants and **BuildDigiCraft** team)
- Unsupervised group work (two to three breakout rooms)
- Group-based supervision and feedback session offered by the expert team of the **BuildDigiCraft** project

Day 5: Closing – BuildDigiCraft's Contribution to the New European Bauhaus

Final group presentation

- Group 1 – Digital Manifesto "**BuildDigiCraft**" (Fig● 27)
- Group 2 – High-quality Baukultur Manifesto (Fig● 28)

2.0 Results and sustainability

The **BuildDigiCraft** training program enables young scientists and professionals in the field of architecture, engineering and urban planning to come together and exchange their ideas, concerns and visions about the future of the built environment in the context of the quickly developing digital and data-driven work environment, without losing focus on the technological, environmental, and societal challenges of our time. The three core elements developed within the **BuildDigiCraft** project triad model for the deconstruction of Baukultur – Process, Knowledge, and Material – is offered to the participants as a method for scientific reflection, which allows them to set their individual research within the holistic framework of "high-quality Baukultur in the digital age through craftsmanship."

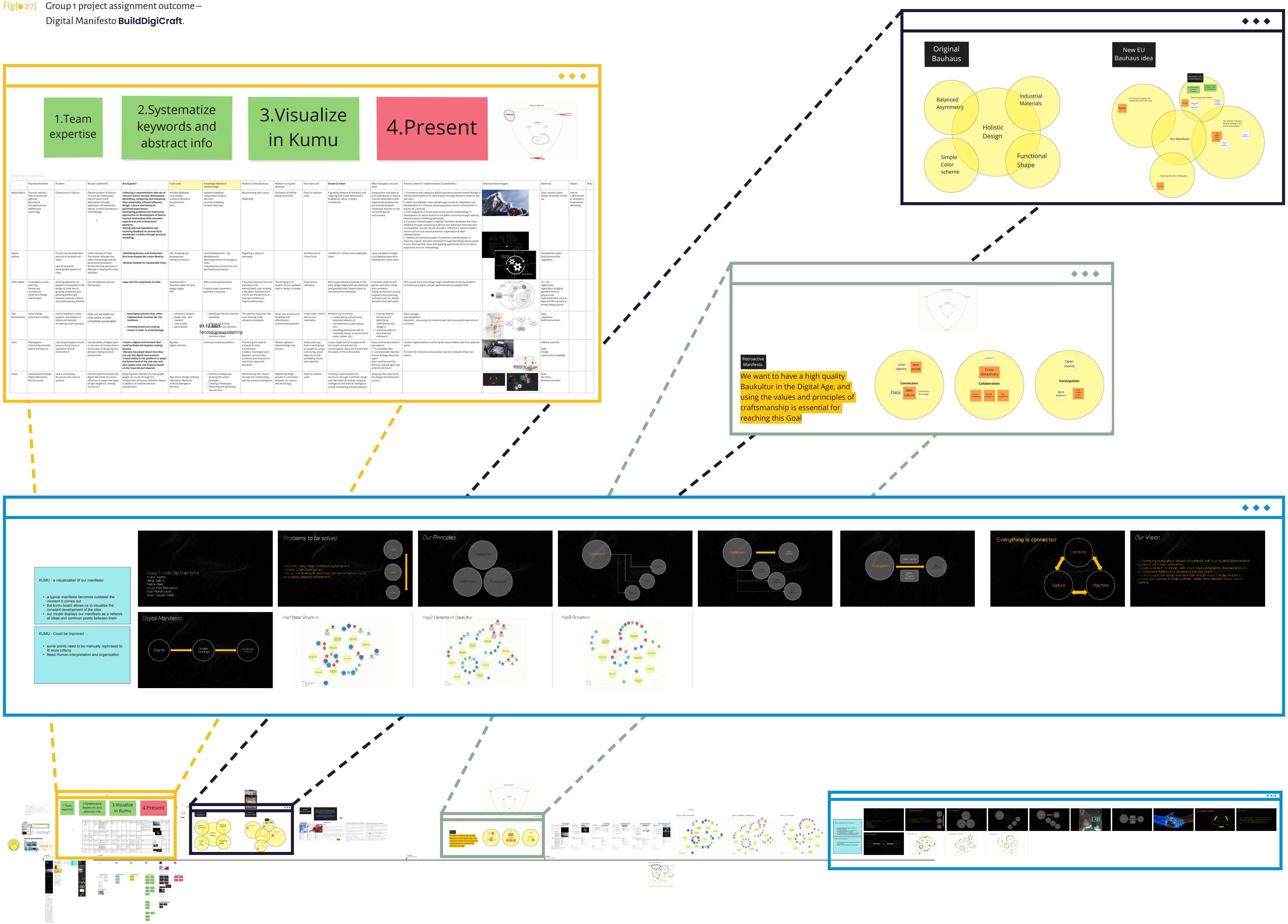
The training program is to be understood as an interdisciplinary, international, and interregional doctoral school. Each participant enters the training program wearing their own "digital," "disciplinary," and "ethical" lenses about a broad variety of thematic issues and questions related to the future of the built environment. In the pilot edition of the **BuildDigiCraft** training, the spectrum of the topics covered by the participants was quite broad and ranged between the research questions and topics briefly described below.

Some ISP participants were interested in exploring how to "resurrect geometry in architecture and engineering in connection with the rapid development of new digital tools for design and production," for which they considered the "mathematical breakthroughs in geometry, which have led to new ways of visualization and design of surfaces and structures."[6] Geometrical, structural and architectural potential and limits of digital tools and computational methods were explored in other research projects, too, for instance in the context of "bending-active torsional structures,"[7] but also in the context of "integrated sustainable, structural and architectural design concepts for timber-only structures (structures made from salvaged

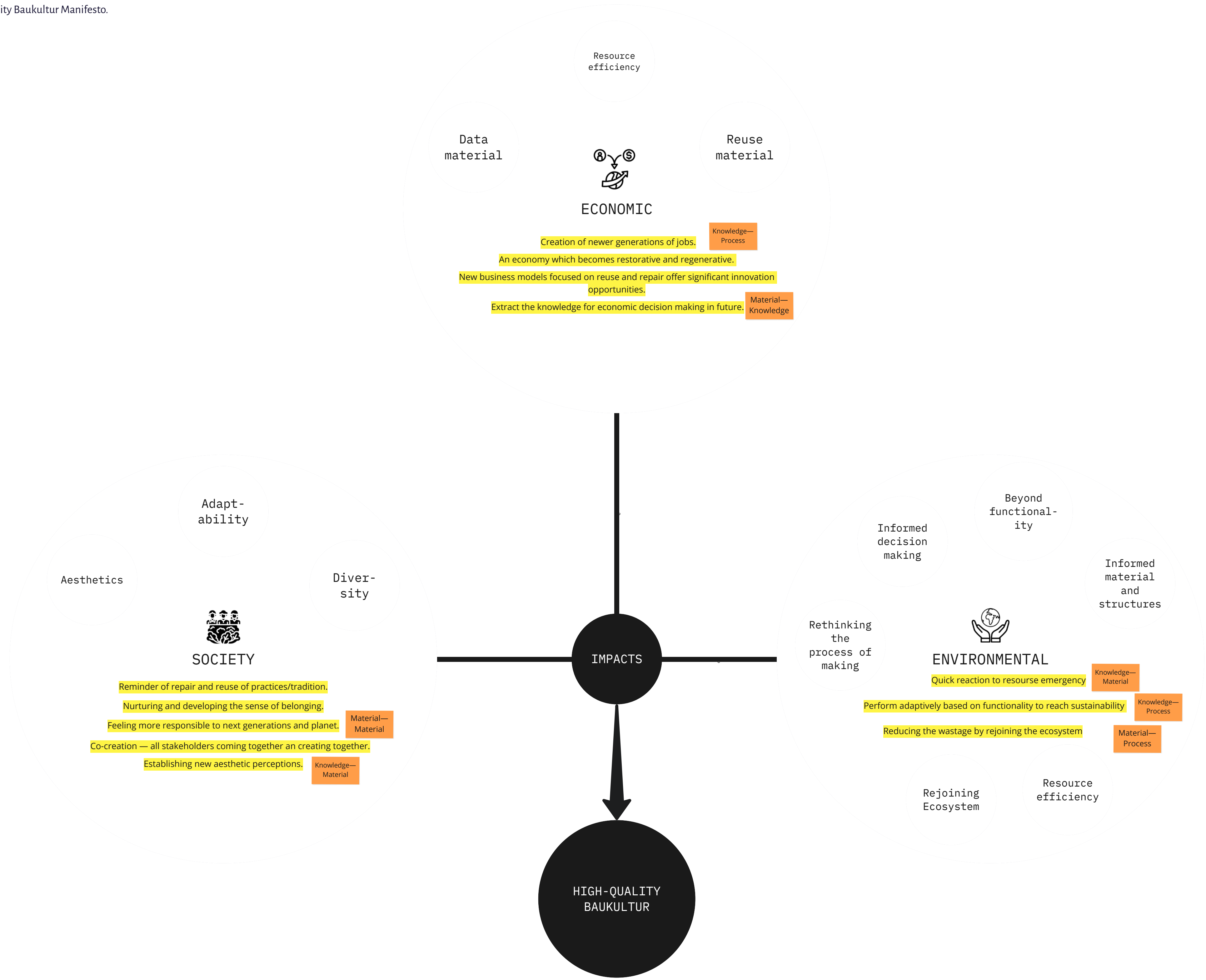
6 PhD project by Emil Adiels, Chalmers University of Technology (https://www.builddigicraft.eu/renaissance-of-geometry/)

7 PhD project by Serenay Elmas, Aalto University (https://www.builddigicraft.eu/torsion-as-design/)

Fig[● 27] Group 1 project assignment outcome – Digital Manifesto **BuildDigiCraft**.



Fig[● 28] Group 2 project assignment outcome – High-quality Baukultur Manifesto.



timber and wooden nails only)."[8] Other participants of the training program looked at complex societal questions in the field of urban design and urban studies such as a research project exploring the question of architectural democracy, "focusing on how people can understand cities, with their increasing automatisms, and how one can still be relevant for the decision-making of these."[9] How urban data helps us to understand where and what the activities are that are offered at the interchange points where urban life occurs was explored in a research project on "informalities and urban identities of cities in Albania."[10] In a project about "experiential nature architecture" with the help of visual databases, nature architectural cases were cataloged in order to investigate the organizational typology of tourism application, which would eventually lead to a better understanding of the environmental impact of mass tourism on nature architecture reserves.[11] Further topics related to latest trends in the digital world such as "the digital twin" in the context of buildings and cities, new digital tools enabling public participation for planning processes as well as AI-based decision-making for finding form in structural and architectural contexts were also among the research interests of the ISP participants. This large range of topics was essential for the explorative process throughout the pilot edition of the training program.

Each of the four Intensive Study Programs carried out within the **BuildDigiCraft** training format has a specific focus, starting from the Concepts and Fundamentals (ISP1) through to the Digital Futures (ISP2) and Craft and Craftsmanship (ISP3), culminating in a joint reflection on Rethinking the Baukultur of the Digital Age (ISP4). Each ISP builds on the previous one, and participants took one part after the next. At the same time, a non-consecutive participation in the ISPs was possible, too. From the overall 69 participants in all four ISPs of the **BuildDigiCraft** training, six took part in all four ISPs, nine in three of them and 15 in at least two of them. One PhD project was finished within the program and at least one more is in the process of being finalized (upon publication of this material). Although the participation in the ISPs could be officially recognized and awarded with credit points for the transfer of record at the home university, only few PhD candidates actually used this opportunity. The reason for not considering it was mainly because they formally did not need any credit points for accomplishing the requirements within their doctoral studies. It turned out that the main motivation of the participants for joining the **BuildDigiCraft** training program was the relevance of its topic, the input offered by both the internal scientific staff and the invited experts and most importantly, the use of the **BuildDigiCraft** model as a method for scientific reflection on the individual research project.

Extensive material was able to be collected throughout the **BuildDigiCraft** training program. This included all the participants' contributions within the Preparatory task assignments, the individual presentations, the Glossary Matrix exercise, as well as the outcomes of the group work and the group discussions. The input of 21 invited experts, all offering insights on the current ongoing transformation in the building and planning professional sector as well as on the theoretical and ethical aspects behind the cultural values in both the built and digital environment should also be considered as outcomes of the **BuildDigiCraft** training program. In a next step, the scientific team of the project evaluated the material and outcomes of all ISPs by deconstructing it to the main elements of Baukultur, as suggested within the **BuildDigiCraft** model for scientific reflection. The outcomes of the ISP are thus transferred as an intellectual exploration of the Process, Knowledge, and Material, the three elements that enable the development of Baukultur. Additionally, an open framework for a shared understanding through the introduction of the Glossary method is established and a final joint declaration of statements about the future Process, Knowledge, and Material of the Baukultur of the digital age developed.

8 PhD project by Gengmu Ruan, Aalto University (https://www.builddigicraft.eu/timber-only/)

9 PhD project by Pedro Esteves Galvão Aibéo, Aalto University (https://www.builddigicraft.eu/architectural-democracy/)

10 PhD project by Ilirjana Haxhiaj, Gdańsk University of Technology.

11 PhD project by Matijs Babris, Riga Technical University.

Transfer of ISP results:

Process	*Guidelines for a design process leading to a high-quality Baukultur in the digital age*
Knowledge	*Toward guidelines for the development of a higher education curriculum: bridging craft and digital for a high-quality Baukultur*
Material	*The meaning of Material, Materiality and the Digital for Baukultur*
Manifesto	*Joint declaration of statements on Baukultur in the digital age*

Impact beyond the BuildDigiCraft training program

The outcomes of the **BuildDigiCraft** training program will be disseminated among higher education experts, professional communities and policy decision-makers. The **BuildDigiCraft** Manifesto is the starting point for a broader discussion on the future quality of Baukultur in the digital context, it introduces a new perspective on the Davos Declaration for High-quality Baukultur and seeks to introduce an innovative framework for scientific reflection on the qualities of craftsmanship in the digital work environment of the professionals in the built environment. The ideas of the **BuildDigiCraft** project have already given impulses beyond the participants' scope of the training program. The main concepts and ideas as well as some of the training formats are already being introduced to several qualification programs on Master's and PhD level at the participating project universities. For instance, they were presented in a multidisciplinary Master's course at Chalmers University of Technology, in the training format of the PhD division as well as in an ongoing application for a joint European course of studies related to digitalization in architecture at Gdańsk University of Technology. All keynote lectures, together with an exhibition of selected PhD projects that were part of the training program, remain publicly available on the dissemination channel of the project as well as on the project web page.

3.0 Critical review and recommendations

The **BuildDigiCraft** training program is taken both in physical and digital format. The current guidelines are based on the experience had during the coronavirus pandemic in 2020 and 2021, when international mobility was restricted through factors related to "force majeure." The new situation sped up the disruption processes related to the introduction of new digital technologies in our work and everyday life. New types of work collaboration, communication and product fabrication proved to be irreplaceable also in the professional world of the specialists in the built environment. Even though the training program proved to be manageable in a completely digital context, it is important to recognize the fact that some direct personal exchange through physical meetings could have helped participants intensify the intellectual discourse between them. Nevertheless, the first digital contact established between some of the "regular participants" proved to be of long-lasting interest for future collaboration on similar research topics. Further opportunities for continuation of the exchange using other scientific formats were recognized and some participants of the training program managed to meet physically outside of the **BuildDigiCraft** project.

One of the main critiques regarding the implementation of the training program in digital format was its intensity. A five-day long intensive study program can be easily carried out in physical format, allowing for breaks and unplanned informal exchange between the participants. This was possible, however, only to a limited extent in the digital realm. Also, the fact that collaboration and discussion rounds were possible only via the constant use of a digital device influenced the level of perception and concentration of both participants and supervisors. Even though the daily program within the ISPs was limited to only four to five working hours per day, the duration of five consecutive days turned out to be hardly manageable by all participants. In a time when all academic and training offers became available online, the competence for keeping the attention of participants only to one training course for one whole week proved to be very difficult. Therefore, in order to improve the future performance of the program when carried through in a digital format, the **BuildDigiCraft** team suggests a new distribution of the workload. Instead of five consecutive days, the program can be achieved in a combination of three intensive study days in the first week and two or three additional ones in the following one to two weeks. In between, the participants thereby have the chance to continue and intensify their studies in an offline mode.

In all cases, the **BuildDigiCraft** training program is the foundation for further and future collaboration on a doctoral level in the Baltic and North Sea region. It created a holistic framework on a highly relevant societal topic that brings a wide spectrum of interdisciplinary research projects together and aims to uncover the essence of the changing culture in the Baukultur in the digital age.

2.2 Glossary

Intellectual Output 1

Glossary as a method for reflection on complex research questions

Authors

Małgorzata Kostrzewska, Justyna Borucka, Bartosz Macikowski, Dorota Kamrowska-Załuska, Lotte Bjerregaard Jensen

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1.0 Introduction

Globalization and digitization are strongly influencing the process of shaping the built environment. The latter is causing the new design tools to emerge faster than ever before in history, while the former is speeding up not only the development, but also the broad roll-out of more agile and interdisciplinary methodologies and work approaches. The design process is also becoming more and more inter- and trans-disciplinary. This is leading to the formation of design teams, in which team members bring together not only very different backgrounds and experiences but also different sets of vocabulary, which is one of the causes impeding flawless cooperation and a lack of common understanding within the team.

These trends call for a shared platform of understanding and clarification of professional terms and concepts in order to make the design process not only efficient, but also fully relatable and well-founded. In today's highly specialized world, professionals and specialists immerse themselves deeply into their fields, using a highly specialized, often hermetic vocabulary that is becoming less accessible and comprehensible to the wider public. Fragmentation in specializations, technological progress and greater and greater confinement to thematic professional bubbles are conducive to increasing isolation and exclusion of various groups from the possibility of mutual understanding about certain topics. The number of specialized terms is constantly growing, and professional language is becoming more and more complicated.

On the other hand, despite the increasing complexity of terms and the ever greater fragmentation of disciplines and professional paths, the importance of interdisciplinary and transdisciplinarity is continuously growing.

Shaping the built environment by implementing the goals and principles of Baukultur and striving to build high-quality spaces in the process is also based on the interdisciplinary approach which in turn requires reflected cooperation between the many different disciplines and fields involved in the process.

One of the main goals of the **BuildDigiCraft** project is to discuss, create and introduce new tools that enable an innovative way of thinking toward building a bridge between the digital world, the craftsmanship and material-based approach to work. As participants of the project, we believe that despite the constant progress in applying digital tools to design and manufacture products, the techniques, values and skills of manual work and traditional craftsmanship are becoming even more important for the process of shaping a high-quality built environment in the digital age. Creating a material environment with objects and buildings filling the space requires a certain understanding of and sensitivity toward properties of material such as texture, color and performance related to outdoor and indoor factors, resulting from the characteristics of the material from which the objects are made. Therefore, the questions we pose in the project relate, among other things, to whether virtual reality and artificial intelligence are able to fully reproduce the properties and performance of real objects in physical space.

Just as effort is required to build a bridge between the physical and digital world, it is also difficult to build a common platform for understanding – a shared language – that enables mutual appreciation between participants of interdisciplinary design and fabrication processes.

Therefore, the aim of this intellectual output is to create a foundation for a shared understanding of the main concepts explored within the **BuildDigiCraft** project. We worked on the premise that this could be achieved by developing a multidimensional glossary database, a core source of shared knowledge, which would be used as a base component in the development of each of the other intellectual outputs of the project.

The **BuildDigiCraft** project explores what concepts and notions researchers and participants use who are involved in design processes aimed at a high-quality built environment. The question we face is whether engineers, architects, planners, builders, designers, craftsmen, artists, environmental engineers and other experts, regardless of whether they deal with digitally-driven or traditionally-based methods and tools, are actually able to understand each other today using a mutually comprehensible linguistic corpus.

2.0 Description of the Glossary Matrix method

2.1 The concept of the Glossary

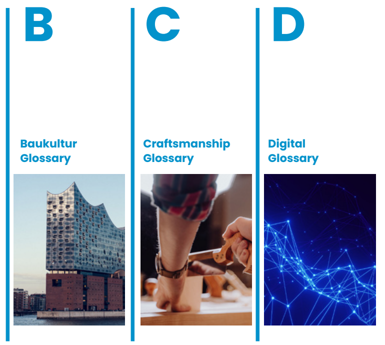
As defined by Wikipedia [1], a glossary usually provides an alphabetical list of terms in a particular domain of knowledge. During the course of the **BuildDigiCraft** project, we attempted to identify, collect, and create a set of terms that were to be included in the "Glossary." One of the roles of "our" Glossary was to enable joint work on the text of the Manifesto as an expression of the commitment to a high-quality built environment. Another aim was to observe whether the concepts and phrases used by participants in their research projects and during the workshops could be understood by everyone and used in similar contexts. We also considered to what extent the specialized vocabulary, in the case of the **BuildDigiCraft** project relating to the architectural, urban, artistic, technical and engineering aspects of the built environment, might be incomprehensible to a wider group of non-specialists and whether it can be used in public debate on shaping the quality of the built environment, i.e., striving for high-quality Baukultur. The project thereby provides the chance of specifying the essential words and notions associated with the digital aspects of designing the built environment. It sets them in relation to those introduced in the **BuildDigiCraft** project triangulation of Process [Chapter 2.3 | IO2], Knowledge [Chapter 2.4 | IO3], and Material [Chapter 2.5 | IO4].

[1] Glossary definition, https://en.wikipedia.org/wiki/Glossary [accessed: 12.05.2022]

Methodologically, the Glossary has been developed in an analog way, based on face-to-face discussions at project meetings and during the four intensive study programs (ISPs). The discussions included both group and individual reflections on pre-selected notions and concepts as well as the identification of new ones. Within this phase a specially developed "Glossary Matrix" is used as a framework tool for knowledge organization and documentation.

The **main aim and motive** of the Glossary is to help describe, explain and thereby provide a shared, contextual definition of all the concepts and notions that the project participants came across during the joint investigation of the main project question: **how do we shape the future built environment in a world of growing digitalization and professional specialization?** There is a strong need for a tool that enables inter- and trans-disciplinary design teams to build a common platform to share ideas. This platform allows different team members to set their concepts and notions in a common **BuildDigiCraft** framework. First, the Glossary method can help team members identify the most essential and vital ideas in their design and research work. Secondly, they can start exploring these ideas through the framework of the **BuildDigiCraft** and the Glossary Matrix. Thirdly, this may lead to a shared understanding of the individual ideas and respectively to the consideration of the specific context in which they are embedded.

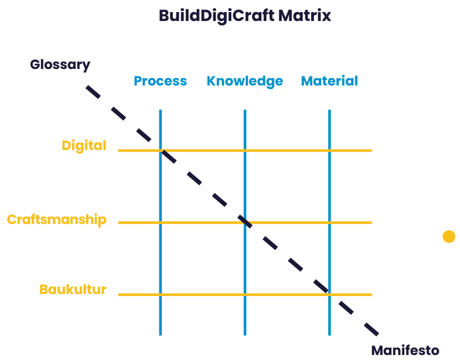
The main focus of the Glossary was on the intersection between **Baukultur, Craftsmanship and Digitalization.** The concept and structure of the Glossary were created at the beginning of the project and were applied and tested during the first two ISPs. In the next project stages, it continued to be used already as an established concept and tool allowing for regular updates. It proved to be useful in establishing a common ground (vocabulary) for members of all professions and disciplines involved in the project training program: structural and architectural engineering, architectural and urban design as well as urban planning. So finally, in an attempt to define the Glossary, we can say that it is a resource tool that allows you to organize, group and collate word concepts in the context of the **BuildDigiCraft** project. It should also be added that one of its most important roles is to build the conceptual base needed to develop the last of the intellectual outputs, which is the Manifesto.



Fig[●1] **BuildDigiCraft** Introductory Presentation "Glossary" (ISP1, ISP2). Photos by: Jonas Tebbe (left), Bailey Alexander (middle), and Conny Schneider (right) on Unsplashed.

2.2 The context of the Glossary

The Glossary builds on the concept of the **BuildDigiCraft** project matrix and specifically on one of its two main axes, containing the three components of Process [Chapter 2.3 | IO2], Knowledge [Chapter 2.4 | IO3] and Material [Chapter 2.5 | IO4]. It was within the exploration of the Process–Knowledge–Material interrelation that the foundation for the further development of the Glossary was built.



Fig[● 2] **BuildDigiCraft** matrix.

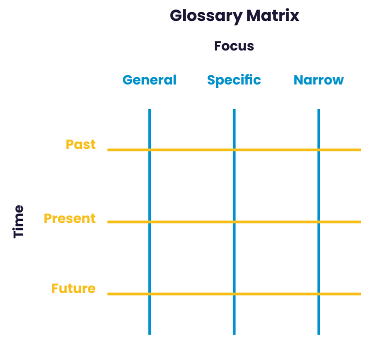
The **BuildDigiCraft** matrix is built on the following fundamentals and concepts (Fig[● 2]):

- on the vertical axis we find: (1) **Digital(ization)**, which influences the current and future process of shaping the built environment, (2) **Craftsmanship**, which addresses the gap between the actual situation of Digitalization and its potential, and finally, (3) **Baukultur**, which lays the values and principles we follow in the process of shaping the built environment and at the same time joins the above concepts. We believe that there is a strong connection between these three components as they all refer directly to the quality of space created by the design team as well as to the acceptance of the proposed design by civic society, including all the actors involved both directly and indirectly in the process.
- the horizontal axis consists of the following components: (1) **Process**, which includes the whole cycle of design, planning, construction, maintenance, and end of use, (2) **Knowledge** defined as tacit and implicit knowledge that influences these processes and (3) **Material**, which relates to the physical representation of design in the built environment and also responds to the need of understanding materiality in the digital context.

The outcomes of the Glossary are expected to enrich the three main components of the project: "Process," "Knowledge," and "Material" by providing common ground for further discussion. At the same time, the Glossary, as a reflection of the concepts and notions used within the digital context of the built environment that interweave with the principles of craftsmanship, provides the foundation for the **BuildDigiCraft Manifesto** [3.0 Manifesto (IO5)].

2.3 Glossary Matrix

The idea of the Glossary was further operationalized to create the Glossary Matrix (Fig[● 3]), which serves as a framework tool for establishing the dimensions within which the posed concepts and notions can be explored. The Glossary Matrix helps to identify and structure the content of the Glossary.



Fig[● 3] Glossary Matrix.

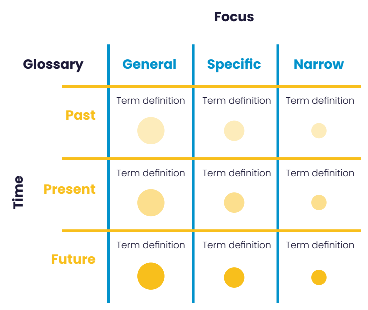
The two axes of the Glossary Matrix are: **focus** and **time**.

The **"x" axis** of the matrix – **Focus** – enables the identification and use of notions and ideas according to the scale of their focus, which is connected with the availability and use of different terms derived from a broad spectrum: **general**, which is available to a wide range of non-specialists, through to a more **specific** one, which is used by specialists in the context of their profession, up to a **narrow** one – used strictly in relation to the problems of specific research projects such as PhD or Master's theses of the ISPs' participants.

Time factor, pictured on the **"y" axis**, is used to describe the meaning and appearance of notions and ideas throughout time. This section is divided into: the **Past**, meaning both the distant and more recent past , the **Present**, which includes both the present time and the very near future, and finally, the **Future**, both near and distant, including the future that is very difficult to predict.

2.4 Step-by-step Glossary

In order to use the Glossary Matrix, a specific work formula has been created. The formula is thought to be open and is easily used for various topics of research. Depending on the topic, the form of description of individual entries differ. The first step of the formula is the definition of **keywords** in the context of time and focus. The graph on the next page illustrates the matrix table with its main definition axes **focus** and **time** (Fig[● 4]).

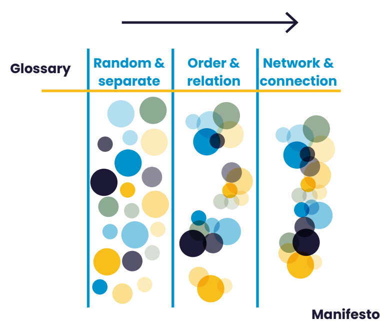


Fig[● 4] Glossary Martrix: keyword definition.

The following steps make up the work formula for the matrix:

- The preliminary step to start working with the matrix is to define the most relevant and representative group of keywords related to the selected topic of study.
- The next step is to assign these keywords to the appropriate matrix cells. They should be described following the axes of time and focus. The form of description depends on the preferences of the user of the matrix. The matrix itself allows for different forms of representation: written description, only one word, one sentence, very detailed observation and description, pictures, photo, graphics, etc. Users of the matrix should match the keyword set to the table according to their individual level of knowledge, perception and research approach.
- Filling in all of the cells of the matrix is not necessary. Some of the fields may be left blank. This will be the case if the term did not exist in the past or the user of the matrix does not see the need to describe the keyword in the specific context of focus or time line.
- The users of the matrix decide for themselves when to finish working on the table. This offers the possibility of continuous fine-tuning depending on the knowledge acquired and the development of the research field. The description and understanding of the selected term are constructed in such a way that the matrix table gives a full picture and definition of this term in the context of the specific research field. By studying individual terms and keywords, the user can conduct an in-depth analysis of a research topic, which in turn can lead to new research links.
- In the final stage, the matrix leads to a better understanding of the evolution of terms and their changeability over time in regard to the differentiated focus and to the identification of the Glossary content. The content of the Glossary builds on the basis of the completed matrices. This will not only allow researchers and practitioners from different disciplines to define research inquiry better and thus build a common platform and framework for trans-disciplinary research, but could also identify and help prepare new directions for future research.

2.5 Glossary collider



Fig[● 5] Glossary collider.

The next stage of using the Glossary Matrix tool is the application of the **glossary collider**. This stage of the vocabulary analysis corresponds to the search for connections and collisions of individual definitions from and within various domains, which again provides a broader context for understanding individual meanings.

- After adding the terms to the matrix, the set of **individual definitions** is obtained (see the description of the matrix formula above). The keywords are separately and independently defined at this stage. In order to identify connections and relations, the contents of the matrices (keyword definitions) need to be structured accordingly.
- In this case, an **arrangement of contents** (grouping, sorting, positioning, classification according to the desirable categories) is required. What is important is that the individual terms need to be arranged by identifying the mutual relations and interactions between them.
- The final and complex Glossary combining different research disciplines and approaches can be built upon the understanding of interactions between terms, their arrangement and meanings in different contexts.
- In this way, a network of connections is built between a network of terms. Identified groups of terms (individual, separate words belonging to a group – a discipline or a process, e.g., a group of words related to architecture) are able to create/form a network of terms (a network of organized words – broader, complex terms, formed from the grouped words, which are equally understandable to everyone representing a given discipline or profession), so as to build a platform for shared understanding.

The individual phases of searching for relationships and connections between particular words and their definitions are shown in the Fig[● 5].

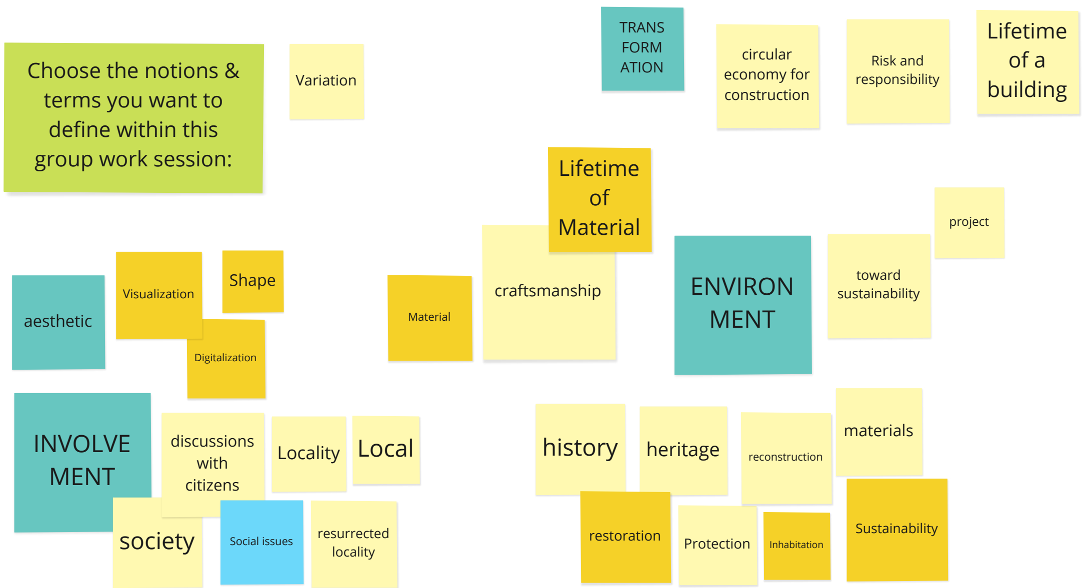
2.5.1 Glossary Matrix examples from the ISP1

The pictures presented further below show possible and different approaches to the Glossary Matrix tool by the participants of the first Intensive Study Program (ISP1). The participants were asked to bring their individual keywords relating to their own scientific research. During the group work the participants listed and then selected terms that they considered important – which related on the one hand to their own research work, on the other hand to the **BuildDigiCraft** contexts discussed at the ISP1, such as Baukultur, Craft & Craftsmanship, and the digital (built) environment. The following days of the training were devoted to these specific aspects. The below illustrations show the interpretation and outcome analysis of the research topics created during the ISP1 using the Glossary Matrix tool.

Baukultur context

The first of the presented pictures shows the group of words selected from the range of scientific topics of various PhD researches in the context of Baukultur. The members of the working group 1 first identified and created several groups of words using stickers on an interactive white board, thereby outlining the fields of possible interpretations.

Fig[● 6] ISP 1, Day 2, Group 1.



Next, the agreed and selected terms were matched with the appropriate matrices. The below examples show two of the matrices that the group looked into. Particular words like *"heritage"* and *"material"* (as seen in the graphs) and others were placed in the matrices, a new possible interpretation of the words being generated in the process.

Fig[● 7] ISP 1, Day 2, Group 1.

Heritage	General	Specific	Related to (PhD) thesis
Past	Piece of architecture	Church of St. Nicolaus in Gdańsk Function: church	**Testing the material**
Present	Heritage	**Church of St. Nicolaus in Gdańsk Function: church**	
Future	**Heritage**	**Church of St. Nicolaus in Gdańsk Function: church/museum/ object of adaptation**	

Fig[● 8] ISP 1, Day 2, Group 1.

Material	General	Specific	Related to (PhD) thesis
Past	Material of natural origin	Trees	Study of the properties of materials
Present	Buildings	Wooden constructions	Composite materials
Future	**Reuse**	Recycling of waste wood	Artistic strategies for the reuse of material components

The second group chose the word *"Materiality"* as relevant to the term Baukultur. It can be observed that the *"Material"* and *"Materiality"* terms, in the context of shaping the built environment, are in both cases related to recycling, reusing resources, reducing consumption, and a sustainable approach to design and build processes.

Fig[● 9] ISP 1, Day 2, Group 3.

MATERIALITY	General	Specific	Related to (PhD) thesis
Past	Stability	Understanding material strength Design over the wall, materiality is defined during the structural design process	Material properties in the last stages of design
Present	Durability	Understanding material quality Collaborative design, materiality is defined during the design process	Product behavior Material properties input
Future	Sustainability	Replicability of existing materials with sustainable ones Collaborative design, materiality is one of the main inputs for the design process	Recycle/reuse of the materials Material-driven design

The other group, as is seen in the illustration below, placed the term *"Baukultur"* itself in the matrix to try to define it and discuss its meaning in relation to focus and time. The graph illustrates how the matrix construction allows for organizing one's thinking and defining the term under the inclusion of various aspects.

Fig[● 10] ISP 1, Day 2, Group 2.

Baukultur	General	Specific	Related to (PhD) thesis
Past	Relation of culture and built environment	Sustains social cohesion, well-being and resilience	Existing construction – cultural heritage assets and contemporary creation were separate
Present	Construction is both a cultural act and creates space for culture	Embraces every human activity that changes the built environment	Existing construction and contemporary creation must be considered as a single entity
Future	Need to implement a new, adaptive approach to shaping our built environment	**Baukultur calls for contemporary creation and the existing buildings**	**Baukultur does not only refer to the built environment, it also relates to the process of creation**

Craft & craftsmanship context

The four matrices presented below show the individual approaches toward the term *"craftsmanship."* It is a good illustration of how the matrix supported by pictures can relate to the elaborated term and how different the interpretation of the word can be in the context of history, the future role, the meaning and form of craftsmanship. This opens the field for discussion as to how the traditional understanding of the word could vary in the present and future, or whether craftsmanship will in future be replaced with a different meaning, or whether and in what form it will even exist.

Fig[● 11] ISP 1, Day 3, Group 1.

Craftsmanship Egils	General	Specific	Related to (PhD) thesis
Past	Everything is handmade	Scale models, architectural details, construction work	Manually doing things, data gathering, a lot of labor needed
Present	High-quality work involves manual labor in combination with technologies	Scale models, architectural details, prefab, digital data, CNC, laser cutters	Looking into solution on how to work smarter and more efficiently while not losing quality
Future	Technologies take over manual labor, fully automatized solutions with some human supervision	Robotized solutions, higher educated people needed with know-how	Working smart, data-based solution not professional guessing

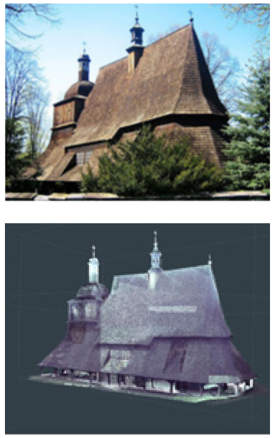
Fig[● 12] ISP 1, Day 3, Group 1.

Asad Craftsmanship	General	Specific	Related to (PhD) thesis
Past	It was a collective act within society	Craftsmen working habitually, internalized skill, open source	**Evolution of skills and construction**
Present	There is an artisan's perspective of the issue	Closed system, lack of narrative	Possibility of integration of skills and construction as one entity
Future	**Bringing back the quality to objectification**	**Work is the extension of identity in society**	Skilled confidence + skilled cooperation + quality

Fig[●13] ISP 1, Day 3, Group 1.

Craftsmanship Matijs	General	Specific	
Past	Necessity	Part of trade. One of main providers of income	Technique
Present	Relic?	**Conservation** of existing buildings mostly?	**3D scanning**
Future	Luxury	**Informational bandwidth extension** – digitalization drawing, hand–eye coordination	**Virtual planning?**

Fig[●14] ISP 1, Day 3, Group 1.



Craftsmanship *Rzemiosło* (Polish)	General	Specific	Related to (PhD) thesis
Past	Small-scale manufacturing including making and repairing utility items by hand or with simple tools	Carpentry works (show of skills and abilities)	Object with its **orginal function** (in this particular church)
Present	With reference to the fields of art: mastery of technique, creative workshop (in retreat)	Object of preservation (a great carrier of skills and abilities from past)	**Object** of interest as a great **specimen** of knowledge
Future	Automatization, Digitalization of crafts (algorithms, computer-aided crafts: 3D prints)	Hopefully still existing object (still as a great carrier of skills and abilities from past)	**Digital reconstruction** of piece of architecture (with possibility to share the knowledge and show former ways of constructing buildings)

Other groups selected the terms related to craft and craftsmanship and these were, for example, *"making + tool,"* but also *"Material"* – the word already discussed in the Baukultur context. It shows how the same term can be defined and discussed differently, depending on the context in which it is used.

The presented matrices show the possible transformation of understanding *"Material"* and *"Materiality,"* and also what *"making + tool"* could mean. Both analyses present the evolution of the terms' meaning, showing the transition from the physical and material world to the digital and programmable one. The need to care for nature and implement a circular economy when focusing on materiality is also stated very clearly.

Fig[●15] ISP 1, Day 3, Group 4.

MAKING + TOOLS	General	Specific	Related to (PhD) thesis
Past	Handmade Customized High level of detail	Slow but high-quality process Unique detailing High level of tacit knowledge	Mastery of the process of making
Present	Industrialized and human-driven Standardized Low level of detail	Fast and mass production. Low level of freedom	Embracing the digitalization in the building sector
Future	Automated and machine-assisted Customized High level of detail	Fast and mass-customized process and tools. High level of freedom and environmentally friendly	Use of AI, big data and digital fabrication as mainstream

Fig[●16] ISP 1, Day 3, Group 4.

MATERIAL	General	Specific	Related to (PhD) thesis
Past	Good quality and "natural"	Materials were taken from nature. The human interaction was made by hand-driven tools.	Accept the material as found in nature
Present	Redesigned materials and "industrialized"	Industrialized and standardized products. More precision and control. Standardized production process by machinery	Creation of new materials but not accepted in the mainstream industry. Analyze where to use materials in a more efficient way
Future	Redefined materials as performance	Flexible and circular	Development and creation of new smart, programmable materials. Use of data to enhance performance
Future	Design with waste		

Digital (built) environment context

As with the previous topics, the two different approaches to terms related to digitization are very clear. One of the groups initially inserted the word *"Digital"* into the matrix, trying to define it in the context of their research interests, while other groups defined relevant concepts in the context of digital design and built environment.

The below illustrations show the sample matrices elaboration around the words connected with digital: *"Digital"* itself, *"Control in digitalization"* and *"Digital fabrication."*

The analysis of the term *"Control in digitalization,"* according to the presented matrix, shows the growing role of digitalization, which has a powerful influence on people at present. Yet the future will see a strong connection between the digital and physical world, leading to the development of customization, and better relations between humans, the digital world and nature.

Fig[17] ISP 1, Day 4, Group 4.

Digital	General	Specific	Related to (PhD) thesis
Past	Database	CAD	Information, data
Present	Data operation, visualization, parametric design	BIM, 3D, big data, analyzing tools (Grasshopper, Dynamo)	Pre-knowledge, software development
Future	Interoperability Co-production Merging of physical and digital	AR & VR, scanners, 3D printing, sensors. Machine learning and neural networks-assisted design	Neurolink, AI, brain-computer interfaces

Similarly, observing the *"Digital fabrication"* term with the matrix lens, where the mix of technologies and the human factor is significant, leads us to the conclusion that prefabrication, hybrid and smart design can act in symbiosis with nature.

Fig[18] ISP 1, Day 4, Group 2.

Control in digitalization	General	Specific	Related to (PhD) thesis
Past	Digitalization is supplementary	2D and 3D modeling; printing out drawing; physical models	**Learning from physical models, developing modeling tools and merging into virtual world**
Present	Dependence on digitalization. Also confidence in digitalization as a problem solver	Only 3D modeling. Requirements for simulation of indoor climate and energy use which often differs from the physical world	Focus more on sustainability
Future	Digitalization provides customization. People are again in control	3D models and VR. Strong connection between the digital world and the physical world. Digital prototyping	Better understanding for the possibilities but also limitations of digitalization, enhancing the control of human-based to understand nature better

Fig[19] ISP 1, Day 4, Group 2.

Digital fabrication	General	Specific	Related to (PhD) thesis
Past	Massive, industrialized production Simple, repetitive	Small prefabricated unit in construction	Learning experience from how carpenters use and process natural materials
Present	Beginning to use 3D printing and CNC cutting	**Whole construction in small-scale project or prefabrication of main components and assembly on site**	**Combining the knowledge and fabrication process**
Future	**Combination of digital fabrication and other technologies. The mark of human hands**	**Highly prefabricated, hybrid and smart design/construction**	"Collaborate" with nature

In addition to the concepts directly related to *"Digital"* that included this term, some groups defined other concepts that they believed related to digital processes of designing or shaping the environment. In this way, a variety of concepts have been embedded in both the closer and looser contexts of the entire **BuildDigiCraft** project.

Examples of such terms related to digital are *"design process"* or *"quality and evaluation,"* which were analyzed through the matrices. The presented examples show that the reflection on these issues in the framework of the matrices leads to rather optimistic conclusions. Digitization and new technologies will be able to support various processes of shaping the built environment to an ever greater extent, contributing more and more to overcoming the negative phenomena that our world already faces, and which will increase in the future. So digital tools are seen rather as an ally in the fight for a better tomorrow of Baukultur.

The last matrix dealing with the topic of digitization is interesting in that it touches on the integration of the physical and digital world, which should be considered as the direction in which technologies related to architecture, structures, construction, and environmental shaping at all scales are heading. Artificial intelligence and virtual reality are treated as fully controlled tools in the hands of designers, which brings to mind the previously presented matrix on control in digitization. It can be said that the conclusions drawn from the analysis of both matrices are similar.

Fig[● 20] ISP 1, Day 4, Group 3.

Design process	General	Specific	Related to (PhD) thesis
Past	Standardization (Mass production)	Design process deals with standard products and measures. Mass production affects the design and the building process. Process "over-the-wall," whereby the architect finishes the design, sends it to an engineer, then sends it to builders and so on. The design as a product	**Use of industrial process to mass-produce better solutions**
Present	Automation (Customization)	Design process deals with a level of customization. The possibility of digital fabrication allows specific solutions. Collaborative design process between architects and engineers. The design as a system	**Use of digital fabrication and generative systems to build up systems that provide solutions for a class of problems**
Future	AI(zation) (Mass customization)	High freedom of design, with mass-customized solutions. It is uncertain how AI will take part in the CREATIVE design process. The design as a system of systems	**Use of AI and big data to find better solutions for very specific problems. Design of products and unique solutions**

Fig[● 21] ISP 1, Day 4, Group 3.

Quality and evaluation	General	Specific	Related to (PhD) thesis
Past	Client satisfaction	Manually/visually checked	The construction industry slow to adopt changes, backwards, client dissatisfied with the result, behind schedule, budget. Change does not happen – change movement
Present	Client satisfaction, economic value, aligned toward sustainability, energy efficiency, etc.	According to regulations, computer-aided check	Diffusion of innovations: "hard" and "soft" parts, acceptance
Future	Global challenges: population growth, shortage of resources	Entrusted to AI	Radical change through digitalization. The overlooked negative consequences, learning from failure and the supportive structures (e.g., education)

Fig[● 22] ISP 1, Day 4, Group 4.

Integration of digital and physical	General	Specific	Related to (PhD) thesis
Past	Co-existence of physical and digital with architect and builder as a bridge	Two-dimensional attribution, CAD drawings, scale models. Mediation through print or hand drawings	**Digitalization of drawing, Information input bandwidth extension. Increasing dimensionality**
Present	Combining digital and physical approach through interactive mediums	**Real time integration of Extended realities, BIM and parametric modeling**	**Enabling assisted creation. Augmented reality in construction. Spatial design in VR**
Future	Robotics and automatized creation. Selection as a process of design	Merging of digital and physical through 5G-enabled distanced real-time creation	**Artificial intelligence-assisted buildings, bio-architecture. Brain–computer interfaces**

The sense and logic of these types of tasks was to span the analysis of specific terms between past and future to understand the possible forms of continuation of positive humanistic aspects of craftsmanship and digitalization. As Baukultur postulates development through quality, presented matrices and their outcomes open the broad spectrum of links between past and future, between human-made environment and nature, technology and art, etc.

The tool of the matrix has shown that it can be used in a variety of ways and in a variety of contexts. Using the tool can help in building discussions, defining concepts, finding contexts and relationships. It's up to the users how deeply they delve into defining the terms – it may depend on their specific needs. Working with the matrix showed how important it was for building mutual understanding and relationships in the working group. Each of the group members was, on the one hand, embedded in the context of their own research work, but on the other hand, the group had to build a platform for mutual understanding by defining term concepts relevant to everyone. The matrices were able to help with this.

3.0 The Glossary Matrix as a reflection of the individual scientific work embedded in the concepts of the BuildDigiCraft project

3.1 The relation of the Glossary to the Manifesto

Many important documents relating to the shaping of space and related aspects that arose in the past and are still being created took the form of open manifestos, presenting the most important assumptions and guidelines. Such a task was set for the **BuildDigiCraft** project – to create a Manifesto proclaiming how to still draw in the modern and future digitalized world from the value of manual work and craftsmanship, how to build a bridge between the world of artificial intelligence and computer capabilities and the values of the physical, material world that still remains and surrounds us. It's the physical creations that create our surroundings – the built environment. The quality of our life depends on the character of the physical products of engineering, architecture, art, and town planning.

The Manifesto should be understandable to everyone and written in clear language with an unambiguous message. It should not be addressed only to a narrow group of specialists, but to all users and recipients of design processes who are simply users of the space and the built environment.

The Glossary was created as a tool that can help define the most important concepts and reflect on whether these concepts are understood similarly in different professional environments and society in general. Processing words in the Glossary allows for reflection on to what extent the functioning words are hermetic concepts, understandable only to a narrow group of specialists and to what extent they are widely understood. Another question that the Glossary can help to answer is whether a given concept means more or less the same at all and whether it is understood in a similar way by both specialists and society at large. It may turn out that the same concepts are understood in completely different ways and mean something entirely different for different groups. This in turn can lead to a lack of mutual understanding or to a false reading of the Manifesto.

Therefore, one of the aims of the Glossary was to create a database of keywords proposed by ISP participants, which, on the one hand, were closely related to the research or projects they were working on, on the other hand, were relevant to the pursuit of high-quality Baukultur and finally, were to be linked to the world of digital tools used in design or to craftsmanship, materials, and other physical aspects of design.

On the basis of the group of keywords and their processing in matrices, it is possible to check the different meanings and contexts of various concepts directly related to the processes of designing and shaping the built environment.

3.2 Glossary as a reflection of the individual scientific work

In addition to creating a database of concepts used to write the Manifesto, the matrices can also be used individually to reflect on the conducted research in the context of the key vocabulary used. The processing of keywords in matrices can become a reflection of scientific work through the prism of the terms used. Matrices can be helpful in defining the most important key concepts with which one can describe one's own research work, but also disseminate and distribute it to a wider audience, clear in the knowledge that the concepts used will be understood in the right way.

Therefore, as part of the ISP, participants had to look at their own work and research projects through the prism of the Glossary Matrix to find a conceptual and verbal reflection of their work.

This method of working with the matrix as a reflection of the individual scientific work was used during **ISP2 "Digital Futures"**: word processing by matrices can reflect the individual scientific work through the lenses of the **BuildDigiCraft** project's values and pillars, thus contributing to building the platform of common understanding within different groups of specialists aiming at building a Baukultur of high quality.

3.3 The use of matrix during the ISP2 – description of the method

The leading topic of **ISP2 "Digital Futures"** was set, of course, in the context of the **BuildDigiCraft** project, and therefore primarily in the context of Baukultur. The aim of the second ISP was to reflect on the direction digital tools involved in design and construction processes were taking in shaping a high-quality built environment. What is their role now and what will it be in future, to what extent will further digitization of design processes take place? How do individual ISP2 participants position themselves with their research projects in this context? The most important concept from which the work on matrices and the discussion began was the term "*Digital*," for which various contexts, extensions, and associations were then built in relation to individual research projects and in relation to the idea of Baukultur as a whole.

The method of working with the matrix used during the second training shows how widely and in which multi-faceted ways it can serve. The way the matrix is built allows for its multi-layered and multi-directional use – wherever it is necessary to reflect on definitions, meanings, concepts and how they are embedded in various contexts and dimensions.

The **"x" axis** of the matrix organizes the concepts in relation to how widely they are used and how they are understood – in general terms, i.e., how they are understood by the general public without division into individual professions, then how the concept is understood in a narrower context, e.g., within the professional group for which it is a concept used on a daily basis in project or research work. The last and narrowest approach is to define the word excluded in the context of individually conducted project or scientific work.

In turn, the **"y" axis** of the matrix shows the views of a given concept in the context of time. It is looking at a concept through the prism of the past, present and future. This approach allows us to observe whether a given concept existed in the past, and if so how it was understood, how its definition or application may have changed today and how it may change in the future.

Each of the concepts can therefore be defined, associated and observed from nine perspectives represented by the fields of the matrix relating to the scope of meaning and time.

3.4 Steps of the process

Word processing in the matrix has been divided into consecutive stages.

Step 1 Getting acquainted with the initial set of keywords introduced by the participants of the Intensive Study Program

The preliminary task for the participants was to propose five keywords relating to their scientific work. The group prepared the words during the group work session on their first day of the ISP.

Step 2 Selecting keywords from a set prepared by the participants as a preliminary task, relating to or associated with the term *"Digital"*

The objective of steps 1 and 2 was to select a set of keywords relating to the concept of "*Digital*." From a collection of all the terms and concepts proposed by the participants, each group then chose the words, which to their mind most closely related to the concept of "*Digital*." In this way, a set of words was created, which was then processed in the matrices throughout the entire training program.

Fig[● 23] Collected keywords in Pre-task 1, ISP1.

- 3D-SCANNING
- ADAPTABILITY
- AESTHETIC
- AGILE
- ALGORITHMIC
- DESIGN
- ALIVE
- ARCHITECTURE
- BAUKULTUR
- BUILDING NDUSTRY
- BUILT and UNBUILT
- BUILT ENVIRONMENT
- CARE
- CHANGE
- CIRCULAR
- CIRCULAR ECONOMY
- COLLABORATION
- COMMUNICATION TOOLS
- CONNECTION
- CRAFT
- CRAFT TECHNOLOGY
- CRAFTSMANSHIP
- DATA-AVAILABILITY
- DATA-INTEGRATION
- DETAIL
- DEVELOPMENT
- DIGITAL
- DIGITAL FABRICATION
- DIGITAL TOOLS
- DIGITALISATION
- EMOTIONAL
- ENVIRONMENT
- FUTURE-ORIENTED
- GENERATIVE DESIGN
- HERITAGE
- IDENTITY
- INFORMED PROCESS
- INTEGRATION
- INTEGRITY
- INTERACTIVE DESIGN
- INVOLVEMENT
- LEARN
- LIFE-CYCLE
- LIFESTYLE
- MACHINE LEARNING
- MANAGEMENT/ ECONOMIC SYSTEMS
- MATERIAL
- MATERIAL COMPUTATION
- MATERIAL REUSE/ RECYCLE/UPCYCLING
- MATERIALITY
- MATERIALITY & DIGITAL
- MEGASCANS
- OPEN BUILDINGS
- OPTIMISATION
- OWNERSHIP
- PARTICIPATORY
- PEOPLE
- PHOTOGRAMMETRY
- POLICIES
- PRESERVE
- PROJECT
- REFLECTION
- RESILIENCE
- RESISTANCE
- RESPONSIBILITY
- REUSE
- REVITALISATION
- SAVE
- SCALE
- SHAPE
- SOCIAL
- SOCIAL ISSUES
- SOCIAL PARTICIPATION
- STRUCTURAL ART
- STRUCTURES and ARCHITECTURE
- SUSTAINABILITY
- SYSTEM
- TACIT KNOWLEDGE
- TACTILE
- THINK OUTSIDE THE BOX
- TIMBER-ONLY STRUCTURES
- TIME
- TRANSFORM
- UNIQUE
- UNREAL ENGINE
- URBAN PLANNING
- VR HDM MODELING
- WELL-BEING

Step 3 Processing the word *"Digital"* the matrix

In the next step participants added the word "*Digital*" to the matrix and tried to describe it by using the words selected in the second step. They aimed to define the term "*Digital*" in the context of focus and time by using the keywords to observe whether they relate to the past, presence and future and to what extent they are used and/or understood in general, specific (professional) or very narrow (individual) contexts.

Fig[● 24] Matrix example for "Digital."

Focus

Time / Digital	General	Specific	Narrow
Past		CAD	
Present	AI	Parametric design AI	CAD Rhino
Future	AI	Parametric design AI	Rhino

Example: the word "*Digital*" could have been described by the possible selected words – "parametric design," "artificial intelligence (AI)," "computer-aided design (CAD)," "computer program Rhinoceros 3D (Rhino)."

The following illustration is an example that shows a possible approach to this task. This illustration was given to the participants as an example from which they could build their matrices in the group work.

The matrix helps to observe in which context related to focus and time the terms are placed in the matrix. This may lead to understanding how the terms related to design processes are captured by different interest groups in relation to time, i.e., how they were captured in the past and how they will be understood in future.

Fig[● 26] ISP 2, Day 2, Group 2.

Digital	General (used and accepted by the society)	Specific (used and accepted by the academic field)	Related to (PhD) thesis Narrow (used and accepted by the expert)
Past	Parameter Data shuffling	Computer-aided design	Optimization Data collection Data analysis
Present	Digital Interfaces 3D scanning DIGITALIZATION	DIGITAL TOOLS Algorithmic MACHINE LEARNING 3D SCANNING Generative design Material computation Computer-aided manufacturing INTERACTIVE DESIGN	DIGITAL TOOLS MACHINE-LEARNING 3D SCANNING Digital fabrication Optimization Craft technology MATERIAL COMPUTATION
Future	Circular economy AI INTERACTIVE DESIGN	GENERATIVE DESIGN MACHINE LEARNING INTERACTIVE DESIGN MATERIAL COMPUTATION	MACHINE LEARNING Optimization Complex structures INTERACTIVE DESIGN MATERIAL COMPUTATION

The above illustration is the response of the participants as a result of this stage of group work. It is clear how significantly the range of available digital tools changes when comparing the past with the present, and interesting that this number does not increase in relation to the future, but is similar, or even decreases.

Fig[● 25] Matrix example for associations with "Digital."

Focus

Time / Digital	General	Specific	Narrow
Past	Calculating machine, calculator, Turing machine	Digit, binary system	Machines solving the problems
Present	Informarion era, smartphone, internet	Parametric design	
Future			

The word "*Digital*" was included in the matrix again and this time described with the relevant associations, definitions or pictures. General and specific associations with "*digitality*" were identified as part of a group effort. All of the participants were also asked to identify their own definitions of digitality related to their respective individual scientific work (the narrow individual context).

This helped to observe the term of "digital" in the broader context – from the general view through the lens of society to the very narrow definitions and associations related to the individual research topics.

Fig[● 27] ISP 2, Day 2, Group 1.

Digital process	General	Specific	Related to (PhD) thesis
Past	Digits, particularly binary digits	How to create a bridge between digital tools and current situation	Aid of CAM/CAD for vulnerable communities settlement
Present	Digital presentation of data	Using digital tools as a medium for 2D and 3D presentation	Vast majority of people do not benefit from digital design and fabrication
Future	Data-driven presentation of data	Using the virtual models for analysis and further steps ... 4D, 5D ...	Using digital tools for affordable process and implementation

Step 4 **Processing of the terms selected in step 2 (terms related to "*Digital*") in relation to the three pillars of the BuildDigiCraft project: Process, Material, and Knowledge.**

The aim of processing the terms was to observe and define them in the context of the individual scientific research through the lens of the Process, Knowledge, and Material. As a group, the participants sought to divide the given set of the "Digital" words into the subgroups related to "Digital/Process," "Digital/Material," and "Digital/Knowledge."
Each of the groups then selected the keywords from each subgroup to categorize them by matrix.
Example: as a term associated with the "Digital/Process," the "parametric design" could have been selected and placed with the matrix. The associations/definitions/pictures relating to the "Digital/Process/parametric design" terms could have appeared in the matrix.

This step produced a set of concepts and terms that could act as a bridge between the general concept of Digital and its role in design processes with the values and pillars of the **BuildDigiCraft** project, which aims to find tools to create built environment of high quality. The collection of the obtained concepts and their descriptions on the one hand shows a very wide range of the concept of digitality, on the other hand, shows their approach in the context of Processes, Knowledge, and Materiality, and thus embeds them in a set of concepts directly related to the concept of Baukultur. It also shows very individual, highly specialized research paths in which the commonly understood concepts related to the digital world acquire completely new meanings and represent different values.

The concepts, descriptions, definitions, and associations presented in the matrices build a base of concepts that should be included in the discussion on the digital future of design processes aimed at building a physical, real environment. This set of concepts should also be reflected in the Manifesto ending the project.

3.5 Glossary Matrix examples from the ISP2

The following examples illustrate the path taken by each of the working groups in developing the words in the matrices following the step-by-step diagram described above. These examples also prove that the matrix is a flexible tool and that it can be used depending on the needs, e.g., whether the result of the study is to be purely about definitions, about searching for associations and synonyms, or searching for given contexts.

The examples presented next make reference to the conducted training program entitled "Digital Futures." They show how the participants' research topics could be analyzed and described in matrix formats.

Step 1+2 **getting acquainted with the list of terms prepared by the participants and selecting a few keywords relating to the term "*Digital*"**

Summary of the list of terms that had been categorized as ***"Can be digital"***:

- 3D-SCANNING
- ABUNDANCE
- ADAPTABILITY
- AESTHETIC
- AGILE
- ALGORITHMIC
- ALIVE
- ARCHITECTURE
- BUILDING INDUSTRY
- BUILT ENVIRONMENT
- CHANGE
- CIRCULAR
- CIRCULAR ECONOMY
- COLLABORATION
- COMMUNICATION TOOLS
- COMPUTER-AIDED MANUFACTURING
- DATA ANALYSIS
- DATA AVAILABILITY
- DATA INTEGRATION
- DESIGN
- DEVELOPMENT
- DIGITAL
- DIGITAL FABRICATION
- DIGITAL TOOLS
- DIGITALIZATION
- DIVERSITY
- FUTURE-ORIENTED
- GENERATIVE DESIGN
- HUMAN-ORIENTED
- IDENTITY
- INFORMED PROCESS
- INTEGRATION
- INTERACTIVE DESIGN
- INTEROPERABILITY
- LIFECYCLE
- MACHINE-LEARNING
- MANAGEMENT/ECONOMIC SYSTEMS
- MASS CUSTOMIZATION
- MATERIAL COMPUTATION
- MATERIAL REUSE/ RECYCLE/UPCYCLING
- MATERIALITY & DIGITAL
- MEGASCANS
- REVITALIZATION
- SCALE
- SHAPE
- STRUCTURAL ART
- STRUCTURES & ARCHITECTURE
- SUSTAINABILITY
- SYSTEM
- TACIT KNOWLEDGE
- THINK OUTSIDE THE BOX
- TIME
- TRANSFORM
- OPPORTUNITIES
- OPTIMIZATION
- OWNERSHIP
- PARAMETER
- PHOTOGRAMMETRY
- PRESERVE
- PROCESS-ORIENTED
- PROJECT
- REFLECTION
- RESPONSIVE
- SAFETY
- SCALE
- SHAPE
- STRUCTURAL ART
- STRUCTURES & ARCHITECTURE
- SUSTAINABILITY
- SYSTEM

The narrower set was selected, which was entitled as ***"exclusively/mainly digital"***:

- 3D SCANNING
- ALGORITHMIC
- COMPUTER-AIDED MANUFACTURING
- DIGITAL
- DIGITAL FABRICATION
- DIGITAL TOOLS
- DIGITALIZATION
- GENERATIVE DESIGN
- FUTURE-ORIENTED
- INTERACTIVE DESIGN
- MACHINE-LEARNING
- MATERIAL COMPUTATION
- MATERIALITY & DIGITAL
- MEGASCANS

Step 3 the working groups add the term "*Digital*" itself to the matrix

The below examples show the matrices elaborated by different working groups. It is interesting how differently and at the same time similarly the groups approached the matrix tool while working on the term "Digital."

Fig[● 28] ISP 2, Day 2, Group 2.

Digital	General (used and accepted by the society)	Specific (used and accepted by the academic field)	Related to (PhD) thesis Narrow (used and accepted by the expert)
Past	Parameter Data shuffling	Computer-aided design	Optimization Data collection Data analysis
Present	Digital Interfaces 3D scanning DIGITALIZATION	DIGITAL TOOLS Algorithmic MACHINE LEARNING 3D SCANNING Generative design Material computation Computer-aided manufacturing INTERACTIVE DESIGN	DIGITAL TOOLS MACHINE-LEARNING 3D SCANNING Digital fabrication Optimization Craft technology MATERIAL COMPUTATION
Future	Circular economy AI INTERACTIVE DESIGN	GENERATIVE DESIGN MACHINE LEARNING INTERACTIVE DESIGN MATERIAL COMPUTATION	MACHINE LEARNING Optimization Complex structures INTERACTIVE DESIGN MATERIAL COMPUTATION

Fig[● 29] ISP 2, Day 2, Group 1.

Digital	General	General tools	Specific	Specific tools	Related to Phd. Ms.	Related to (PhD) thesis
Past	Supporting tool (not within the process) Limitation of software Availability of data Efficiency Modeling objects	2D design software	**Visualization Representation level**	Autocad, CAD	**Learning from historical buildings/ constructions**	Hand drawing – graphic statics, Geogebra
Present	Efficiency/effectiveness Powerful computational power, automatically formed shapes based on parameters, digital fabrication (Grasshopper, FEM) modeling performance of objects	3D, 4D design software	**Cost estimation Time management Data-driven design**	Grasshopper Rhinoceros, BIM, GIS	**Cost effective/Innovative design solutions, Data capturing based on available data**	Specific Grasshopper plugins: Karamba, kangaroo and so on; FEM (Ansys, Abaqus) for structural analysis ReCap, ContextCapture
Future	With machine-learning and AI, future-oriented design, more environmental consideration Automation vs. social Modeling systems performance & interaction?	AI, 5+D design softwares	**Automated design and process Prediction Performance/interaction-driven**	?	City modeling/analyzing tools for new forms of data?	CItyEngine

Design for reuse and reassembly

Efficient structural design: material, form and cost

How to justify (the cost of) implementation of digital twin city model?

CAM/CAD for vulnerable communities

How the digital design process can be better socially integrated with real-life performance in the future built environment?

Fig[● 30] ISP 2, Day 2, Group 4.

Digital	General	Specific	Related to (PhD) thesis
Past	PARAMETER Data shuffling	Computer-aided design	Data collection Data analysis Optimization Visualization
Present	DIGITALIZATION PARAMETER Algorithmic MASS CUSTOMIZATION	MATERIAL COMPUTATION Machine-learning Computer-aided manufacturing	DIGITAL TOOLS Integration COMPLEX STRUCTURES DATA ANALYSIS Optimization Craft technology
Future	Artificial Intelligence	Bio-digitalization Brain-machine interfaces Limited/prohibited application for AI regulations	COMPLEX STRUCTURES Neuralink? Deep learning Estimating the resulting experience and ratings (Airbnb type) before building the object

Step 4 processing the terms related to the **BuildDigiCraft** project pillars discussed during the consecutive days of the ISP2 (Process, Material, Knowledge)

During the changes the participants developed the selected terms and concepts in the matrices that on the one hand were placed in the context of the topic of individual days (Digital/Process, Digital/Material, Digital/Knowledge) and on the other hand related directly to the individual research work carried out by the participants.

As can be seen, the groups first wanted to find out what would happen to the concept of "*Digital/Process*" once it was placed in the matrix, and only then developed related but individual concepts. The same applied to the term "*Digital/Material*."

Digital/Process

Fig[● 31] ISP 2, Day 2, Group 1.

Digital process	General	Specific	Related to (PhD) thesis
Past	Digits, particularly binary digits	How to create a bridge between digital tools and current situation	Aid of CAM/CAD for vulnerable communities settlement
Present	Digital presentation of data	Using digital tools as a medium for 2D and 3D presentation	Vast majority of people do not benefit from digital design and fabrication
Future	Data-driven presentation of data	Using the virtual models for analysis and further steps ... 4D, 5D ...	Using digital tools for affordable process and implementation

Fig[● 32] ISP 2, Day 2, Group 1.

Digital Process (timber structures)	General	Specific	Related to (PhD) thesis
Past	Low computational power, manual manipulation, hand-made carpentry (hand drawing, AutoCAD)	Material modeling is too complex to achieve, structural system is more based on experience, limitation of computation	Learning from traditional timber constructions (data collection from history)
Present	Powerful computational power, automatically formed shapes based on parameters, digital fabrication (Grasshopper, FEM)	Possible to simulate material properties, fast generation of optimal shape with targeted optimization	High potential in high-rise timber constructions, material-efficient mass timber, form-finding of timber structures
Future	With machine learning and AI, future-oriented design, more environmental consideration	4D, 5D modeling ... optimized solution with consideration of structures, environments, reuse ...	Highly automatically fabrication with high structural performance, highly precise timber connections/joinery fabrication

Fig[● 33] ISP 2, Day 2, Group 4.

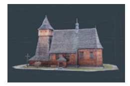
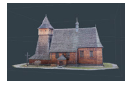
Bio-digitalization	General	Specific	Related to (PhD) thesis
Past	Literal examples in nature	Digital cultural generative design	1988 DNA analysis, cell computation 2012, establishing the field
Present	Inspiration from nature	Swarm Robotics. Mathematical biomimicry. Digital Microtechnology	Prof. Ludwig Ferdinand – construction botany – faster/modular way of plant assembly. Hybrid living nature and technology. Assembled and merged into shape
Future	Merging of natural and digital LIFECYCLE EIA (Environmental Impact Assessment) LIFESTYLE ENVIRONMENT FUTURE-ORIENTED	Molecular nanotechnology and self-assembly. Swarm robotics	Protohome – generative design for additive manufacturing

Digital/Material

Fig[● 34] ISP 1, Day 1, Group 1

Digital/ material/ availability	General	Specific	Related to (PhD) thesis
Past	Local materials	Denmark used bricks from clay, concrete from lime, etc. Norway and Sweden used timber due to high resources of timber (large forests)	
Present	Available materials between nations Digital tools optimizing structures or forms through machine-learning	Every nation has access to a worldwide "shop of materials," e.g., China buying a lot of steel Even fragile materials can be very strong, and handle a lot of loads if the structural system is correct	Optimization Testing
Future	Synthetic biological materials Fungus Spiderweb (gene-modified goats)	Growing materials in labs or farms through biological processes Composites of new material can maybe lead to new statical systems (free-form) using AI	New material properties Machine-learning Biodegradable

Fig[● 35] ISP 2, Day 2, Group 4.

Intangible/tangible immaterial/material HERITAGE	General	Specific	Related to (PhD) thesis
Past	Heritage was mostly "material" with the possibility of a tangible approach towards the object	Gothical church in Binarowa  Photogrammetry did not yet exist	Authenticity
Present	Today we are witnessing the digitalization of most of the existing material heritage. Photogrammetry, 3D scans, 3D inventories of the objects	 	Authenticity/digital representation of authenticity
Future	In future the object can be destroyed, damaged, dismantled due to many reasons. But with the use of digital tools we can preserve the object and memory, etc. even though it no longer exists	Authentic object no longer exists 	Digital remains

Fig[● 36] ISP 2, Day 2, Group 3.

Materials and their feelings, and applications	General	Specific	Related to (PhD) thesis
Past	Finding materials in nature and investigating their aesthetic aspects, availability, diversity, abundance and emotional feeling Symbolism	Doing crafts with circular materials like wood	Research on the technical aspects of material especially mechanical and chemical aspects
Present	A wide range of materials for different applications Artificial material and 3D printing	Chosen materials for defined applications for ALGORITHMIC, BUILDING PHYSICS SYNERGY OPTIMIZATION COMPUTER-AIDED MANUFACTURING ENERGY OPTIMIZATION	Digital fabrication facilitates the building of complex structures and artificial materials
Future	Flexible selection of materials that should be converged for general to specific applications	Machine-learning to predict the best material for the desired application	ALIVE materials can be integrated in buildings

Digital/Knowledge

On the day devoted to the concept of Knowledge in digital reality, participants no longer defined the terms "*Digital/ Knowledge*" – only one group did so. Other groups either juxtaposed it with the notion of "*Data*," or immediately moved on to the terms related to Knowledge, but that were already embedded in their individual research work. The term "*Data*" was actually the most frequently researched and developed word in the context of knowledge.

Fig[● 37] ISP 2, Day 4, Group 2.

Knowledge & Digital	General	Specific	Related to (PhD) thesis
Past	Limited information and digital tools Single disciplinary Defining Creation of knowledge	Transferred through skills and books	from physical to digital (transfer)
Present	Unlimited information / automated information systems Fragmented data Organization of multi-disciplinary connections Re-defining Dissemination of knowledge	Filters. Automated knowledge retrieval. Distanced learning? Self-learning? Control by algorithm. Data generated from the physical world. Machine learning any formats	from physical to digital and back to physical (transfer)
Future	Easier accessibility Learning from experiments Mixed physical/digital-complex systems/AI realities Fully multidisciplinary Connections between academia and industry, where knowledge access is flexible, relevant for the environmental/social/economic aspects Learner-oriented Public vs. individual – privileged groups benefits	Brain–machine interfaces. Artificial intelligence	parallel to digital and to physical (transfer) Neuralink

Fig[● 38] ISP 2, Day 4, Group 4.

Data vs. knowledge	General	Specific	Related to (PhD) thesis
Past	Data: problem Knowledge: application of data	Data: information Knowledge: transition of the information	Data: hypothesis, question Knowledge: interpretation of results
Present	Data: wicked issues Knowledge: addressing wicked issues	Small data Mega data Big dataset	Data: statistical models and solution Applying machines (artificial intelligence, machine-learning, deep learning) Knowledge: high-rate results, reliable results
Future	Data: multi-criteria Issues Knowledge: interdisciplinary science	Data: mega data, big dataset knowledge: digital language	Data: applying machines (artificial intelligence, machine-learning, deep learning) Knowledge: wisdom

Fig[● 39] ISP 2, Day 4, Group 2.

Digital data & analysis	General	Specific	Related to (PhD) thesis
Past	Produced and collected data Few specialized tools for handling data with low availability	Auto CAD visualization, excel for text data, printing 2D	Computer statistics, relational and non-relational databases. Data warehouses
Present	Aggregated different types of generated data multiple interactions Many specialized tools with easier availability	Wide range of data sources and representation, 3D printing, virtual reality, AI, Grasshopper, Ladybug – passive software	Business intelligence, data mining. Big data, cloud data, analytics in the cloud
Future	Automatically generated data diversity of networks beyond our original geographical places or disciplines Risk, loss Reconstruction Open vs. private data/ownership	AI-enabled analysis. Aware/Active software. Not only visual, but also other senses included in data, like sound digits, etc. Nudging towards sustainability	Predictive, cognitive and augmented analysis (natural language and world/environment processing). Virtualization

Fig[● 40] ISP 2, Day 4, Group 3.

Data analysis in timber engineering	General	Specific	Related to (PhD) thesis
Past	Less data samples available, slow process	The record of timber properties and timber structures is limited, diversity based on geological areas	Data collection and review of previous timber buildings
Present	Quick testing record with technology, more complex material models	Bigger data than before, simplified model, conservative	Statistic analysis and comparison between data from different sources
Future	A huge dataset including data from the past	Data distinguishing, more complex data analysis model	Identification of good data for certain purpose, optimized design output based on optimized data, the combination of human subjective ways of thinking

Digital technologies and tools must be data-fed to do their jobs. This data is processed, interpreted and becomes the source and object of building knowledge about the surrounding reality, too. The linguistic work with matrices has revealed how common and in how many contexts the word "*Data*" is used, which seems to be the basic and universal term wherever digital technologies have entered the equation. Working with words based on the example of matrices allows us to reflect on meanings. From the examples above, you can see that the participants needed to revise their understanding of the definition of "*Knowledge*" and "*Data*" in the context of the wealth of information that we are surrounded by on a daily basis.

Social context

On the last day of the training participants discussed the social context of digital technologies and looked at relationships between the human world, the world of technology (digital reality) and the physical world. As the goal of the Baukultur movement, also enshrined in the Davos Declaration (Davos Declaration 2018), is to care for the quality of the built environment and to demand its continuous improvement while minimizing the impact on the natural environment and limiting the use of natural resources, the need to reflect on ethical issues and values that creators, engineers, and designers should follow has become all too apparent.

The matrix tool was used again to discuss ethics and values in relation to the built environment and to examine the relationships between them. Participants considered the concepts of ethics and values, but also other terms, such as those relating to culture or sustainability.

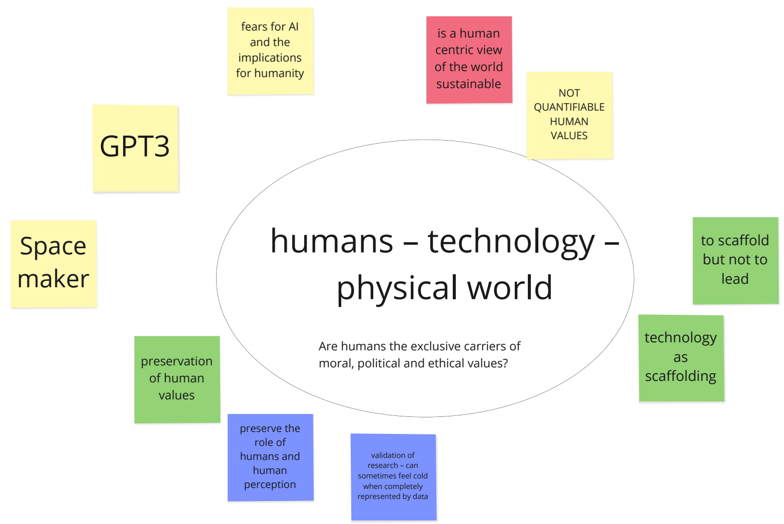
In addition to filling in the matrices, the participants also created diagrams and drawings to analyze and understand the discussed relationships. In this case, therefore, the matrix has become a linguistic resource, while diagrams allow an understanding of the relationship, hierarchy and interdependencies between the concepts. In this example you can see that both methods support each other, providing a more complete picture.

The above examples show two levels of analyzing vocabulary. First, the general level shows the relation to the potential field of interest of the research with the context of the Baukultur quality assessment. The second level looks at the closer relation between the first level and the individual research of the participants.

The words, terms, sentences, and related statements can explain, provoke ideas, generate possible uses and pave the way to think about the future aims. They also allow an interpretation of contemporary facts, relationships between past, present, and future, relationships between craft and crafted, creator and creation. The matrices show the way how the possible relationships in the different fields of research can relate to each other and find common language and vocabulary platforms of possible interactions, but also allow the formulation of hypotheses concerning what the digital environment could look like in future.

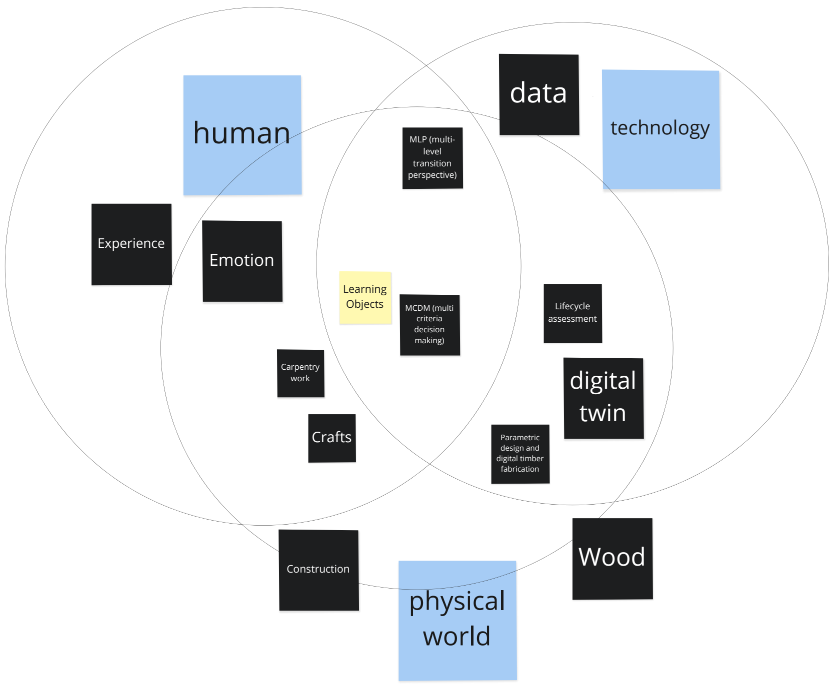
Fig[● 41] ISP 2, Day 5, Group 2.

Values and ethics	General	Specific	Related to (PhD) thesis
Past	Religion and culture about continuing the human race, like having children	in the past it was mainly about preservation of human life. Inability to deal with global aspects and challenges	Working with indigenous materials with tacit knowledge
Present	About continuing the life on our planet, like sustainability UN goals, etc.	Examples of how we are interested in larger aspects, like resources, sustainability, food for all, education for all	New materials and structures defined through digital tools and a combination of tacit and explicit knowledge/technique
Future	Need to develop a critical framework across different disciplines to treat each other humanely, fear of technology used in inhumane way	As a society we must not lose control, we must preserve human rights and privacy, make sure that technology is a scaffolding and support and not to be misused	Using technology to its best but preserving human and humanistic values and approaches



Fig[● 42] ISP 2, Day 5, Group 3.

Timber constructions (sustainability, culture)	General	Specific	Related to (PhD) thesis
Past	Handmade constructions, craftsmanship	Wood carpentry in timber temple construction	Materials follow functions; representative meaning of religion
Present	Digital fabrication with robots	Parametric design of wood joinery, digital fabrication ... (slogans)	Waste of materials; only an environmental issue (more or less limited in the general public)
Future	Optimized digital fabrication with robots, taking sustainability, material properties, aesthetics into account	Machine-learning, based on various sets of motivations	Minimizing waste of materials; future representative meanings



4.0 Discussion and conclusions

The aim of this intellectual output was to create a common foundation for a shared understanding of the main concepts explored within the **BuildDigiCraft** project.

During the course of the project an attempt was made to identify, collect, and create a set of terms that was then referred to as the “Glossary.” At the beginning of the project, when the idea of the “Glossary” and the matrices, with which the terms and concepts were to be processed, were developed, it was not really known how working with the matrices would look like and what its effect would be. The idea of working with matrices assumed quite a lot of freedom and openness to ideas, associations and interpretations of the users. In the first Intensive Study Program (ISP1) each of the groups working with matrices approached the topic differently. It became clear that the method of working with matrices would not lead so much to the creation of a specific resource of defined concepts, but instead be an attempt to build the foundations for a specialized linguistic corpus related to the design and shaping of space, with particular emphasis on the context of knowledge, design processes, and materials.

The participants’ task was, on the one hand, to propose and define the most important concepts related to the subject of undertaken research and projects, i.e., to create a defining Glossary, but on the other hand, work with matrices allowed for the acquisition of textual resources, similar to the work on linguistic corpora.

However, the linguistic corpus is not a dictionary, which is worth mentioning in the context of the **BuildDigiCraft** project. The corpus is a collection of texts used for linguistic research, e.g., determining the occurrence frequency of word forms, the syntactic structures and contexts in which given words appear (Corpus linguistics definition). Importantly, linguistic corpora should be saved in electronic form (Bennett 2010, Wynne 2004), thereby being able to be used for text analysis and processing by computers. The corpus is a set of texts containing typical constructions and uses of words along with information about their meaning and function.

Corpora are created in order to represent a given language area, e.g., for a specific field. Depending on the application of a given corpus, the following types can be distinguished: general, specialized, and parallel corpora (Bennett 2010). Specialist corpora contain texts on specific specialist topics, e.g., engineering, architecture, medicine, economics. Therefore, in the case of the **BuildDigiCraft** project, we can talk about an attempt to create a specialized database of concepts and texts in relation to urban design, architecture, structural engineering and construction, craftsmanship, all of which allow the pursuit of high-quality Baukultur.

Text corpora are authentic linguistic materials, thanks to which one can take a closer look at the forms in which the written word functions. This allows the isolation of typical uses of words and constructions, the possibility of studying their meanings and functions and the opportunity to observing the evolution of the language. Corpora are necessary for linguistic research, creating and updating dictionaries and preparing foreign language textbooks. They are a valuable source of knowledge not only for linguists, but also computer scientists, e.g., to create computer translators or other programs supporting work with language. Language corpora are also used as teaching and test datasets in machine-learning methods used in natural language processing (op. cit.).

The linguistic corpus is therefore not a glossary, but a valuable source of knowledge about the use of a language in specific contexts. Real linguistic corpora contain millions of words as they are based on many different texts from different sources. Of course, the resource of concepts and texts that were created as part of the work on matrices and the Glossary within the **BuildDigiCraft** project is significantly more limited and cannot be treated as a real corpus, but this collection allows for the first observations of the terms used by project participants when talking about research and disciplines within the framework of which they work and create. Therefore, it can be concluded that the work on the Glossary under the **BuildDigiCraft** project bore the hallmarks of working on a specialized linguistic corpus, although of course to a limited extent. However, even such a modest resource of concepts that were "acquired" in the project allows for the first observation of what vocabulary is used to talk about design processes in the digitized world in relation to shaping the built environment.

When talking about the Glossary and linguistic corpus in the context of the **BuildDigiCraft** project, it is necessary to pay attention to the fact that none of the project participants were native English language speakers, but have learned English as a second language. For this reason, the English vocabulary built in the project is probably somewhat narrower than it would be if the participants were to speak about the same topics in their native tongues. At the same time, thanks to this narrowing down, the accumulated resource might be more concise and accurate.

The basis of the Glossary was also to create a database of keywords relevant to the subject of the project, at the same time showing the wide range of research that is undertaken in the pursuit of high-quality Baukultur. It is worth paying attention to the relationship between the linguistic corpus and keywords. Creating lists of keywords in context is one of the main tasks of concordance programs needed to handle the language corpus. In such programs, the keyword takes a central position, with the context written to the right and to the left. Thanks to this procedure, it is possible to adapt the use of a given word to the specific needs of the project. The most important function of each linguistic corpus is searching for individual words – quickly and efficiently, without browsing through the next pages of a paper dictionary. After selecting a specific word, you instantly receive a series of concordance lines that allow you to find the appropriate context for a given text.

One of the roles of the Glossary was to create a shared platform for understanding that would enable joint work on the text of the Manifesto as an expression of the commitment to a high-quality built environment. Experience with working on this Glossary within the project shows that even a limited simulation of building a linguistic corpus can yield interesting results, uncovering the tapestry of research topics and concepts important to participants in a variety of contexts and references as well as over time.

In order to create a real linguistic corpus, the texts that are to be included in the corpus must be selected according to specific criteria. Common criteria for creating a corpus include:

- **Type of text** – whether the language is derived from speech, writing, or electronic means
- **Category of text** – whether, e.g., in the case of written text, it is a book, magazine, letter, etc.
- **Text domain** – whether it is, for example, popular or scientific text
- **Corpus language** (or languages) and its/their variants
- **Text placement** – e.g., British English, American English, Australian English
- **Text dating** (Sinclair 2004)

Project members had to embed the matrix-processed word concepts in terms of both time and focus, but also related them to the main contexts of the entire **BuildDigiCraft** project, i.e., Process, Knowledge, and Material in relation to Digitality and Craftsmanship. Thus, it can be concluded that the criteria for creating the real corpus were partially applied, although, of course, in a selective and limited form. Nevertheless, the imposed discipline and the way concepts were worked on through matrices helped to organize the verbal material and ensured the participants focused on precise terms. This led to the creation of a database of terms and concepts, which were then described through a variety of contexts, reflecting how the corpus was created. As the matrices and the obtained sets of contextual concepts and texts were created mostly as part of group work, it can be assumed that the participants, when selecting the final formulations, agreed on them among themselves and used terms that were understandable to everyone.

Interesting feedback on matrices was formulated by the ISP participants, relating to the proposed time categories: past, present, and future. Participants noted that the boundaries between these categories, e.g., between the past and the present, are difficult to establish. Many processes and phenomena started in the past and continue uninterruptedly until today. Therefore, it is often impossible to decide where the boundary between the categories of time is. This is a valuable insight, which confirms that the Glossary Matrix as a tool can be used quite freely and adapted to various needs and assumptions. The matrix initiators recognized that this clear division into time categories was initially needed to organize the linguistic material. However, now in the later stages of working with the matrix, users can decide how they can adapt it to their needs – e.g., by blurring the boundaries between categories or abandoning such divisions. The matrix is thus an open tool.

It can therefore be noted that the matrices obtained as a result of group work, but also other results of group work, such as conducted and saved discussions in the form of diagrams, sets of notes, multimedia presentations, could be a scaffolding for building a linguistic corpus, which is referred to as the Glossary in the **BuildDigiCraft** project. It can also be stated with a high degree of certainty that the concepts, matrices, and obtained text and verbal effects worked out during Intensive Study Programs may become a linguistic basis for the development of other intellectual outputs of the project.

Undoubtedly, the interaction of all participants and partners of the **BuildDigiCraft** project allowed for deepened reflection on the variety and depth of the professional language of the designers of built environment in digital era. There is a clear need to increase the awareness about the concepts and notions already generally used within the context of digitization in order to also be able to better interweave them within the context of Craftsmanship and the context of the built environment.

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2.3 Process
Intellectual Output 2

Guidelines for a design process leading to a high-quality Baukultur in the digital age

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1.0 Introduction

Shaping the built environment is strongly influenced by the processes related to it and the available tools. The tasks of the build environment are quite complex and they become even more so in our times due to technological, environmental, and social developments and challenges. A highly interdisciplinary and holistic approach is therefore needed to develop solutions that address the qualities of Baukultur.

List of abbreviations

AI	Artificial Intelligence
AR	Augmented Reality
BIM	Building Information Modeling
CAD	Computer Aided Design
CNC	Computerized Numeric Control
IFC	Industry Foundation Classes
ISP	Intensive Study Program
LCA	Lifecycle Assessment
LCC	Lifecycle Cost
ML	Machine Learning
VR	Virtual Reality

The quality of the overall environmental intervention – the building activity – is one of creation in the initial step, the design process. This step is of course linked to following processes such as planning, construction or maintenance processes. But inherent in the design process is its great freedom for defining and formulating the building task and its values which finally evaluate the overall quality of the intervention. This means a lot of information and data need to be collected and analyzed which is consequently time-consuming and ultimately – at first sight – more expensive. In contrast, a holistic view reveals the financial and qualitative benefit of a careful and thoughtful initial phase for all following processes and the overall result.

All processes connected to building activities undergo major changes and challenges. They are driven, among other things, through digitalization, and the **BuildDigiCraft** project addresses the consequences, the pros and cons in a holistic manner. Focusing on the processes and their tools now leads to a couple of questions.

First of all, in the context of the built environment we need to deal with the dialectic between the generally creative and interactive character of the design process on the one hand and the targeted character of the realization process on the other; a continuous interaction with the physical world is necessary and characterizes the intersection between the visionary world of design and the physical world of project realization.

Transferring this understanding / these circumstances into the world of digital possibilities implies new approaches: for example, digitalization allows the transfer of an idea or vision into materiality already in the design process. This contains a change of the process: now we can control the design process though physical representations, for example by a printed model of the digital vision. This means on a printed, materialized version a design idea can be evaluated.

Another aspect of the dialectic between the physical and digital world is the digital twin, or more precisely the digital representation of a design as well as a real object. What are the benefits and roles of a digital twin for the physical built environment? A discussion is necessary about the costs and the efficiency of the digital twin, too. However, it is first the design process behind the digital twin that needs to be better understood in order to be able to later answer further questions related to its performance.

Second, any process is characterized by the creator and the connection between the creator and the creation. What seems to be most obvious needs to undergo a new evaluation process under the conditions of the digital time boundary conditions. The most pressing question then is what the connection between the creator and the creation will be in a contemporary process. And what will the role of rapid digital prototyping be? It will prove the idea and it will link the creation closer to the creator. But finally, this project identifies a gap. To fill this gap, the qualities of Craft and Craftsmanship will be introduced into the discourse.

Consequently, and thirdly, a crucial aspect of the design process is that of responsibility. Any design needs a critical review and discourse which is part of the characteristic iteration inherent to the design process. The designer needs to feel responsible for the design and the decisions necessary during the design process. Such an attitude needs to be developed individually by the designer/creator, and is also based on social understanding, which in turn reflects individual and social values.

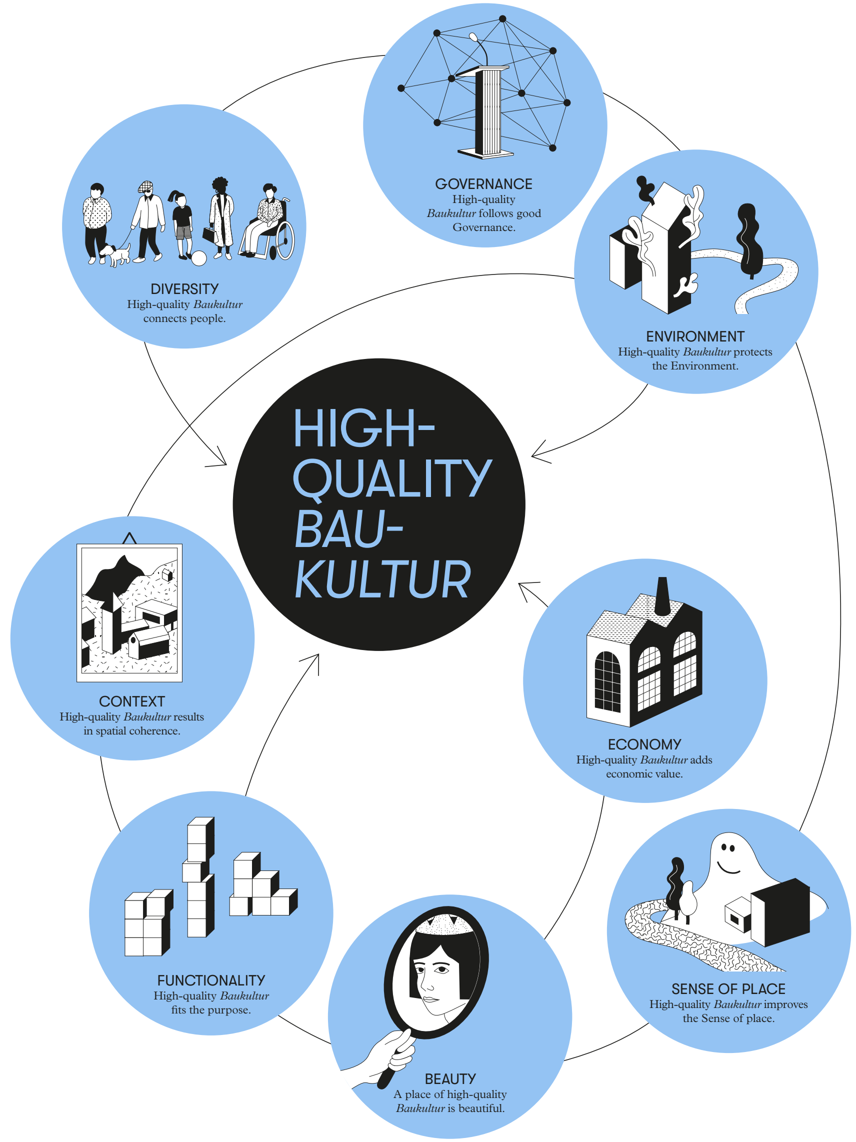
In the context of digitalization new responsibilities now arise. An array of digital tools influences and shapes the design process. This also reveals an ambivalence toward the new tools and processes. On the one hand, digitalization offers new methods and approaches toward essential questions but on the other, digitalization comes with the fear of standardization, simplification and automation – to an extent, the designer's fear of being replaced by a digital process is stirred. But the role and responsibility of the designer is non-negotiable which at the same time needs to be understood by the designer while he/she is drawing his/her own consequences from this fact.

Finally, the role of time is crucial to any design process but this aspect becomes even more essential and influential on the process itself through digitalization in particular. Now processes speed up and new contents are included in the process chain.

As a consequence of these outlined aspects and questions the main challenge in the context of the design process will be to understand the character of the processes, the implications and finally how to handle the process. To generate high-quality Baukultur, there needs to be a holistic attitude which is based on values but at the same time handles the process with respect and caution.

This project uses the approach of Craft and Craftsmanship to lay the basis for the attitude described above. Craftsmanship enables the identification of the designer with the process and the object. Generally, it has a holistic view on the task and is task-oriented. Also, it reconnects the creator with its creation. Consequently, any design approach is highly individual with only a small amount of standardization. The final products and work results are sustainable and of high quality.

A thoughtful and reflective understanding of the design process and its nature leads eventually to accomplishing high-quality Baukultur. Such qualities are in accordance with the Davos Declaration of Baukultur from 2018 and thus with the Davos Baukultur Assessment Framework that was developed. This framework is based on eight criteria to ensure a reflective and thoughtful view towards Baukultur.



Fig[●1] Eight criteria for a high-quality Baukultur — the Davos Baukultur Quality System © Swiss Federal Office of Culture / Illustration: Heyday

The **BuildDigiCraft** project uses this framework to create own guidelines that are mainly focused on the design process. These guidelines enable an informed, reflective design process that is value- and not data-driven. The guidelines provide a set of questions to guarantee the flexibility of the criteria within the design process, which also allow the exploration of the full scope of the building task. At the same time the questions of the guidelines make it obvious that such a holistic design process requires time and resources.

2.0 Aim and method

The main aim of IO2 "Process" is to increase the understanding of professionals, educators, and researchers about the changing nature of the design process in the context of digital future(s) of the built environment in all its scales: urban, city block/district, building, construction detail. By representing and reflecting upon material from the **BuildDigiCraft** training program research as well as the outcomes of the joint discussion rounds during the ISPs and the input from the relevant invited keynote speakers, a set of recommendations for the future direction of the design process is developed. These recommendations are shaped in the form of guiding questions that help designers and planners to identify/check whether their design process is on the right track leading to a high-quality Baukultur in the digital age (see section 6 "Guidelines: a design process leading to a high-quality Baukultur in the digital age").

From a methodological perspective, the results of the ISPs are seen as case studies that can demonstrate a state of the art in relation to digital tools involved in the processes leading to design decisions that later manifest in the built environment. The ISP material produced by PhD researchers enrolled at European universities within the field of the "Built environment" works as a pool of information from which the results and conclusions are made. The following is a report from researchers who have been involved both in the planning and the implementation of the ISPs – with a focus here on ISP2 "Digital Futures." This functions as a backdrop for the Preparatory task of ISP3, which addresses the notion of Craftsmanship. Relationships between design processes and Craftsmanship are mapped this way. The choice was made to follow the structure of the ISP closely in order to communicate the findings as objectively as possible. The results are thus organized reflecting the relevant ISP tasks:

1. State of the art – mapping of digital tools and processes
2. Imaginary digital design processes
3. The role of Craftsmanship in the Process

1. **State of the art** – mapping of digital tools and processes

(ISP2, Digital Futures, Preparatory task 1, Group Work Day 1)

Pre-task 1: Assignment

Reflect on your individual project (PhD project / Master's thesis or any project of personal interest) in respect to the following three concepts: Baukultur, Craft(smanship) and Digital(ization).

Prepare a presentation with four to six slides, addressing the following issues:

1. Personal profile/introduction – who you are?
2. Baukultur – does the term Baukultur play any role in your work?
3. Craft & Craftsmanship – how do you see these in your work?
4. Digital & Digitalization – what dimensions and representations does the Digital have in your work?
5. Share with the audience your personal statement/choice/interest (Joker slide).
6. Suggest your own five keywords in relation to Baukultur, Digital and Craft, and please add/share (your own) short definition of these words.

Mapping guidelines for the group work during Day 1 (ISP2):

1. Present to each other your Preparatory task 1
2. Get to know your group better
3. New joint group work task assignment: Map [y]our digital tools

- What are the digital tools that you are using in your project/for your work?
- Make a collection and cluster them so that you can present them to the rest of the audience in the next session.

Think also of the following issues while clustering:

Why and what do you use them for?
What are the challenges in using them?
What do we gain/lose by applying them: pros and cons.

- Group presentations and joint discussion in the larger round

A mapping and categorization of digital tools that researchers utilize is studied through the material produced during the ISP2 Digital Futures – either as young researchers' individual preparative work or as group work. A state-of-the-art situation of digital tools and processes is outlined in this way. Young researchers and PhD researchers have mapped digital tools and reflected on the way they use them in a current design process (leading eventually to manifestations in the built environment).

Within the task "*State of the art – mapping of digital tools and processes,*" young researchers were asked to map the digital tools they knew and worked with in their design and research and reflect on whether it was possible to "cluster" them in categories. The choice was made to use the name the young researchers gave the tools, be they formal identifications such as "LCA-tool" or a commercial name such as "KARAMBA." A reference list of tool names and what they refer to is one of the results of the mapping.

2. Imaginary digital design processes

(ISP2, Digital Futures, Preparatory task, Day 2)

Pre-task 2: Assignment

Identify a question related to your (PhD) project that you would like to find the answer to/a solution for by applying a conceptual digital workflow or process model. Try to make a preliminary outline of such an imaginary workflow/process. Think digitally and visually, sketch your thoughts. The selected question does not necessarily have to be the main research question of your (PhD) project – it can also be a sub-question related to a specific issue of interest.

This pre-task will be the basis for the group work during the training session.

Mapping guidelines for the group work during Day 2 (ISP2):

1. Present to each other your Preparatory task 2 on Digital Process Modeling
2. Glossary task: according to step-by-step instructions in the Glossary presentation (see Intellectual Output 1)
3. New joint group work task assignment: Digital Process Modeling
   Find a way to map your imaginary workflows by relating them to the:
   a) Glossary Matrix
   b) Digital tools you gathered on Day 1
4. Identify the new and important questions/processes that we need for our future work as professionals responsible for the built environment

The next part of the report is devoted to the analysis of the visualization, i.e., the imaginary future research questions that the participants were to prepare as a pre-task for ISP2. The title of this study is "*Imaginary Future Processes.*" In this task, participants were asked to formulate an imaginary research question that relates to their scientific work, e.g., a doctoral thesis, and to which they would like to find an answer. Then they were asked to create a visual diagram showing the imaginary tools, etc. in a process of finding an answer to the question and in this diagram also include the digital tools that would be involved in the process. "*Imaginary design processes*" is thus a graphic communication of the process's diagrams produced by young researchers to depict the design of a digital process that will answer a research question. The diagrams were produced individually as a Preparatory task for ISP2.

Research questions and visual diagrams showing the processes and descriptions were analyzed by the investigating scientific team. Supporting questions were formulated, thanks to which it was possible to better characterize the processes presented and to relate them to the Baukultur idea of a high-quality built environment.

3. The role of Craftsmanship in the Process

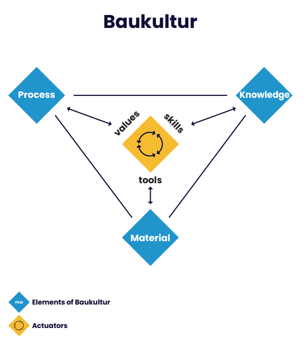
(ISP3, Craft and Craftsmanship, Preparatory task 1, Reflection "**BuildDigiCraft**" model for scientific reflection)

The ISP3 Preparatory task 1 is reported in the same way as for ISP2. The ISP2 results work as a context describing a backdrop for the Preparatory task the young researchers discussed in ISP3 concerning Craft and Craftsmanship. They were asked to map their ideas of craftsmanship in the context of their research and in the perspective of digital design processes in the built environment. The young researchers discussed and presented their work in a group during ISP3 and the group developed visualizations based on their discussions and finally a synthesis, a conclusion.

Pre-task 1: Assignment

Reflect on your individual project (PhD project/Master's thesis/project of personal interest) in respect to the **BuildDigiCraft** graph model (Fig[● 2]).

Analyze and reflect on your individual project by answering the following questions:



Fig[● 2] **BuildDigiCraft** graph model.

1. What is the process, what is the material and what is the knowledge that you are addressing and using in your (PhD) project, and what is the Process, Knowledge, and Material that you would like to derive from it?
2. How do you see the relation between the Process, Knowledge, and Material in the context of your work?
3. What are the values you are following/addressing in your project?
4. Which skills are you applying and which are the new skills that you are developing within your project?
5. What tools do you use and plan to use?
6. Try to define the term Baukultur in your own words and in respect to your individual project.

Submission format: prepare a five-minute slide presentation (no specific layout requirements. Please add an initial slide to shortly present yourself: professional experience, background, interests, and expectations.

Mapping guidelines for the group work during Day 1 (ISP3):
As a group try to derive the "Qualities of Craftsmanship" within the context of the "Process–Knowledge–Material" graph.
For the "Qualities of Craftsmanship" use the input below:

Qualities of Craftsmanship:
Some keywords
… Identity
… Quality
… Material
… Tool
… Profession
… Art
… Skills
… Talent
… Experience
…

Values of Craftsmanship
… pride in achieving a level of mastery and highest quality
… skill level developed through implicit and tacit knowledge
… passed on within the craftsman community
… deeply sustainable

Values of Digital Craftsmanship
… **Re-interpretation** of the relationship between the work of the mind and the work of the hand
… new-age **digital craftsman** works within the continuously changing environment of the rapidly developing tools and new materiality
… Challenges are **multi-dimensional** and encompassing, relating huge number of inter-related values and relationships
… **Digital tools** offer an unseen level of handling of complexity

3.0 Results

3.1 State of the art – mapping of digital tools

(ISP2, Digital Futures, Day 1, Preparatory task 1 and Group work)

As a Preparatory task, participants of ISP2 were asked to list digital tools, which they use in design work and/or in their research projects. Further, already during the first day of the ISP2, they were asked to work in groups to cluster them in different categories.

Fig[● 3] Word cloud of digital tools used by ISP2 participants.

The list of different digital tools that are used in the work of ISP participants is extensive (see Fig[● 3]). PhD researchers mentioned traditional modeling CAD tools such as Autocad, Revit, Archicad, Allplan, etc. However, a wide range of specialized and "self-made" tools showed up as well. They use them in a process-oriented way not only to visualize their designs, but to conduct the whole design process. Participants are increasingly using parametric modeling tools such as Grasshopper and its plug-ins such as Galapagos, Octopus, Kangaroo or Karamba 3D. They use them together with classic stand-alone tools such as Radiance but never with dynamic tools like DIVA.

When asked to describe which digital tools they find the most important, participants focused on open-source tools such as Grasshopper, which can be used to inform almost any process. They rarely mentioned Dynamo Revit Autodesk, which they do not even see as a substitute of the former. It could also be observed that none of the researchers mentioned IFC Standard BIM itself, which might be connected with an urge to go beyond standardized BIM in order to look for more free and explorative approaches to design. Or to design digital tools for a specific project, as is possible with integrated dynamic tools such as Rhino Grasshopper.

Other tools that were listed are visualization tools such as 3dMax, Vray, Lumion, Sketchup or tools from Adobe Suite. Participants naming these mentioned that skills of working with new digital tools replace the old formats. Participants though focusing mostly on the benefits of using those kinds of tools, such as shorter time and higher accuracy early in a design process, also mention constraints which digital tools may pose on free creation, as their functionalities may limit the designer's imagination. Also, immersive technologies, such as AR, VR and 3D scanning, were important for ISP participants as visualization tools, which are easier for non-professionals to read and as such allow for reaching a wider audience.

Those who work mostly on an urban scale focused on urban data analytics, design-planning tools such as ArcGIS or QGIS, but they mentioned them in connection with the new sources of data such as drone or Lidar data. Those type of tools are more and more often combined with AI-based tools using machine- learning algorithms, deep learning neural networks, life structures or fuzzy logic.

In order to use those, there is a need to learn to program in python, C++, Java or R, which are now increasingly starting to be interwoven with parametric modeling and GIS. These tools are used in various types of design tasks from analyzing geometries and structure optimizing through form-finding up to daylight and wind simulation assessment. The above-mentioned tools are becoming increasingly more available – moreover, one requires only basic programming skills in order to use them. At the same time, some of them are perhaps used in too simplistic a way, as there is a need, not only to feed the algorithms with data there, but to ask the "right" questions and understand whether obtained results are reliable and can support the design process.

Sustainability flows as an undercurrent through the projects. Some participants focused on evaluation tools, namely lifecycle assessment, pre- and post-occupation evaluation and sustainability certifications (in both building and neighborhood scales) and the need to integrate them into the design process from an early phase.

The awareness of the whole building cycle, including end of life and reuse is noticeable among the young researchers, while their predecessors ten years ago focused mostly on the design process itself.

Qualitative indicators were analyzed in a more traditional MCDM framework (e.g., information from pre- and post-occupancy evaluation).

Much attention was also given to the fabrication phase where participants listed: 3D concrete and clay printing, CNC, milling, laser-cutting technologies.

Another important group of tools were project management platforms such as Trello or Base Camp, Internet boards (Mural, Miro, Stormboard, Conceptboard, etc.) but also TeamWork and content management platforms such as Teams, Meets, Zoom, Cloud or Github. This is connected with the way of dealing with the recent pandemic, which in turn has influenced the way design teams work. There are fewer personal interactions, the majority of arrangements are made during scheduled meetings, limiting spontaneous peer-to-peer consultations, however also providing a chance to meet more frequently.

3.1.1 Clusters of the digital tools and processes

Group 1

	Grasshopper/Rhino	Structural Analysis software	Data analysis	Optimization	Robots	Validation
Why and what do you use them for?	Modeling Parametric modeling Analyzing geometry Optimizing Form-finding Energy optimization Machine Learning process Solar energy simulation via Diva and Radiance Visualizing machine learning predicted outputs on a city map	Karamba3D Finite Element Modeling Analyzing structures With other grasshopper plugins-optimizing structure	LCA - Lifecycle Analysis LCC - Lifecycle Cost Daylight simulation 6D building site simulation Python Machine learning method Optimizing used hardware	Galapagos , Octapus (Grasshopper) Machine learning Efficiency optimization of solar systems	3D concrete printing CNC (milling, laser cutting) Assembly	3D scanning Structural tests Accuracy metrics
What are the challenges in their use?	Limitation special knowledges are required (computer science/Mathematic,...) Limitation in machine learning components	Different types of elements, leads to different results	Can be inaccurate, and lead to greater costs under production Feature selection Evaluating efficiency	Finds data out of iterations, not logical sense. lack of consciousness	A lot of variables (3DCP)	Destruction of object (3DCP)
What do we gain/lose by their application: pros-& cons	gaining an overview of other aspects of the project at the same time. possibility to integrate with other open source softwares/adds on mistakes could happen by using it in a wrong way	More complex geometries	Help consider what materials to use	Lead to better geometries, and tries out many solutions that would take a long time for humans. offers optimum typology for structures lead to efficiency in material usage	Sustainability Design Freedom Mass Customization	Confirmation of calculations and assembly

Fig[● 4] Group work results of Group 1 during ISP2, Digital Futures, Day 1.

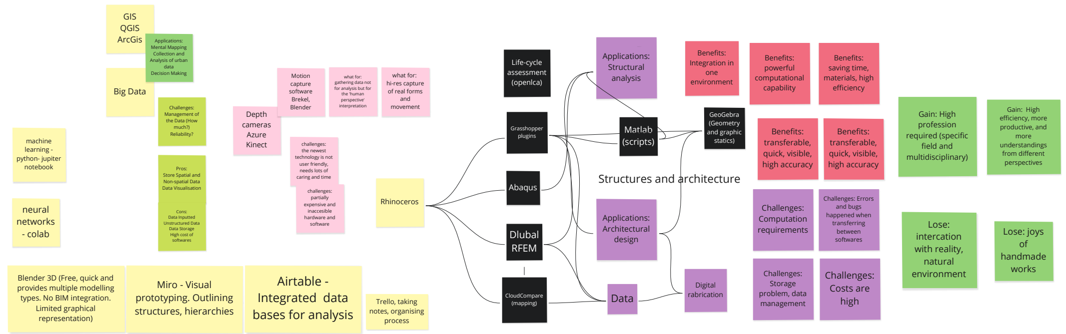
In the Group work Manifesto in Fig[● 4], it can be observed that the researchers did not classify their tools in categories adhering to a normal project line set-up (from industry contracts). However, there seems to be a movement from a more generic tools realm (left) to tools more closely related to the physical world (right). The color code indicates that Rhino Grasshopper (integrated dynamic tools) and related plug-ins like Karamba are a category in themselves. Data analysis and optimization (a classic engineering discipline) are coupled in the same color code. The blue-colored cluster demonstrates digital tools that are directly linked to the physical world – scanning the physical world or concretely producing the physical world (3D printing). It is an observation that generic integrated dynamic tools such as Rhino/Grasshopper, programming (python) and 3D scanning and printing belong non-hierarchically within the same framework. Another observation is that LCA and LCC tools are not seen as evaluation tools for the last design stage, but placed in the middle of a process, informing ongoing processes as well as building simulation tools of e.g., daylight simulations.

The reason why Rhino Grasshopper has its very own category is because it can be used to provide information on many aspects. It is generic. Optimization is no longer seen as the primary engineering task – instead it is the interaction with the digital tool for form-finding integrated in a design process.

Data analysis has its own category, because it is a major task to prioritize and understand the massive amount of data. Robots are mentioned in the same framework as building simulation tools – as an integrated part of the mapping – and are seen as something primarily positive that can help to reach sustainability.

The participants are aware of the fact that the tools have very negative side-effects – when results are reached through automatized, uncontrolled iterations and not through the consciousness of human beings.

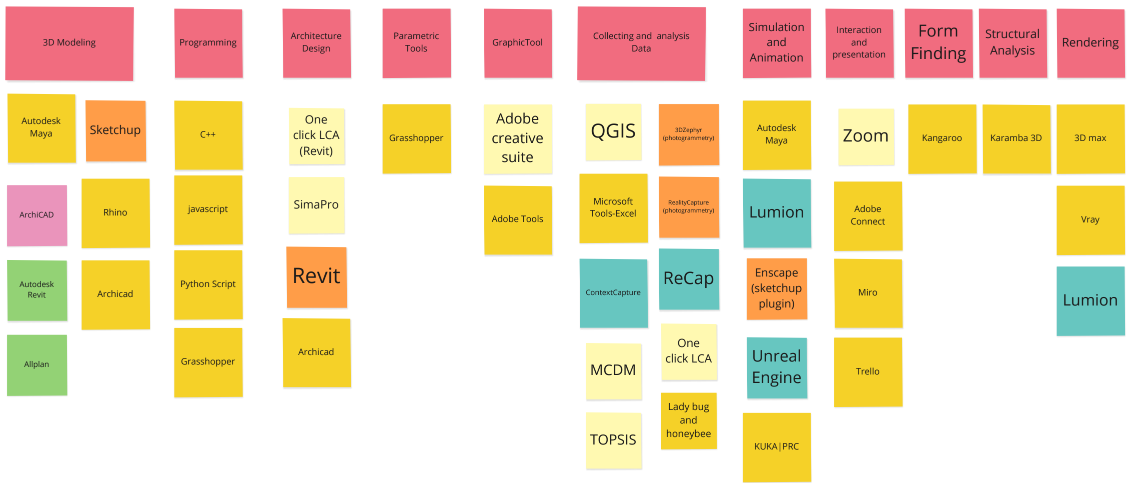
Group 2



Fig[● 5] Results group work "Group work 2."

Fig[● 5] shows that the collaborative tools like the interactive white board Miro are used for visual prototyping as well as "mental mapping" and that Trello is seen as a continuation of analytical tools. Generic data analysis "tools" such as GIS QGIS and ArcGIS are placed in proximity to the collaborative tools – maybe because they can be used as pre-design tools informing the scope of projects before a design process takes place (on the left). However, it is a strong feature in the "clustering" that – again – the PhD researchers chose not to adhere to a classic project line framework. As in fig. 1, Rhino Grasshopper is placed at the center, connecting with a multitude of other tools. The integrated dynamic framework, like Rhino Grasshopper, is set in the middle, acting as a "bridge" between generic data handling and collaborative tools and specific disciplinary tools. Again, we see that tools that capture and 3D scan reality are included in the same line-up as disciplinary simulation tools. Within the "clustering" participants have taken account of the pros and cons related to the use of the tools. Cons are that we lose the interaction with the natural world and the joy of working with our hands. A pro is the high professional knowledge that functions well in a multidisciplinary framework.

Group 3



Fig[● 6] Results group work "Group work 3."

This group has created the following categories: 3D modeling, Programming, Architecture/design, Parametric tools, Graphic tools, Collecting and analyzing data, Simulation and animation, Interaction and presentation, Form-finding, Structural analysis, Rendering.

It is interesting to see that parametric tools such as Grasshopper are central again. There is – once more – no reference to a contract/commercial project line framework.

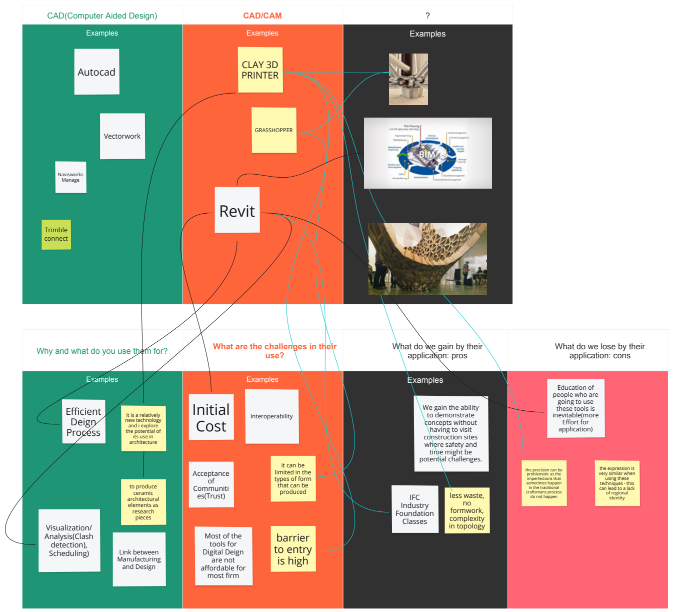
Architecture/design is seen as its own cluster – one should have expected that architecture/design would be the *outcome* of using all the tools – but when architecture is its own category, what is the purpose of all the other tools? Representing information, analyzing information – but for what purpose? Is the hypothesis that good design decisions leading to good architecture?

Do the digital tools create their own right – a kind of artificial self-enforcing demand?

Or is it that architecture/design is what happens when using the Autodesk product Revit, leading to construction drawings and information utilized by construction management to erect a building?

This group has made an addition, whereby they group the tools in two groups – the ones that they know and the ones they have just heard of, as shown in Fig[● 6]. It indicates an ongoing exploration of acquiring still new tools/skills and combining them for different questions.

Group 4



Fig[● 7] Results group work "Group work 4" (interactive white board).

This group's classification demonstrates that parametric tools have isolated older-generation digital tools like "Autocad." The black lines have Revit as a focal point and show how rapid digital prototyping (e.g., 3D clay printing) is integrated in a parametric design process. The group outlines the cons: that it involves high initial costs. Grasshopper represents a parallel parametric design tool realm, where the green lines connect to some of the same aspects. The researchers do not subscribe to an Autodesk monopoly – they place Rhino Grasshopper and Revit as equals and seldom mention BIM, at least it is not central, though it is represented here via a diagram (a reference to the "BIM world" of IFC classes, etc.). However, the Autodesk products that create an efficient lineup in terms of commercial project lines are not given a more significant role to play than Grasshopper and 3D clay printing tools: the researchers know BIM is there, but it is just an option alongside other digital tools. Still, one should keep in mind that BIM itself is not a tool, it is a work methodology used on the basis of 3D digital tools /software.

3.1.2 Partial conclusions

The conducted analyses allowed a mapping of main features and the evolution of design process in the digital era. We are moving beyond commercial design project pipelines and IFC standardized BIM design stages: the PhD researchers do not see themselves as working solely within IFC standardized BIM notions. Digital models are just a prerequisite for any design processes and later representation. They freely design digital design processes for different contexts.

Integrated dynamic tools such as Rhino Grasshopper are mainstream.

A lot of importance is given to visualization tools; however, the PhD researchers also focus on the artistic constraints that these tools pose. Immersive technologies – AR, VR and 3D scanning – were important for ISP participants as visualization tools, which are easier for non-professionals to read and as such allow reaching a wider audience.

Within the framework of the ISPs, young researchers defined boundary conditions as efficient use of digital tools. They are directly linked with the quality of the data available. Digital tools can help to define and frame the city, they may influence the way we evaluate and design buildings and structures. With the massive amount of data generated by people, devices and networks, we can conduct data-driven analyses of the spatial and functional patterns of the city nearly in real time. Urban data helps us understand where interchange points of the urban life lie and which type of activities occur there. Therefore, to inform design process, the study and understanding of the condition of life in the city is necessary, which is manifest also in the design processes outlined in the ISP.

At the same time participants point out not only the benefits of using digital tools, but also the dangers such as digital exclusion, problem of data security or insufficient regulation of the use of AI-based tools. Very few digital tools address social sustainability, as the majority focus on technical or economic problems. There is an expanding range of quickly developing health and environmental sustainability assessment tools.

Diving directly into the design process, new software, no matter how advanced, cloud-based, AI-assisted and form-giving, can be seen as a constraint for a free creative process, limiting the possibility to freely visualize. Before, we could design using only basic tools like pencils or pens, but now we need specific tools which may not be accessible to some people due to lack of their availability or their high price. At the ISP we could observe a strong focus on open-source tools, which is one of the main reasons why tools such as Grasshopper are so popular.

The Covid-19 pandemic has accelerated the digitalization of design work. It has caused more importance to be given to project and teamwork management tools, which not only serve as a platform for project management, but also allow the introduction of waterfall design processes based on more agile principles. However, most participants pointed to the benefits being in the frequency and visualization potential of online meeting tools.

While working on categorization of the digital tools, researchers to a much lesser extent stick to commercial project pipeline in design processes, which for current designers is the usual way to group tools. It may be due to the limited industry practice that the young researchers possess, but one can find such a statement oversimplifying, as similar non-linearity/freedom can be observed in most innovative design companies. Evidence of this is that tools traditionally connected with the final phases of design, for example a lifecycle assessment, start to be used in the pre-design phase. We move from linear design processes to something a lot more holistic. The tools, for this shift, are already there but these processes are not mainstreamed yet. We are in a transitory phase where one can observe that each design studio has its own culture of using digital tools, just as the young PhD researchers do.

The end of life of buildings as an impact from construction and operating buildings is integrated in design processes pointing to an emphasis on circularity.

Generally, researchers stressed the benefits of the implementation of digital tools and technologies, in that they improved the quality and performance, e.g., the material use and structural efficiency or adaptability of design. They also emphasized that digital tools support interdisciplinarity, e.g., BIM technologies facilitating collaboration between different professions. The promised "seamless" connectivity between information realms is still in a natal stage. At the same time, they were also aware of various limitations of these tools, such as their lack of flexibility, which is why integrated dynamic tools like Rhino Grasshopper were the tools of choice as they provided the most freedom.

3.2 Imaginary digital design processes

(ISP2, Digital Futures, Preparatory task, Day 2)

In the Preparatory task 2, Day 2, ISP2 researchers were asked to visualize an imaginary future digital design process that could answer a question related to their research.

The purpose of analyzing these examples in the context of this report was to identify future trends and characterize design processes to see whether they related to the Baukultur idea. In other words: was it possible to look at the Baukultur processes through the prism of the current research topics undertaken by young people in the **BuildDigiCraft** project? Such an approach will allow reflection on the characteristics and complexity of contemporary design processes and their role in shaping the high-quality built environment.

Examples prepared by the participants are presented below – formulated research questions with illustrations of processes. Then the examples were analyzed by answering a set of supporting questions, developed by the ISP organizers for a better evaluation of the complexity of the suggested imaginary design processes. Answers to individual questions are presented below in the order corresponding to the numbering of the presented projects (submitted Preparatory tasks 2, Day 2, ISP2).

Overview of the supporting questions for complexity evaluation of the suggested imaginary design process:

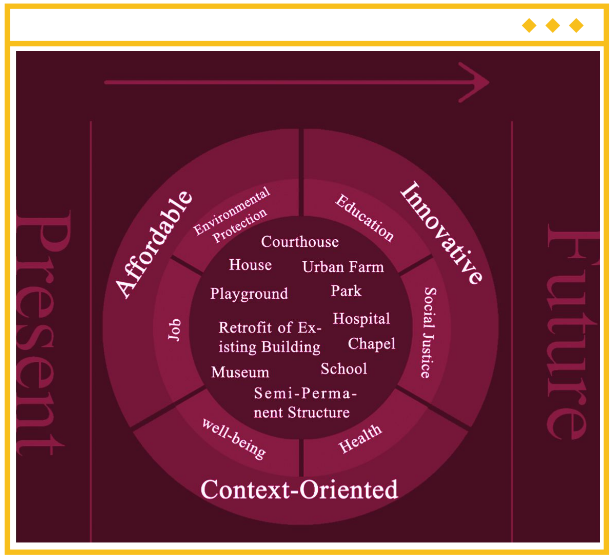
1. *What are the individual research questions and what are their process illustrations?*
2. *What are the needs and problems the research question is answering to or solving?*
3. *What are the aims of the processes leading to answering the research question?*
4. *What is the character of the process (linear, circular, repetitive, iterative …)?*
5. *What is the scale, range and scope of the presented processes?*
6. *Who are the design processes for?*
7. *Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?*

Project 1 by Asad Fallah,
HafenCity University

1. What are the individual research questions and what are their process illustrations?

How can digital design and fabrication bring solutions to vulnerable communities?

Fig[● 8]



2. What are the needs and problems the research question is answering to or solving?

Problem: contemporary living environments are often not affordable for their residents and not sufficiently aimed at improving environmental conditions. Need: human- and eco-friendly communities for a good quality of living (Baukultur), which are affordable, innovative and context-oriented.

3. What are the aims of the processes leading to answering the research question?

Providing health, well-being, jobs, education, social justice and environmental protection to make the communities affordable and innovative, yet immersed in the local context and identity.

4. What is the character of the process (linear, circular, repetitive, iterative …)?

Linear in time, circular in management of the process (identification of problems and needs, vision, design and project phase, implementation, maintenance and management, identification of new problems and needs …).

5. What is the scale, range, and scope of the presented processes?

Neighborhoods and communities scale – influence on the local groups. This process does not have a very wide territorial impact, but is very complex in terms of the individual elements subject to the processes: design (architectural) layer, social layer, environmental layer, economic layer, technical/technological layer, etc.
The processes within each of the layers will require separate tools. And all of these smaller processes are part of the master process of shaping the living environment and the high-quality Baukultur within the neighborhoods.

6. Who are the design processes for?

This process is aimed at groups of residents forming the local communities – the receivers are the inhabitants.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

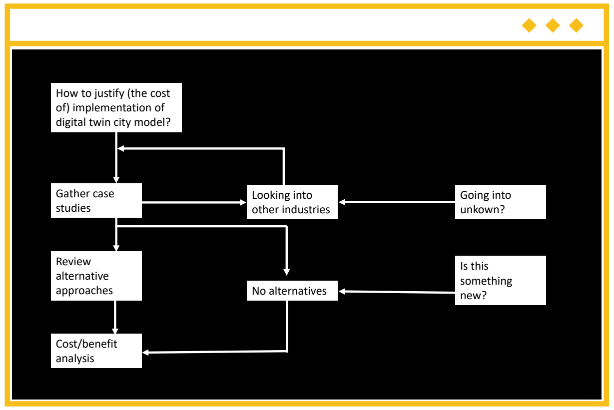
The whole spectrum of the Davos Baukultur criteria: good governance, economical accessibility, eco-friendliness, sense of place and immersion in the local context, beauty of the residential areas (quality of architecture), functionality of living spaces (physical accessibility), diversity – openness for diversified societies and different human needs.

Project 2 by Egils Markus,
Riga Technical University

1. What are the individual research questions and what are their process illustrations?

How do we justify (the cost of) implementation of the digital twin city model?

Fig[● 9]



2. What are the needs and problems the research question is answering to or solving?

Problem: do we need and how do we balance the cost of implementing the digital twin city model? Do we need to put our efforts (and costs) in the creation of the digital twin city model instead of using the same efforts and money in solving the problems in reality? There is a need to check whether we can afford to create the digital twins of city models.

3. What are the aims of the processes leading to answering the research question?

To (check whether we need to) create the digital twin city model.

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Linear in the phase of creating the model, circular and iterative when the updated and upgraded versions are needed.

5. What is the scale, range, and scope of the presented processes?

The process of creating the digital twin city model is fully virtual, but based on the urban processes and case studies from real cities. Technologically specific, involving the AI, AR and VR technologies.

6. Who are the design processes for?

The process is aimed at different receivers in different phases: (1) AI and VR professionals; (2) engineers and designer who create urban spaces and design urban structures and infrastructure; (3) finally – inhabitants being able to see how the city can develop in the future (if the costs of creating the digital twin city model are justified).

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

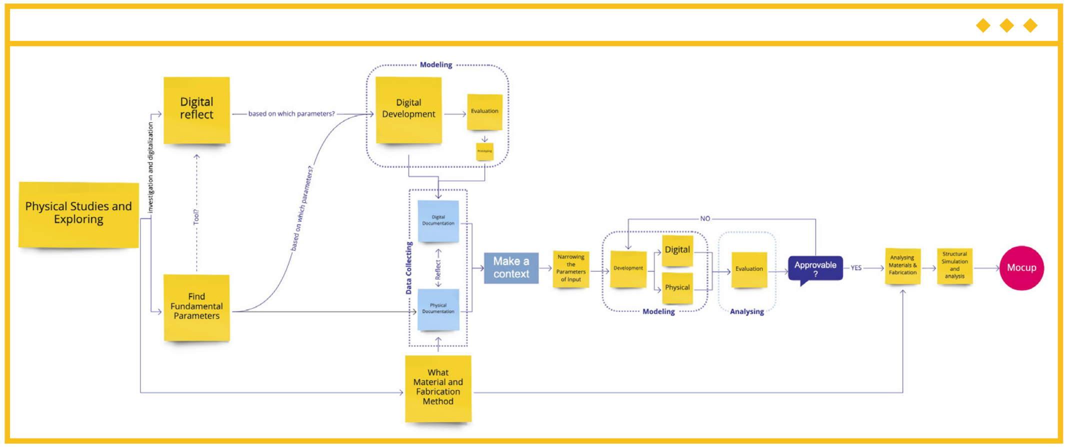
Economy (virtual simulations lead to saving money in real world), environment (simulations of the environmental impact of the city), functionality (testing of the solutions on the digital twin model), beauty, and context (by testing architectural solutions in terms of aesthetic and social values).

Project 3 by Faezeh Sadeghi,
Aalto University

1. What are the individual research questions and what are their process illustrations?

How can the physical studies be transferred to the digital environment in an accurate way?

Fig[●10]



2. What are the needs and problems the research question is answering to or solving?

Problem: does the digital environment allow for the same accuracy as physical studies? What values can be added to the design processes by the parallel physical and digital studies on the materials and prefabrication methods? Need: creation of a pre-production mock-up with the use of the digital tools (to obtain the best quality of a product/design/architecture/construction).

3. What are the aims of the processes leading to answering the research question?

To create a pre-production mock-up by using digital tools and physical studies on the material and fabrication methods and to check in what way and to what extent the digital and physical approach complement each other or can replace each other.

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Linear, leading to the obtaining of the final product of a mock-up (to produce real objects).

5. What is the scale, range, and scope of the presented processes?

The process is focused on the search for a digital equivalent of physical studies, so it concerns designers who understand the essence of the design matter, supported by specialists in digital tools. The scale of the impact of the process is therefore narrow and concerns the production line for the production of specific items, or rather their prototypes.

6. Who are the design processes for?

The process is aimed at designers searching for the most optimal and accurate tools allowing for studies on materiality and form of objects that lead to the creation of pre-production mock-ups.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

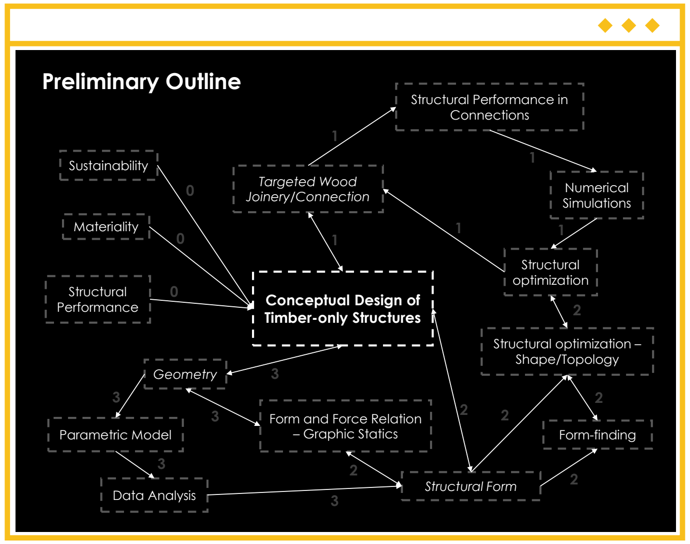
Economy (searching for cheaper and better solutions in design), environment (can digital studies replace physical studies to reduce the impact on the environment?), beauty and functionality (the potential of the digital tools to support the physical studies to enhance quality, functionality and beauty of materials, forms, architecture ...)

Project 4 by Gengmu Ruan,
Aalto University

1. What are the individual research questions and what are their process illustrations?

How can the process of conceptual design of timber-only structures be developed?

Fig[● 11]



2. What are the needs and problems the research question is answering to or solving?

Problem: how to develop and enhance the process of conceptual design of timber-only structures using the physical material (timber to be re-used) and digital tools of design. Need: to re-use timber material in a sustainable way in order to design timber-only structures (without use of any other material) with the support of digital tools allowing for material analyses, parametrization and optimization of the form-finding process.

3. What are the aims of the processes leading to answering the research question?

To re-use timber material to create new forms of timber-only structures with the support of the digital tools.

4. What is the character of the process (linear, circular, repetitive, iterative …)?

Linear in the process of obtaining the new structure design (old material – re-use – finding new forms and parameters of structures and their forms – conceptual design), but circular in the whole process if we do not want to end up with conceptual design but with building (new timber-only structures can be re-used again in time).

5. What is the scale, range, and scope of the presented processes?

Architects and structure engineers can be involved in the process in the conceptual phase, but also craftsmen like carpenters who can “understand” the timber material well. The process is half-physical, half-digital. The process is technologically specific, but at the end the results can be implemented as real structures, which can enhance Baukultur with values of digitally aided sustainability and craftsmanship.

6. Who are the design processes for?

The design process is aimed at structure engineers, architects, carpenters who can use their craft, their technical and digital skills to look for new forms of timber-only structures based on the re-used material.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

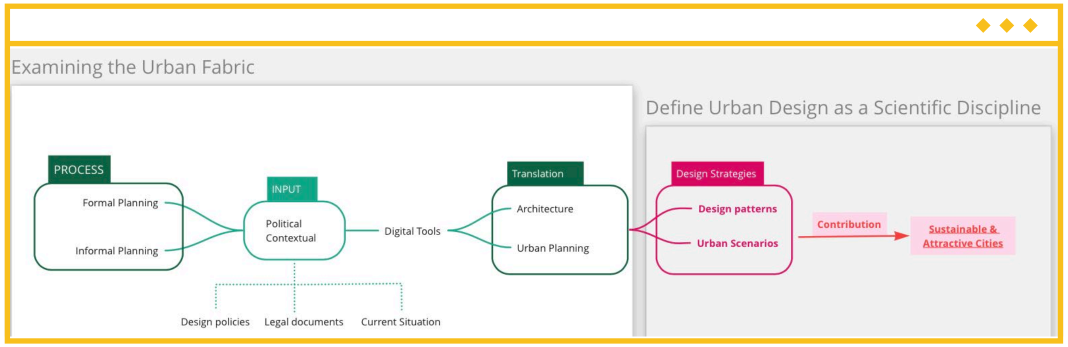
Economy (re-use of the exploited timber material), environment (no need to harvest wood by cutting forests), sense of place and context (timber structures can support the locality of architecture), beauty (beauty of natural materials), functionality (searching for optimization).

Project 5 by Ilirjana Haxhiaj,
Gdańsk University of Technology

1. What are the individual research questions and what are their process illustrations?

How can we strive to create sustainable and attractive cities?

Fig[● 12]



2. What are the needs and problems the research question is answering to or solving?

Need: we want to live in sustainable and attractive cities. Problem: how can this be reached by integrating complicated processes of urban planning systems, architectural design, urban scenarios and using urban patterns, local contexts, digital tools (design, use of big data ...)

3. What are the aims of the processes leading to answering the research question?

To create sustainable and attractive cities immersed in local contexts and based on the local patterns with the support of digital tools of design and planning.

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Circular and iterative, because the process of creating urban spaces never reaches its final shape, as the needs of inhabitants and urban factors are always changing – meaning that the process demands constant verification and recognition of new problems to solve them again and again.

5. What is the scale, range, and scope of the presented processes?

The process is multi-tooled, multi-ranged, and multi-scaled. Physically, digitally, and virtually. The whole community should be involved: inhabitants (participation processes), urban designers and architects should be a bridge between inhabitants and other stakeholders, like businesses and authorities. The processes range is very wide territorially, socially, and professionally.

6. Who are the design processes for?

The design and planning process is ultimately aimed at the local communities and inhabitants of urban spaces.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

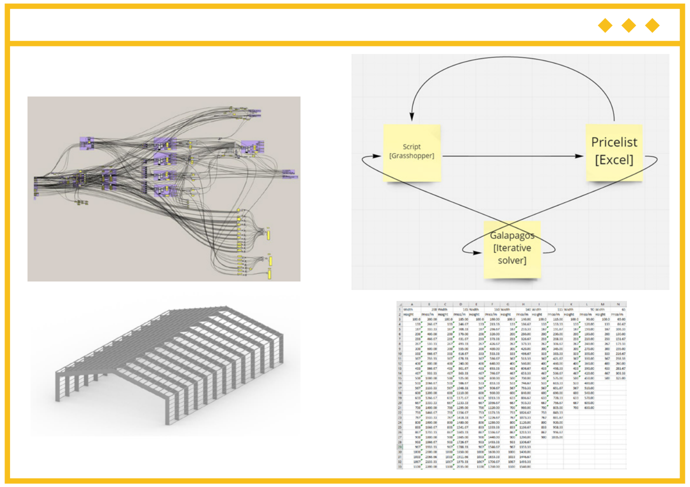
The whole spectrum of Davos Baukultur criteria: good governance leads to well-managed urban areas striving for economical accessibility and eco-friendliness, need of sense of place and immersion in the local context, beauty of the city with high-quality architecture and urban design, functionality of urban spaces (physical accessibility), diversity – openness for diversified societies and different human needs.

Project 6 by Julian Sorensen,
Denmark Technical University

1. What are the individual research questions and what are their process illustrations?

What is the relation/workflow between reinforcement strategies, design and printing process?

Fig[● 13]



2. What are the needs and problems the research question is answering to or solving?

Problem: how to balance the elements of the process of the designed and printed reinforced structures: design process, reinforcement process and printing process? Need: to obtain high-quality reinforced, sustainable structures.

3. What are the aims of the processes leading to answering the research question?

To optimize the process of design and printing the reinforces structures with the support of digital tools (Grasshopper, Galapagos ...).

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Linear + circular – linear as a way to reach the aim, but iterative in the constant enhancement of the processes.

5. What is the scale, range, and scope of the presented processes?

The process is technically specific, with the involvement of specialists only (structure engineers) using the digital tools of design, calculation and printing. Can be imagined as fully digital with the physical product at the end of the process.

6. Who are the design processes for?

The process is aimed at structure engineers searching for the optimization of the design, calculation, reinforcement and printing of structures.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

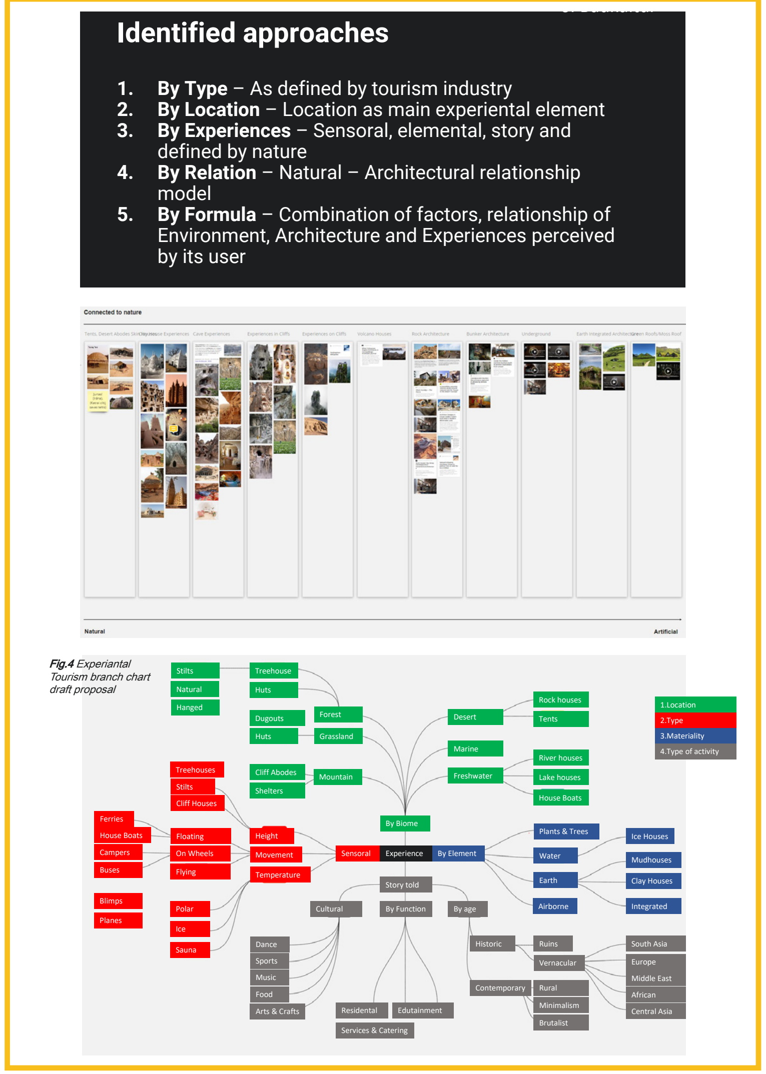
Economy (optimization of the design and production process of the reinforced structures, reducing the material use), environment (balancing the elements of the process should lead to reducing the environmental impact), beauty, and functionality (care for the quality of design and effectiveness of structures).

Project 7 by Matijs Babris,
Riga Technical University

1. What are the individual research questions and what are their process illustrations?

What is experiential architecture organizational typology for nature tourism applications?

Fig[●14]



2. What are the needs and problems the research question is answering to or solving?

Problem: what is experiential architecture organizational typology for nature tourism applications?
Need: identification of the organizational typology of experiential nature architecture for tourism purposes.

3. What are the aims of the processes leading to answering the research question?

To identify the organizational typology of experiential architecture for nature tourism purposes.

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Linear – the identification process leads to creation of typology, which can be finished or developed in time.

5. What is the scale, range, and scope of the presented processes?

The process is specific to architecture, nature and history specialists, needs physical studies and digital processing for organizational and classification processes.

6. Who are the design processes for?

In the identification process, they are aimed at the researchers, but the results may be targeted at the tourism organizations.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

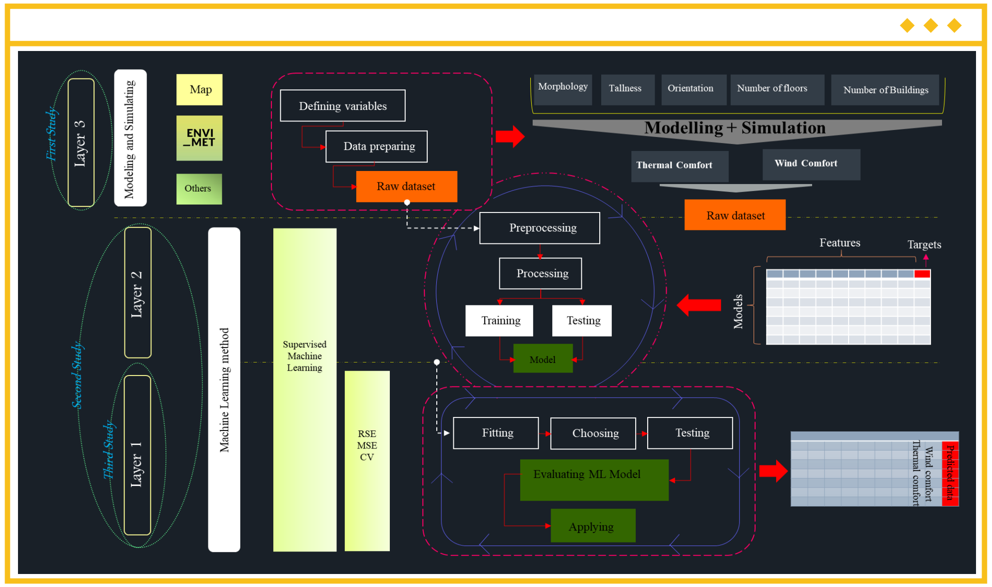
Governance and economy (proper tourism management in terms of experiential nature architecture for the care of its values and potential), environment (treating experiential nature architecture as a part of nature that should be protected), sense of place and context (typology may help in understanding the local identity and connections of the nature architecture with the local architectural traditions – e.g., vernacular architecture).

Project 8 by Nasim Eslamirad,
Tallinn University of Technology

1. What are the individual research questions and what are their process illustrations?

How do we apply machine-learning (ML) to optimize the architectural design?

Fig[● 15]



2. What are the needs and problems the research question is answering to or solving?

Problem: how do we support human–computer interaction with the use of machine-learning in data analysis and forecasting in architectural engineering and urban design? Need: we need better energy efficiency of buildings and need to develop guidelines in the field of optimization.

3. What are the aims of the processes leading to answering the research question?

To identify the design strategy for the sustainable values of the build environment. To optimize the process of design (case study of design solution for the energy efficiency of buildings and outdoor thermal comfort), in particular to use ML for data analysis and forecasting in architectural engineering and urban design.

4. What is the character of the process (linear, circular, repetitive, iterative …)?

Linear + circular (iterative) – linear as a way to reach the aim, but circular/iterative in the constant enhancement of the processes within the layers. The complex character of the process consists of overlapping layers and studies.

5. What is the scale, range, and scope of the presented processes?

The process is focused on searching for the most optimal design using ML for data analysis and forecasting in architectural engineering and urban design.

6. Who are the design processes for?

The process is aimed at architects and urban planners to support human–computer interaction, with great potential to deal with the complexity of the defined problem in architectural and urban environment.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

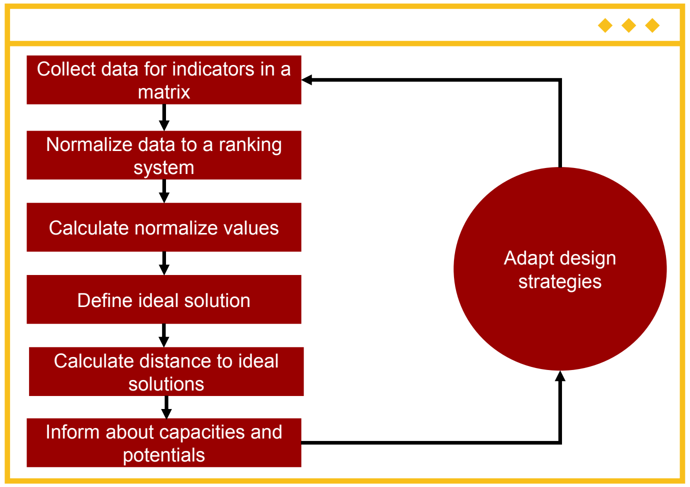
Economy (searching for optimal solutions in design, using ML for data analysis and forecasting in architectural engineering and urban design), environment (collecting more accurate data than the input data of the building energy profile and urban optimization to reduce the impact on the environment), beauty and functionality (the potential of digital tools to support the physical studies to enhance quality, functionality and beauty of materials, forms, architecture, landscape …).

Project 9 by Rune Andersen,
Denmark Technical University

1. What are the individual research questions and what are their process illustrations?

How can the capacity of buildings be used to select transformation strategies that give most sustainable value?

Fig[●16]



2. What are the needs and problems the research question is answering to or solving?

Problem: how can the capacity of buildings be used to select transformation strategies that provide the most sustainable value? Need: implementation of design strategies in relation to consolidated indicators and data in a digital model in order to obtain the most optimal solution strategy to finally visualize and inform about the effects of the strategy / obtain the most sustainable environment.

3. What are the aims of the processes leading to answering the research question?

The improvement of the design and digital fabrication process of the design.

4. What is the character of the process (linear, circular, repetitive, iterative …)?

Linear – the process that consolidates indicators and data in a digital model (from collecting data for indicators in a matrix to the information about capacities and potentials) in order to adopt design strategy. The process can be repeated in the cycle phases.

5. What is the scale, range, and scope of the presented processes?

The process is focused on searching for the most sustainable design strategy. Touching economic, social and environmental aspects on many scales addresses architects and urban planners but also a broader audience (policy-makers and local actors) who will be informed about the design strategies' potential).

6. Who are the design processes for?

The process is aimed at architects and urban planners searching for the optimization of the design process and strategies, however by visualizing and informing about the effects of strategies ultimately also aimed at the policy-makers and local communities.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

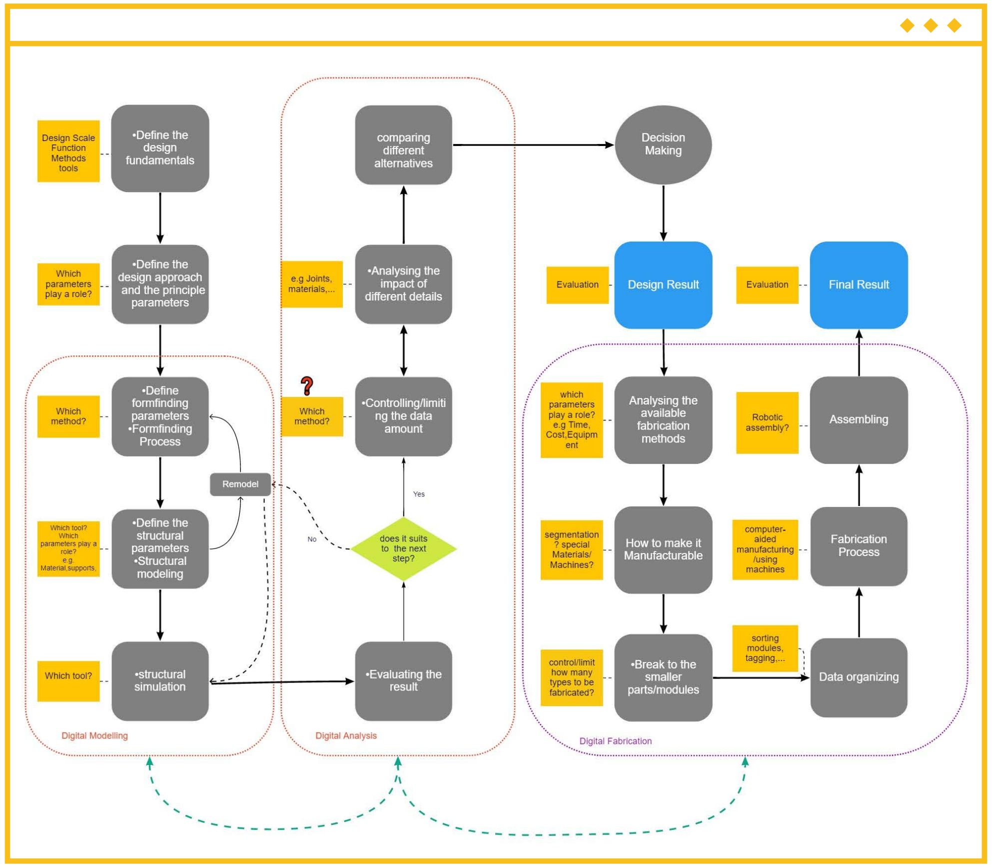
The whole spectrum of Davos Baukultur criteria: good governance, economical accessibility, eco-friendliness, sense of place and immersion in the local context, beauty of the residential areas (quality of architecture), functionality of living spaces (physical accessibility), diversity – openness for diversified societies and different human needs (since the process investigates sustainable values).

Project 10 by Sepideh Barati,
HafenCity Univeristy

1. What are the individual research questions and what are their process illustrations?

How do we make complex stress-line-inspired designs manufactural?

Fig[● 17]



2. What are the needs and problems the research question is answering to or solving?

Problem: how do we make complex stress-line-inspired designs manufactural? Need: to improve the design and digital fabrication process of the design.

3. What are the aims of the processes leading to answering the research question?

The improvement of the use of digital tools by questioning background operations following a perceptional approach.

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Linear – through three phases, leading from digital modeling, through digital analyses (repeatable in the modeling and analysis phase) to digital fabrication to obtaining the final product of the fabrication and evaluation of it (to both product digital and real objects).

5. What is the scale, range, and scope of the presented processes?

The process of creating the final result of digital fabrication is fully virtual, based on the design fundamentals. It concerns the design phase of the narrow area of the complex stress-line-inspired design. Technically specific, involving (most probably) the AI, AR and VR technologies. Can be imagined as fully digital with the physical product at the end of the process.

6. Who are the design processes for?

The process is aimed at designers searching for the optimal and most appropriate tools and methods allowing for digital fabrication of the complex stress-line-inspired design.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

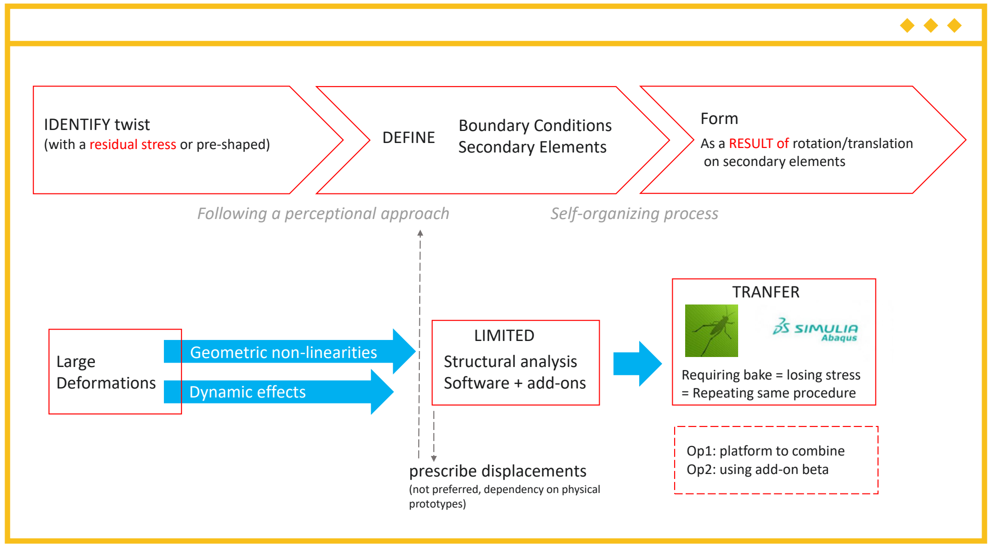
Economy (optimization of the design and production process of the complex stress-line-inspired designs), environment (balancing the elements of the process should lead to reducing the environmental impact), beauty and functionality (care for the quality of design and effectiveness of structures).

Project 11 by Serenay Elmas,
Aalto University

1. What are the individual research questions and what are their process illustrations?

How can I represent active torsion by following a perceptional approach in a digital environment?

Fig[● 18]



2. What are the needs and problems the research question is answering to or solving?

Problem: how do we represent active torsion by following a perceptional approach in a digital environment? Need: to improve the use of digital tools by questioning background operations following a perceptional approach.

3. What are the aims of the processes leading to answering the research question?

The improvement of the use of digital tools by creating the taxonomy of tool paths based on different knitting stitches that can be parametrized.

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Linear – leading to obtaining the final form as a *result* of rotation/translation of secondary elements (three phases process: identification of the twist, definition of the boundaries conditions, creation of final form).

5. What is the scale, range, and scope of the presented processes?

The process is technically specific with the involvement of specialists only (structure engineers) using the digital tools of design and calculation but following a perceptional approach. Can be imagined as fully digital with the physical product at the end of the process.

6. Who are the design processes for?

The process is aimed at designers searching for the optimal and most appropriate digital tools and methods allowing for representation of active torsion.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

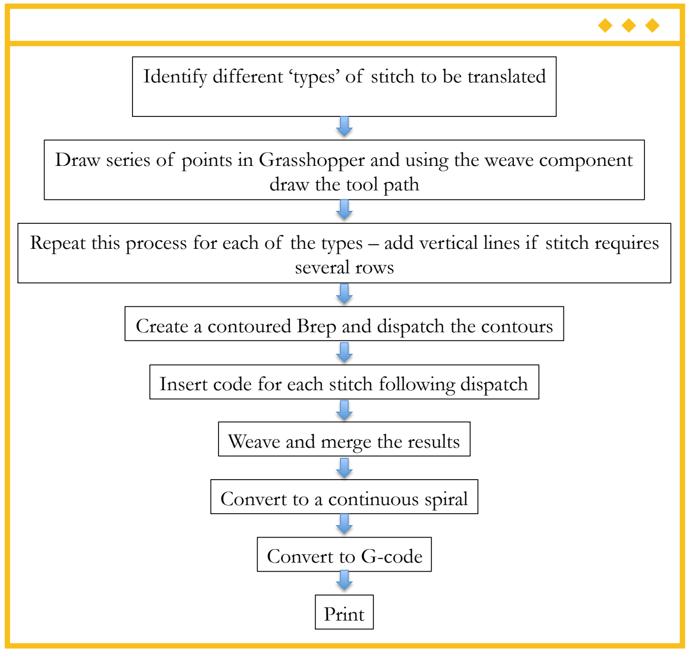
Economy (optimization of the design and production process of the structures, reducing the material use), environment (balancing the elements of the process should lead to reducing the environmental impact), beauty and functionality (care for the quality of design and effectiveness of structures).

Project 12 by Suzi Pain,
Royal Danish Academy

1. What are the individual research questions and what are their process illustrations?

How can I translate a Japanese knit pattern into a digital tool path? How can I create the taxonomy of tool paths based on different knitting stitches that can be parametrized and used for the 3D printing in clay?

Fig[●19]



2. What are the needs and problems the research question is answering to or solving?

Problem: how do we create the taxonomy of tool paths based on different knitting stitches that can be parametrized and used for the 3D printing in clay? Need: translation of a Japanese knit pattern into a digital tool path.

3. What are the aims of the processes leading to answering the research question?

To create an algorithm/digital path for converting the different types/patterns of knitting stitches into a Grasshopper (parametric design) series of steps for 3D printing in clay.

4. What is the character of the process (linear, circular, repetitive, iterative ...)?

Linear + circular – linear as a way to reach the aim (parametricized knit pattern and used for 3D printing), but circular/iterative as the constant enhancement of the processes.

5. What is the scale, range, and scope of the presented processes?

The process is focused on the improvement of the digital tools (mainly Grasshopper) by drawing inspiration from tradition and culture and searching for a digital equivalent of physical studies, so it concerns designers who understand the essence of the design matter, supported by specialists in digital tools. The scale of the impact of the process is therefore narrow and concerns the production line for the manufacturing of specific items or rather their prototypes.

6. Who are the design processes for?

The process is aimed at designers searching for the optimal and most appropriate tools allowing for studies on materiality and form of objects leading to creation of pre-production mock-ups.

7. Which of the eight criteria for assessing high-quality Baukultur do the processes refer to?

Eight criteria: Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity.

Economy (searching for optimal and better solutions in design), environment (can digital studies replace the physical studies to reduce the impact on the environment?), beauty and functionality (the potential of the digital tools to support physical studies to enhance quality, functionality and beauty of materials, forms and architecture, drawing inspiration from tradition and culture.

3.2.1 Partial conclusions

The analysis of examples of research questions and processes geared toward answering these questions shows that young researchers take up issues that are firmly rooted in the values inherent in the Baukultur ideas. They are looking for solutions that lead to a better quality of life, greater material efficiency, more economical production, to reducing the impact of processes on the environment, while they are still embedded in the local culture, context and values. Tools that are essential in these processes are digital data analysis tools, computational methods, design aids, simulations and many others, described and analyzed in other chapters of this report.

The role of digital tools in contemporary design processes is to support humans most effectively, allowing for the reduction of errors and the most accurate analyses and results. However, what can be seen from the illustration of these processes is that digital tools and new technologies do not dominate the processes, nor are they an end in themselves. The ultimate goal of the undertaken research issues is to strive to build better and better quality and search for new solutions and opportunities in the physical world, the true framework of human life.

One can also see the reflection and the questions posed, whether such advanced use of digital tools is always economically justified, whether digital tools are not starting to lead a "parallel life" that has no impact on contributing to the improvement of the quality of reality in which people live.

Creating a design process to answer a specific contextual challenge is a skill that all the participants excelled in. Digital tools at hand were used creatively and contextually – even though the tools themselves might have been developed for a specific design stage, they can be used in new ways.

3.3 The role of Craftsmanship in the process

(ISP3, Craft and Craftsmanship, Preparatory task 1, Reflection "**BuildDigiCraft**" model for scientific reflection)

3.3.1 Introduction

ISP3 addressed the topic of Craftsmanship. This is closely related to the design process in the sense that an act of working with material is the essence of a (building) process leading to manifestations in the built environment. Furthermore, the mapping of tools and processes of ISP2 demonstrated that there is a tendency to think holistically (including e.g., 3D printing and end-of-life perspectives in the design process). The ISP2 works as a backdrop to the ISP3 Preparatory task concerning Craft and Craftsmanship. Essential questions in ISP3 were:

What is craft and craftsmanship to you in your research ?

What is the relation between a design process and Craftsmanship in a digital age?

Craftsmanship involves skills in using tools, and in general, the young researchers' did not make a distinction between physical tools and digital tools.

Answers for these questions were given through a series of exercises (pre-tasks and group work) based on the young researchers own projects and experiences.

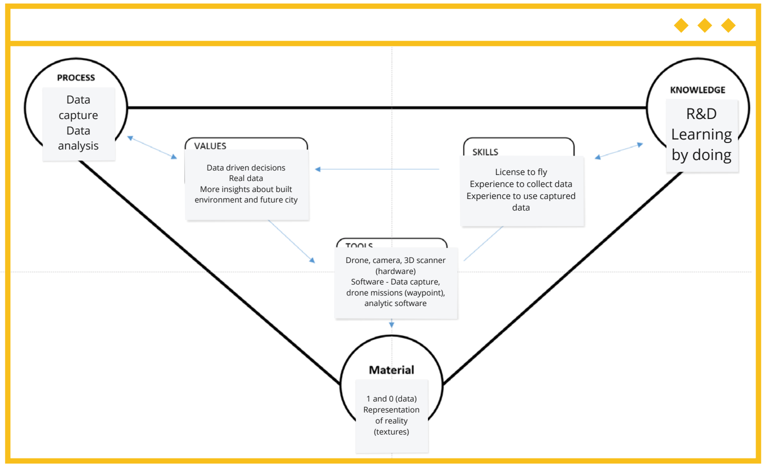
3.3.2 Results

Group 1

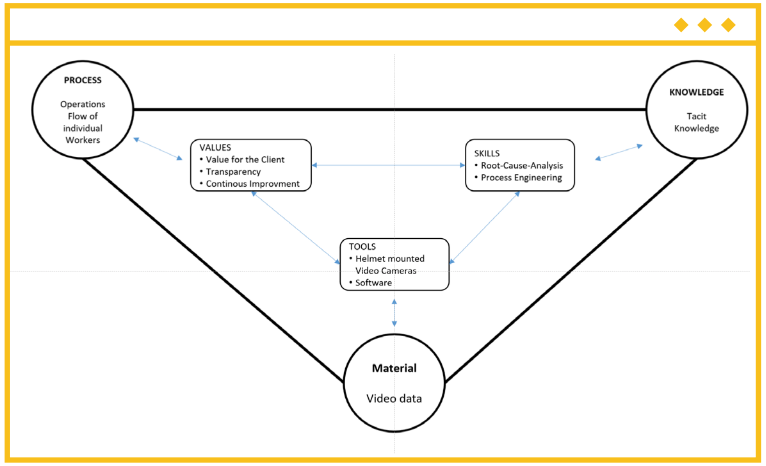
It became evident in one of the exercises that the material processed through Craftsmanship is not considered to be "wood" or "metal" as was traditionally the case.

Instead, the material might be the data and the tools drone, the camera, 3D scanners, etc. (Fig[● 20] and Fig[● 21]).

Fig[● 20]



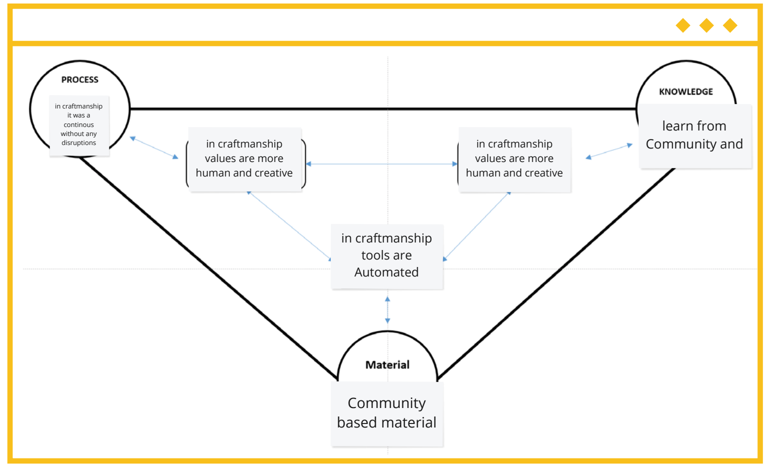
Fig[● 21]



Fig[● 22]

However, “Craftsmanship” is discussed by this group as having a certain connotation of something that involves the human hand and as such is expected to represent humanistic values, experimentation, and artistic values. (Fig[● 22]).

Fig[● 23]



The group created a synergy graphic of their conclusion.

In Fig[● 23] the “Craftsmanship” is visualized as a synthesis that can involve automation, if the process is continuous and without disruptions, and as having to represent human and creative values, involve knowledge from a community and work with material – both digitally and physically – rooted in a community.

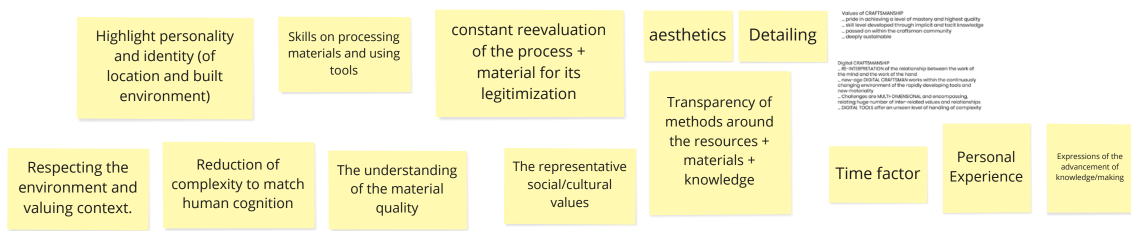
Group 2

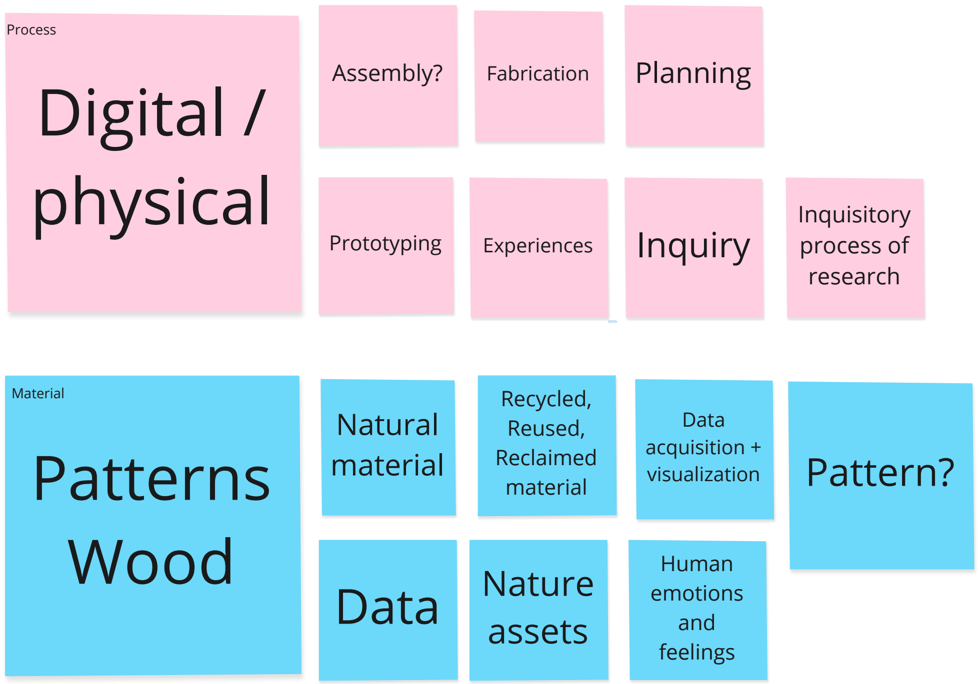
An outline of the notions of Craftsmanship is provided through a juxtaposition of **Process**: digital/physical – and **Material**: patterns/wood (Fig[● 24]):

Process: assembly, fabrication, planning, prototyping, experiments, inquiry, planning.

Material: natural material, recycled, reclaimed material, data, human emotions and feelings.

Fig[● 24]





Fig● 25

Based on this initial discussion, further traits of what can be understood as Craftsmanship today were described (Fig● 25):

Craft and Craftsmanship:

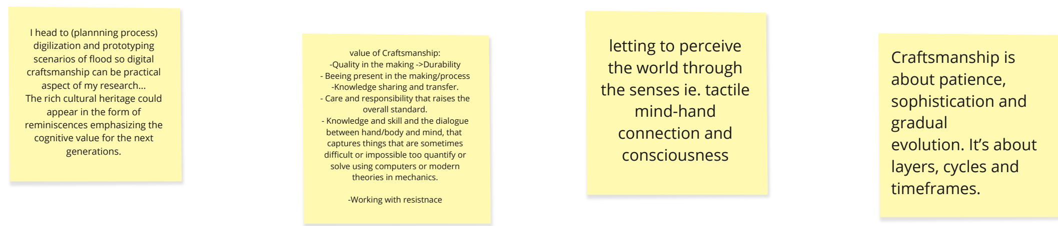
- Highlight personality and identity (of location and built environment)
- The representation of social/cultural values
- Constant re-evaluation of the process + material for its legitimization
- Reduction of complexity to match human cognition
- The understanding of the material quality
- Transparency of methods around the resources
- Time factor and personal experience

Group 3

The young researchers outlined the meaning of "Materials," "Process," and "Knowledge" in the particular context of their own research projects – and with this also implicitly skills and tools.

Fig● 26

Based on this discussion the group outlined the following traits of Craftsmanship today:



Fig● 27

Craft and Craftsmanship:

"Digitalization and prototyping scenarios of flooding – can be practical aspects of my research. The rich cultural heritage could appear in the form of reminiscences emphasizing the cognitive value for the next generations."

"Value of Craftsmanship: quality in the making – durability. Being present in the making/process. Knowledge sharing and knowledge transfer. Care and responsibility that raises the overall standard. Knowledge and skills and the dialog between hand/body and mind that captures things that are sometimes difficult or impossible to quantify or solve using computers and modern theories of mechanics – working with resistance."

"Allowing the world to be perceived through the senses, i.e., tactile mind–hand connection and consciousness."

"Craftsmanship is about patience, sophistication and gradual evolution. It's about layers, cycles, and time frames."

3.3.3 Partial conclusions

The notion of Craftsmanship was explored within the framework of Process in a digital age as a backdrop. It can also be the skills to work with data and digital tools, machining prototypes. However, the Craftsmanship aspect has to do with the way it is achieved, the consciousness behind it; patient, undisrupted evolution, caring and responsibility, a connectedness (between mind and hand), a sense of belonging (to a community).

In spite of working with digital production technologies in their research, the young researchers chose to define Craftsmanship as adhering to humanistic values. These can be present also when working with 3D print, etc.

It is a general trait that the Craftsmanship aspect is understood to incorporate a specific set of values behind the way it is performed, a consciousness behind the act.

4.0 Conclusion on the evaluated ISP tasks

Generally, researchers stressed the benefits of implementing digital tools and technologies to improve the work quality and performance, e.g., through material use and structural efficiency or adaptability of design. Implicitly, they generally referred to the sustainability challenges. They stressed that digital tools support interdisciplinary, e.g., BIM technologies facilitating collaboration between different professions. At the same time, they were also aware of various limitations of those tools such as lack of flexibility. They pledged that "seamless" connectivity of BIM is still evolving. It could also be observed that standardized IFC-BIM and a linear process management is being bypassed by the more open development of their "own" digital tools and the use of cloud-based tools, which can provide solutions.

The PhD researchers are preoccupied by the risk of losing humanistic values – that the digital tools will lead to just iteration without artistic energy.

While working on the categorization of the digital tools, some researchers to a much lesser extent stick to a project line, which for current designers is the default way of grouping tools. It may be due to the limited design practice they possess, but one can find such a statement oversimplifying as similar non-linearity/freedom can be observed in most innovative design companies – tools traditionally connected with the final phases of design, for example a lifecycle assessment, are beginning to be used in the pre-design phase for optimization purposes. We move from linear design process to something a lot more holistic. The tools for this shift are already there, but these processes are not mainstreamed yet. We are in a transitory phase where one can observe that each design studio has its own culture of using digital tools.

While discussing the role of digital tools, ISP participants focused on analyzing, evaluating and optimizing the design through form-finding simulations. Optimization is no longer seen as the primary engineering task. Instead, this task is defined as an interaction with the digital tool for form-finding and strictly integrated in a design process.

Efficient use of digital tools is directly linked with the quality of the data available. Digital tools can help to define and frame the city, they may influence the way we evaluate and design buildings and structures. With the massive amount of data generated by people, devices and networks, we can conduct data-driven analyses of the spatial and functional patterns of the city nearly in real time. Generating indicators, obtaining data on which designers' decisions can be based is an integrated part of the designers' design process – be it qualitative (e.g., post-occupancy evaluation) or quantitative data (such as the number of sun hours on façades).

At the same time, participants point out not only the benefits of the use of digital tools, but also the dangers, for example digital exclusion. It is costly to buy the tools, compared to pen and papers. The exclusion also happens from the skills needed to operate the digital tools, such as basic python programming. The educational background needed to operate these high levels of informed design is in itself excluding parts of the world that do not have access to building up these skills. The problem of data security or insufficient regulation for the use of AI-based tools also need to be taken into account. Very few digital tools address social sustainability, as the majority focus on technical or economic problems. There is also an expanding palette of ever-growing range of quickly fast-developing health and environmental sustainability assessment tools.

Diving directly into the design process, new software, no matter how advanced, can be seen as a constraint for a free creative process, limiting the possibility to freely visualize. Before, we could design using only basic tools like pencils or pens but now we need specific tools which may exclude people from using them due to a lack of their availability or their high price. During the ISP we observed major appreciation for open-source tools, which is one of the main reasons why tools like Grasshopper were so popular among the participants.

The Covid-19 pandemic has accelerated digitalization of design work which in turn has meant that more importance is given to project and teamwork management tools. These don't only serve as a platform for project management, but have also allowed an introduction to waterfall design processes based on more agile principles.

Craftsmanship is seen as humanistic, and artistic values behind the work as "material." Material is understood as both traditional building materials like "wood," but also data, emotions and information from a community. Craftsmanship is thus transformed into the digital realm as representing, for instance, uninterrupted experiments, a special time quality as well as artistic quality.

5.0 Discussion: relation of the young researchers' design processes to the processes within the Baukultur idea and eight criteria for high-quality Baukultur assessment framework

5.1 The scope of identified processes, their range and multidisciplinarity

The presented illustrations of processes show a very wide spectrum of research undertaken by young scientists. They also show diversity in terms of scales, specialties and fields of study. It can be said that they reflect the complexity of the processes involved in shaping the built environment. Importantly, regardless of whether a given process concerns a selected issue in structural engineering, architectural design or shaping a complex urban environment, each of these processes involves many digital tools, each project is inter- or multidisciplinary, involving specialists from various industries. This reflects the reality in which science is moving away from narrow specialization in favor of a more holistic approach, which is especially important in shaping the built environment.

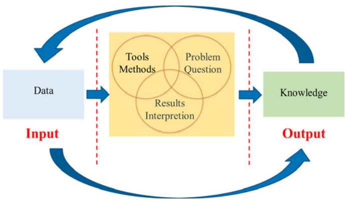
The Davos Declaration and the eight criteria for assessing the high-quality Baukultur also reflect a holistic approach to shaping the human environment – in deference of nature and culture, respecting resources, limiting consumption, and in the social sphere – with an emphasis on equalizing economic opportunities and inequalities – striving to access various resources. The Davos Declaration clearly shows that engineering, architecture and urban planning do not serve to meet only aesthetic needs and that the concept of quality means much more than just the quality of materials and a good neighborhood. Research issues developed by the participants are an expression of similar sensitivity and awareness across disciplines and research projects.

5.2 Needs and problems identified, and aims of the processes relating to reaching high-quality Baukultur

In their research, the participants strive to solve a number of important problems that result from very specific needs formulated by the participants of the project processes. Most of the identified needs result from real problems faced by engineers, designers, but also policy makers, ordinary residents and everyday users of urban spaces. The goals that young researchers want to achieve are overwhelmingly consistent with the goals of the Baukultur movement – building a high-quality built environment at all scales and affordable for all people along with a sustainable approach to the environment as well as resources and cultural heritage.

5.3 The character of the processes and its relation to the character of the processes within Baukultur

As for the character of the processes, in most cases they are identified as complex, often divided into phases and overlapping stages in the constant enhancement of the processes, combining linear with circular and iterative characters. A major observation is that digital design processes in the framework of the ISPs are contextual, and thus emphasize the "sense of place" as a primary quality. The solutions are contextual, but the digital processes are also contextual in the sense that they are "tailored" to a specific challenge or question. This is worth noting, because digitalization in the built environment opens up for cost reduction and efficiency by simple "copy and paste" maneuvers in all design phases from pre-design to completion. The advanced documentation demand, e.g., concerning sustainability, could in a negative sense push for "building the same building" again and again in a sort of platform-thinking known from industry. However, the young researchers are united in insisting on the contextual potential of digitally informed design processes.



Fig[● 28] "Data vs. Knowledge" (source: Group 4, ISP2 Workshop, Task 1).

Using digital tools and transferring some processes to the virtual world allow you to perform a series of iterations in order to achieve the best possible results. Relating these processes to the character of processes within the Baukultur idea, it can be stated that currently most processes are looped, iterative, because striving for high quality requires many corrections and consistently reacting to new, constantly emerging problems. In shaping the built environment, in principle, none of the processes are closed, because the environment is subject to constant changes, and these in turn require an ongoing adaptation of tools and methods along with an evolving of knowledge and frequent reformulation of development and strategic goals.

Processes are no longer only linear but complex and interconnected; mostly circular and iterative. The factor of time and effort in the process has changed through digital technologies. Since new tools and technologies have been introduced to all stages of the processes from design to implementation, it allowed for optimization and increased efficiency of the output.

5.4 The scale and range of the processes and their relation to the scale and range of the processes within Baukultur

In terms of the scale and scope of the processes presented by the participants, they can be easily related to the variety of scales and scope of the processes within Baukultur. It is worth noting that it is not only about the scale understood as the scale of projects, e.g., architectural or urban projects, but also about the impact of the process – how many participants are involved in it, who will be affected by these processes and who will be the beneficiaries of the processes. Since the main goal of Baukultur is to create a high-quality living environment, the range of processes within

Baukultur refers primarily to the scale of local communities, neighborhoods, districts, but also entire cities or – on the other side of the scale – small groups organized around an idea (university, local community, groups of people who want to change something in their environment). Many of the processes presented by the participants correspond to these types of processes, where the goal is to create sustainable communities and become immersed in local culture and values.

Of course, due to the scientific nature of the presented processes, some of them concern the solution of very specific problems, such as in the field of structural engineering, where the result is the development of, for example, a new form or method of production of structural elements. It can be said at first glance that this is too small a range of impact to talk about embedding this type of project in the Baukultur idea, but the introduction of new, ecological construction elements may have an impact on the creation of, among others, more accessible, low-emission, cost-effective structures, of which new housing estates will be built. Thus, even the smallest scale or scope of the process can fit in with the ideas of Baukultur, as long as the goal is to care for a better quality of human life in connection with technology, nature and culture.

5.5 The receivers of the processes and the relation to the processes within Baukultur

Considering the issue of who is the recipient of the project processes, it can be concluded that the recipients of the processes illustrated by the participants are very diverse groups – social, professional and specialist. The size of the recipient groups is also varied. From quite narrow groups of designers, specialists in the field of engineering and design who will, for example, use new solutions or technologies, to entire communities – from local neighborhoods to residents of entire cities, which consist of socially, economically, professionally, and ethnically diverse groups.

The Baukultur movement is aimed at all members of the community. From this premise, the recipients of high-quality built environment – based on aesthetic, social, cultural and environmental values – should be as wide a group of users as possible. This assumption is in line with the idea of inclusiveness, too, which is also an element of Baukultur. In today's world it is very easy to exclude others, therefore it is necessary to emphasize the importance of those processes where the aim is to integrate, include or deliver high-quality products or services available to the widest possible audience.

It is very valuable that young scientists who want to reach out with their solutions or to a wide audience think about the recipients of processes in a similar way as the Baukultur idea promotes. And even if not broadly, these solutions are to bring improvement to certain groups of stakeholders. Often, however, one small change entails another, so many of the processes presented can also be seen as processes initiating a whole chain of subsequent processes, which, in effect, will lead to the achievement of Baukultur's goals. Such an approach also confirms the above-mentioned feature of processes that they are iterative, interrelated and intertwined.

5.6 Multidisciplinarity, simultaneity, overlapping, distinction of processes – relation to the eight criteria of Baukultur

Contemporary processes of shaping architectural and urban spaces are complex. This results from the nature of the projects they concern. The construction of buildings, structures, design and construction of housing estates require many stages of work, from strategy development, through design, implementation, to use and maintenance, and later renovation, modernization, and revitalization, then recycling and/or upcycling of the used materials and structures. Each of the major processes is made up of many smaller sub-processes. This complex nature is also evident in the examples of young scientists. Each of them tried to illustrate one, their own process aimed at answering a research question, but it is clear that each of these issues is or may and should even be a part or sub-process of other processes. Sometimes the opposite is true – for complex issues such as striving to create attractive and sustainable urban environments, participants recognize that this cannot be achieved in a single process, that it is a complex task combining multiple disciplines, multiple professionals and projects.

The idea of Baukultur and the created criteria for assessing the high quality of the human living environment also reflect the complexity of the processes. Eight evaluation criteria indicate that each project or implementation should be assessed in light of many aspects. In order to achieve the desired goals according to eight criteria, it is necessary to undertake at least as many processes, and one overarching one, which will coordinate the sub-processes. Of course, this is a simplification, but it illustrates the complexity of contemporary design processes well.

Baukultur's eight quality assessment criteria clearly show the characteristics of inter- and multidisciplinary design of built environment and the complex knowledge and competent specialists it requires. The aspect of engineering, i.e., the competences of constructors, architects, and urban designers, is only a part of these processes. In order to create high-quality space, the competences of management, economy, sociology, energy, environmental protection, transport, culture, and many other disciplines are needed. Within each of them, we can additionally talk about the necessary digital competences – about the need to use various digital tools and new technologies, thanks to which processes can become faster, more effective and less prone to error. However, it is also a trait of digitalization that the many aspects can be weighed against each other and integrated in a design decision.

5.7 Responsibility for the process(es)

Considering the contemporary conditions of life in general, in particular the multidisciplinarity and the interweaving of individual processes related to the built environment, the answer to the question about responsibility is as complex as the character of the processes themselves.

Any process or action within processes demands one person's responsibility. Transdisciplinarity is an obvious circumstance, and the parallel occurrence of individual processes and their overlapping is inevitable. Hence, responsibility is present in the implementation of individual research projects, projects that ultimately form part of a larger whole anyway.

Apart from that, the responsibility for the processes is divided into individual stages of the processes taking place, from planning through implementation and maintenance of a sustainable environment. In each of the phases of given tasks, we must ensure their reliable implementation. It is inevitable to manage these processes to make them visible and effective.

This corresponds very well with the eight Baukultur criteria. It is important to take responsibility within each one of them. For these criteria (Governance, Economy, Environment, Sense of Place, Beauty, Functionality, Context, Diversity), the first priority is management and economic issues as key to the realization and successful implementation of a sustainable environment.

Today, we live in a reality of constant changes, challenges and threats. Desirable features facilitating adaptation to such conditions are flexibility, adaptability to changing needs, readiness to take risk, but also the ability to minimize it. It becomes possible, among other things thanks to new technologies and artificial intelligence, which enable the creation of simulations, digital twins and observation under the influence of changing factors.

Young scientists are aware of this, which is why at this stage of their research they also use a variety of tools and, one could say, consciously complicate the processes they undertake in order to put their research projects to many possible tests.

One of the most important aspects of the idea of Baukultur is the issue of the identity of the place, values flowing from and within the local context and culture. Such an approach is necessary, if we want to preserve the regional and cultural uniqueness and distinctiveness of architecture and elements of the built environment. Architecture, as a carrier of culture, should connect people with the place where they live and from where they come, it should also emphasize the uniqueness of culture, nature, landscape and urban context. This is to prevent the creation of repetitive objects taken out of context, which, thanks to the use of digital tools and technologies, are very easy to multiply and spread across the world regardless of culture.

Therefore, emphasis should be placed on the conscious use of digital tools, which need to be at the service of culture and local identity, not instead of them. As mentioned above, the digital processes are not standardized or adhering to a project line. In that sense they are "tailored" to a specific context.

It should also be remembered that we design for people and through people. Living in a very digitized world today, there is a fear that we will lose control over digital tools and processes, that architecture and the newly shaped living environment will lose the human factor. We are currently fascinated by the achievements of technology and use them extensively, but we must always relate the results of our work to the culture of history and heritage that constitutes our identity. We must ensure that all processes are aimed at and relate in effect to the users of space who are diverse and unique at the same time. Examples of such design processes are shown in the ISPs' work.

Craftsmanship as a notion is translated by the young researchers to be values behind the acts of using digital tools.

Baukultur and the evaluation criteria give hope that these values will be considered and taken care of in contemporary design processes, using all the latest methods and tools, both digitally and traditionally, to create beautiful and sustainable spaces and living environments.

6.0 Guidelines: a design process leading to a high-quality Baukultur in the digital age

The idea is that the design process is often overlooked as something invisible, not tangible. However, it is the series of decisions made in a design process that will eventually lead to poor- or high-quality Baukultur. We now have a situation where designers involved in design processes of Baukultur have access to new digitalized, visualized information that was not accessible just a few years ago. We have thus the potential for **creating design processes** that will lead to higher levels of sustainability and cultural appreciation. Digitalization also pose considerable risk, because design processes used to be regulated by industry standards and tradition. They are now much more free, and the guidelines are there to help designers reflect on the quality and values behind the design processes they perform.

Two main points to think about:

Commercial mainstream processes and artistic process – what is the balance?

- *Is there a conflict between a mainstream automatized, standardized digital process as compared to the artistic/values in the process?*

Criteria-driven or value-driven process – what is the balance?

- *Is there a conflict between a **criteria-driven** process and **value-driven** process (based on architectural tradition, etc.)? If so, how do I address this conflict in my design process?*

6.1 Guiding questions to (digital) design processes

Background for the guideline question:
How is the design process created?

- Informed processes (support decision-making and potentially provide access to better choices). Leading to high-quality Baukultur. Nearly none of the ISP participants works in REVIT, BIM is rarely mentioned, young researchers work more freely and exploratively. While working on the categorization of the digital tools, researchers and designers to a much lesser extent stick to a linear, standardized project process.
- This may be due to the limited design practice of young designers and researchers of this project. On the other hand, such non-linearity/freedom of using digital tools can be observed in most innovative design companies. Moving from a linear design process to a more holistic process is a general trend.
- An example is that there is an expanding range of fast-developing urban comfort and environmental sustainability assessment tools as well as tools traditionally connected with the final phases of design, e.g., LCA, that are starting to be used in the early design phase.
- We are in a transitionary phase where each design studio has its own culture of using the digital tools. Designers should thus be aware that they are actually creating a design process and that the way they choose to inform design decisions matter.

Q Which design process could I design to fit this specific context, place, and task? What are the questions I would like the process to answer?

Background for the guideline question:
Who has access to the new levels of information behind design processes?

- There is a risk that the overwhelming access to information will give a lot of power to parts of society that can afford a prolonged pre-design phase and can pay for the software, tools, and IT expertise. But what about those who can't?
- Before, only basic tools like pencils or pens were used, but now we need specific tools which may exclude some people due to a lack of availability or because of their price.

Q Is there an open-source version of the digital tool you want to include in your design process?
(A strong focus on open-source tools (such as Grasshopper).

Background for the guideline question:
Who can misuse information involved in this design process?

- Benefits of the use of digital tools, but also the dangers, such as digital exclusion, the problem of data security, or insufficient regulations for using AI-based tools.

Q Will my use of this data compromise privacy and dignity of anybody?

Background for the guideline question:
Are humanistic values and social sustainability included?

- The Covid-19 pandemic has accelerated the digitalization of design work which has caused more importance to be placed in project and teamwork management tools.
- They do not serve only as a platform for project management, but also allow to change the waterfall design processes to agile and more participative ones.
- Visualization in digital tools allows for inclusion.
- There is a risk that what doesn't have a number – i.e., what is not "captured" by the digital process – is not emphasized in the design. This could be the craft of the

human hand, humanistic values, not easily captured aspects of biodiversity, human well-being, social inclusion, beauty, sense of place, artistic expressions and ideas.

Q How can I plan online meetings to avoid long-distance flights and use online collaboration platforms to better involve stakeholders?

Q How can I ensure accessibility to design collaborative platforms for all stakeholders? What about also addressing citizens?

Q Are the visualizations adequately designed to communicate to stakeholders and create transparency and inclusion?

Q Have I included information about social sustainability in the design process?

Background for the guideline questions:
What about living nature? Qualitative and non-measurable criteria?

- Very few digital tools address biodiversity and sense of place as majority focus on technical or economic problems.
- As mentioned, there is a risk that what doesn't have a number – meaning, what is not "captured" by the digital process – is not emphasized in the design. This is important concerning living nature, which as such doesn't have a voice – and as an extension of living nature, also the sense of a specific place on this planet.

Q Have I included in the design process information concerning:
- **sense of place (genius loci)**
- **biodiversity**
- **beauty?**

Q Have I included considerations of environmental impact?

Background for the guideline question:
Are art and work of the human hand included?

- If there is little scope for original ideas involved in the design process and/or the design processes do not show enough artistic or creative elements, this will have a negative impact.
- Immersing directly into the design process, new software, no matter how advanced, can both inform and constrain a creative process.
- Optimization is no longer seen as the primary engineering task.
- The digital tool is for form-finding and is strictly integrated in a design process.

Q Have I reflected on whether the digital tools in this project have improved or indeed at times restricted artistic freedom and working with values?

Q Have I checked whether the automated iterations are running wild? Who or what controls the "design" of the design process?

Q Have I left space for "*the mark by the work of the hand*"?

Q Have I included more lifecycles and considerations about end of life and reuse?

Background for the guideline question:
Is there transparency in weighing qualitative and quantitative information?

- Having a well-informed digital design process could be a quantum leap toward creating truly regenerative architecture that not only avoids negative impact but regenerates lost balances in nature and cities. With the information now available and visualized by designers, it is possible to holistically include "everything" – many parameters, criteria, and indicators – to make the right design decisions for all phases of the built environment: its use, end of life, reuse …

Q **Q: Do I have a multi-criteria framework where I have an overview and can weigh qualitative and quantitative information and criteria?**

Q **Q: Have I established transparency in how to weigh different criteria and indicators? Have I included both qualitative and quantitative information in my design process?**

Background for the guideline question:
Is your process on the DAVOS Baukultur track?

- If one of the keys to high-quality Baukultur is the design process, what characteristics of the PROCESS / kind of PROCESSES do we need now and in future? How do we assess the processes that lead to high-quality Baukultur?

Q **How does the process relate to the eight criteria: Governance, Functionality, Environment, Economy, Diversity, Context, Sense of Place, Beauty? What question(s) am I trying to answer with this simulation at this point in the process?**

6.2 Strategic recommendations:

- Criteria needs to be flexible at the beginning of the design process.
- The process should be based on values (art, culture, sense of place, nature, humanity …) not data-/criteria-driven.
- Use more time and resources on design process – make sure it is artistic, driven by humanistic values (digitalization can harm the quality of the design processes behind the built environment because it is tempting to "copy and paste" financial reasons, instead of creating a sense-of-place-driven original design process for it).

2.4 Knowledge
Intellectual Output 3

Toward guidelines for the development of a higher education curriculum:

bridging craft and digital
for a high-quality Baukultur

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Contents

Abstract

The aim of the "**BuildDigiCraft**" project IO3 – Knowledge is to explore how the digital revolution of our time relates to the complex concept of knowledge and the vision of a high-quality Baukultur expressed in the European Union Davos Declaration from 2018. A more specific and limited aim is to identify how digital tools can support the knowledge production, integration of "implicit and tacit knowledge" into "explicit knowledge" and how this can ensure the transfer and creation of the cultural values expressed in the Davos Declaration.

The method was to review the output material from the different activities performed during the project addressing selected questions:

1. ***What kind of knowledge did we collect in the project?***
2. ***What methods were used for knowledge development / knowledge production?***
3. ***What is the role of knowledge in multidisciplinary research and what is the role of a multidisciplinary approach in knowledge creation? How do we transfer knowledge?***
4. ***How and where can we use collected knowledge in future? Contextualization of these questions helped to frame important links to contemporary discourse on the topic of knowledge, challenges, and approaches to knowledge production. Material presented in case studies exemplified selected outputs from pre-tasks, ISPs and lectures in relation to forms of knowledge and knowledge production.***

Results from the project show that "knowledge" is a wide concept. The project reveals that students from early research education can learn how to integrate different forms of knowledge in projects by reflecting on the interplay of actors in inter-/transdisciplinary projects and practice-based learning. The exemplified students' projects (PhDs or advanced Master's theses) show a variety of approaches to knowledge production in the field of the built environment. Common aspects discussed in their work are linked to digitalization and application.

Students' projects present emergent topics, and innovation through reconfiguring existing knowledge in connection with the rapid development of new digital tools for design and production. Digital tools are useful and common in the new production and exchange of knowledge. There is much attention paid to obtaining, testing, exploring, modeling, and visualizing the data. The ambition to address existing problems within a framework of sustainability, regeneration, efficiency, resilience, socially consensual and negotiated knowledge production and co-production is tangible, the aim being the quality of the space and sustainable lifestyle in the built environment and high-quality European Baukultur. In conclusion, the university in the up-to-date complex environment of information transfer plays an important role as a knowledge hub that shares knowledge between society, science, and industry. Individuals in higher education are given an opportunity to learn to grow in their own work as professionals. Moreover, the designer needs training, too – in learning how to make informed design decisions and how to implement the craftspeople's practical knowledge.

1.0 Topic and challenge

The aim of the **BuildDigiCraft** project IO3 – Knowledge is to explore how the digital revolution of our time relates to the complex concept of knowledge and the vision of a high-quality Baukultur expressed in the European Union Davos Declaration from 2018. A more specific and limited aim is *to identify how digital tools can support the integration of "implicit and tacit knowledge" into "explicit knowledge" in order to ensure the transfer and creation of the cultural values expressed in the Davos Declaration*.

Knowledge in its essence can be explicit or implicit, the second also including the unspoken aspects that tacit knowledge includes. Where explicit knowledge can be easily accessed and transmitted to others by articulation, codification and verbalization, the tacit and implicit knowledge is gained by personal experience and is more difficult to express and transfer. Craftsmanship is a skill level developed through implicit and tacit knowledge and passed on within the community of craftspeople.

Where in industrialized times it was important to accumulate specialized expert knowledge, which then had to be applied in a highly specialized and mostly mono-disciplinary context, in the digital era there is a strong need to learn how to integrate this specialized knowledge in an inter-/transdisciplinary setting marked by a permanently increasing level of complexity. By addressing this complexity in decision-making processes for sustainable cities and global threats in research, the culture of how knowledge is produced, developed, managed or transferred comes to light. Research practice has become highly reflexive and must be made more accountable by society. This stresses the growth of mutual learning between scientists and societal actors. More than ever, knowledge plays a key role in meeting social demands to approach and solve urgent issues in the society and knowledge democracy, where digitalization plays an important role in producing and communicating this knowledge.

Digitalization addresses the way we are handling knowledge today in terms of the increased amount and intensity of the available data and the indefinite number of complex relations that can be recognized within the specific data vs. information vs. knowledge context. However, decision-making on how data should be acquired, selected, arranged, evaluated, and communicated remains a process principally dependent on the human factor. Humans tend to rely on implicit knowledge, which also involves some sense of intuition, when dealing with specific problems that require customized decisions. Based on this, the relationship between the two types of knowledge is explored within the WP3 from different perspectives and in a multidisciplinary context; also, the general question of how knowledge relates to shaping the built environment is looked at and and how this knowledge is generated, structured and transferred within the context of digitalization.

2.0 Methodology and limitations

The investigations are mainly based on the output from the different activities performed during the project and especially the output from the Intensive Study Programs (ISPs). In order to structure this material, a set of research questions was formulated:

1. *What kind of knowledge did we collect in the project?*
2. *What methods were used for knowledge development / knowledge production?*
3. *What is the role of knowledge in multidisciplinary research and what is the role of a multidisciplinary approach in knowledge creation? How do we transfer knowledge between cultures, disciplines, technologies, methods, programs, practice, and science?*
4. *How and where can we anticipate the future demand of knowledge?*

The first question requires a historic review and a contextualization of the concept of knowledge (chapter 3.0). The examples selected after the literature review refer to an important discourse on knowledge with highlighted topics/sub-chapters: *The many faces of knowledge* by Bernt Gustavsson (chapter 3.1.), *The Nicomachean Ethics* by Aristotle (sub-chapter 3.1.2.), *The Concept of Mind* by Gilbert Ryle (chapter 3.1.3), *The Reflective Practitioner* by Donald Schön (chapter 3.1.4), Implicit, tacit and explicit knowledge (chapter 3.1.5).

The second and third question collect and compare different approaches to knowledge production (chapter 3.2), old vs. new knowledge production (sub-chapter 3.2.2), knowledge management (sub-chapter 3.2.3) and up-to-date approach to data collection, transfer and data analysis in knowledge generation (chapter 3.2.4). Formulated concepts explain the roles of disciplines in shaping the built environment.

Based on the material from the **BuildDigiCraft** (chapter 4.0), project case studies are selected to exemplify and discuss different approaches to knowledge: knowledge production (chapter 4.1), knowledge management (chapter 4.2) and students' perception of learning (chapter 4.3).

The fourth question uses the material to look into the future. This section reflects in general on discussed results from the project (chapter 4.4), highlights the future knowledge production, craftsmanship and the role of digitalization. The text specifically concerning the *Craft in a Digital Era* based on the lecture by Claes Caldenby held during the ISP1 phase discusses the necessity of re-identification of designers' work with the work of a craftsman (chapter 4.5), and a discourse is provided on Baukultur and the connection to the Davos Declaration (chapter 4.6).

Within the WP3, working guidelines for knowledge transfer to re-identify the work of the designer with the work of the craftsman are discussed in chapter 5.0 – Final reflections and guidelines.

3.0 Background theory

3.1 The many faces of knowledge

Contextualization of question 1

3.1.1 Introduction

The essay *The many faces of knowledge* by Bernt Gustavsson (2000) gives an overview of concepts of knowledge that spans from the three forms of knowledge formulated by Aristotle to contemporary discourses. He shows how Aristotle's three categories of knowledge – episteme (scientific knowledge), techne (knowledge of craft) and phronesis (ethical knowledge) – still hold relevance, not least for the application of knowledge in practice. For example, in the Swedish higher education system these three forms of knowledge have over decades been the framework for defining the criteria to be fulfilled for different academic exams.

A more commonly used conception of knowledge over the last centuries relates to the Platonic definition usually known under the term of episteme and from which the term epistemology stems. This definition of knowledge tells us that knowledge emerges from what we believe or hold to be true. What we believe is true must be supported by good arguments. The definition has its origin in the works of Plato and is based upon a distinction between *doxa*, to have a meaning or a sense of meaning, and *episteme*, to possess certain or objective knowledge. Gustavsson claims that epistemology has a dominant position in our understanding of knowledge in the Western world, specially in Anglo-Saxon philosophy.

However, the issue of practical knowledge has become a topic of increasing interest. With a background in different philosophical perspectives, the content of knowledge in different human activities has been explored, not least the relationship between the theoretical and the practical. Gustavsson brings forward Gilbert Ryle's distinction, first published in 1949, between *knowing that* and *knowing how*. The reflective practitioner, a term coined by Donald

Schön in 1983, was applied in conjunction with unspoken knowledge and knowledge in practice. At the same time, one further perspective of knowledge – practical wisdom based upon Aristoteles' tradition of ethics – has attracted the interest of researchers and thinkers. This form of knowledge has an ethical dimension, and it represents an alternative to other views.

3.1.2 The Nicomachean Ethics, Aristotle (384/322)

To understand the essence of knowledge, it is helpful to take a look at *The Nicomachean Ethics* by Aristotle. Aristotle agrees with Plato that knowledge is of what is true and that this truth must be justified in a way that shows that it must be true. Gustavsson (2000) explains how the Aristotelian conception of human knowledge focuses on a person's involvement in a number of activities or forms of life: episteme, techne, phronesis.

Episteme or theoria – represents scientific or proven knowledge and refers to understanding. *Techne or poesis* is used in connection with tacit knowledge or the reflective practitioner and represents the activity in which a person brings something into being that did not exist before (craft work, art, poetry). *Phronesis* refers to wisdom connected to and earned from practice. Phronesis is an ethically rooted kind of knowledge and can be understood as prudence, practical virtue and practical wisdom related to how practical action develops.

This conception of classifying human knowledge basically describes three different styles of thinking. And these three categories of knowledge are relevant even today. At the very beginning, for Aristotle, these types of knowledge were not structured hierarchically, they were not prioritized. Yet over time some types of knowledge were given more importance than others. For instance, *episteme* and *techne,* which root themselves greatly on facts and physical reality, are quite often given more practical value than *phronesis* is. This kind of priority setting, though in itself problematic, becomes indeed threatening when one branch of knowledge is entirely negated or diminished.

3.1.3 Knowing how and knowing that

In his book *The Concept of Mind* published in 1949, Gilbert Ryle (2002) introduces the terms *knowing how* and *knowing that*. The first refers to skills, to be able to perform certain actions, and the second to knowing how things are. Knowledge is seen as rational activity, but the two forms of knowledge are based on different kinds of rationality. Theoretical knowledge, to know that, is linked to logical conclusions. In a practical context, attention during the activity itself is the basis for the formation of knowledge. The knowledge is then tested by what we do. To *know how* thus means both what we can do and what we understand or have insight into when we act. Knowledge here means that we can perform a certain operation, a skill, and that we can explain what we have done.

3.1.4 Knowledge in practice

Architecture is a profession where knowledge is about the ability of taking well-grounded design decisions in complex situations. In *The Reflective Practitioner* (1983), the design theorist Donald Schön formulates the two fundamental concepts *"reflection-in-action"* and *"repertoire"* as essential elements of design work.

On *"reflection-in-action,"* he writes:

"A designer makes things. Sometimes he makes the final product; more often, he makes a representation – a plan, program, or image – of an artefact to be constructed by others. He works in particular situations, uses particular materials, and employs a distinctive medium and language. Typically, his making process is complex. There are more variables – kinds of possible moves, norms, and interrelationships of these – than can be represented in a finite model. Because of this complexity, the designer's moves tend, happily or unhappily, to produce consequences other than those intended. When this happens, the designer may take account of the unintended changes he has made in the situation by forming new appreciations and understandings and by making new moves. He shapes the situation, in accordance with his initial appreciation of it, the situation 'talks back,' and he responds to the situation's 'back-talk'."

The concept of "*repertoire*" is about the collection of impressions, ideas, examples and events that the designer consciously or unconsciously uses in his reflection. Donald Schön writes further:

"When a practitioner makes sense of a situation, he perceives to be unique, he sees it as something already present in his repertoire. To see this site as that one is not to subsume the first under a familiar category or rule. It is, rather, to see the unfamiliar, unique situation as both similar to and different from the familiar one, without at first being able to say similar or different with respect to what. The familiar situation functions as a precedent, or a metaphor, or … an exemplar for the unfamiliar one."

This kind of knowledge is closely related to the design process. It's individual and a result of experience, an extensive design practice based on reflection-in-action and a lifelong build of a personal repertoire.

3.1.5 Implicit, tacit and explicit knowledge

A contemporary approach defines knowledge as information that is relevant, actionable, and based at least partially on experience (Leonard & Sensiper, 1998). Three basic categories of knowledge are differentiated and depend on how the information is obtained: explicit, implicit, and tacit. Different categories interact in the information transfer process to form a model of communication, learning and development. Explicit knowledge is shared through combination and becomes tacit through internalization, while tacit knowledge is shared through socialization and becomes explicit through externalization.

Explicit or documented knowledge is the most basic form of knowledge and is easy to pass along since it is accessible by written means. When data is processed, organized, structured, and interpreted, explicit knowledge is obtained. Explicit knowledge is easy to articulate, record, communicate, and store.

Implicit or applied knowledge is the practical use of explicit knowledge, such as the necessity of performing a definite task. This could spark a conversation between the partners about the options or methods of completing the task regarding the expected outcomes, leading to a well-founded determination of the best course of action to take. A team member's implicit knowledge would educate the conversation on how to do something and what could happen. Additionally, the best practices and transferable skills obtained from a task to a different task are examples of implicit knowledge.

Tacit or understood knowledge is personal knowledge gained from personal experience and context. This is the knowledge that, if asked, would be difficult to explain, articulate or present in tangible form. Tacit knowledge is the application of implicit knowledge specific to a person's needs, so it is a significant resource for many activities, especially innovation. The tacit dimensions of individual knowledge are not publicly available unless embodied in the people being recruited. The tacit dimensions of collective knowledge are woven into the organization's structure and are not easy to imitate. Therefore, tacit knowledge is a source of competitive advantage. The creativity required for innovation stems not only from evident expertise but also from an invisible source of experience.

3.2 Approaches to knowledge production

Contextualization of question 2 and 3

3.2.1 Introduction

A reflection by Roode Liias, Tallinn

When we think about the pyramids in Egypt, for example, we know that they were built up to 5,000 years ago. So the facts and data about these structures have been there ever since then – the researchers and even the general public (e.g., tourists) have had the possibility to see these artefacts and admire the quality of engineering from ancient times. The textbooks about history and about the pyramids have provided full details on how these artefacts, consisting of millions of stony blocks, were built. Though there are several unanswered questions about how in fact the pyramids were erected, the content of these books has become our common knowledge about construction processes – including the construction process of pyramids and also about how the structure developed.

New survey technologies based on laser scanning have made it possible to study the structures of the pyramids in depth, and it emerges that quite often only the envelope structures consist of solid stone blocks. Also, smaller pieces of stones were used to fill in the main body of the pyramids. Scanning the river Nile and the desert around the pyramids has provided more and more information about the logistics of transporting and prefabricating the blocks and also about the working conditions and technology used on the construction sites. Accordingly, the deeper study of artefacts allows us to uncover new information, and the amount of new knowledge on the objects of study has rapidly increased in society. To acquire and produce new knowledge, new data and information first have to be found.
Not only new data is needed, but we also have to use the existing – though sometimes rather defective – knowledge that provides reasonable new interpretation possibilities.

Following Aristotle's classification of knowledge, we now have scientific knowledge and based on it, we try to explain everything we have around us. Today, all engineers can explain – with scientific knowledge as the premise – how a pyramid must be built to guarantee stability of the structure. But the next step is based on the question of how these artefacts were in fact created. To this end, we use our knowledge of craft (*techne*) – the logic of how things are normally developed. Experts start to furnish this gap in our knowledge – how moving and lifting these heavy blocks was possible – with the common know-how about different technologies. And finally, we use our ethical knowledge about the society of those times and try to generate the bigger picture of how the construction works were achieved – what were the working conditions and tools, what did the workers eat and where were they accommodated?

Therefore, deeper studies of the major artefacts and various smaller objects together with the critical interpretation of existing knowledge give us the chance to develop common knowledge for society. Common knowledge is accessible to everyone in society and used by all – based on our common knowledge, we educate our children and our society as a whole. In order to create this common knowledge, researchers have to actively use all the contemporary methods and tools for picking up new information and sharing it in society and to the public.

3.2.2 Knowledge production

Approach 1 for knowledge production

Old vs. new knowledge production (by Cooper, Klein and Bunders according to Gibbons)

The concept of knowledge production in building cultures is evolving. There are serious challenges involved in achieving sustainable development when collaborating communities, researchers and decision-makers increasingly seek to tackle problems that require both specialized knowledge and integrative skills to cope with complexity.

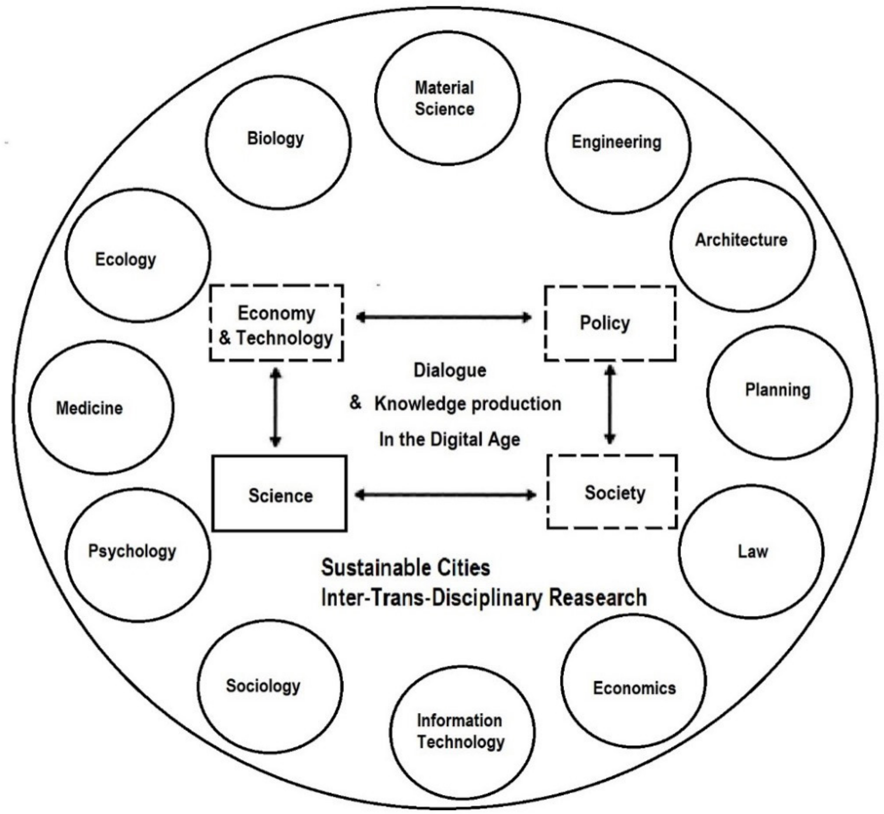
The perspectives on knowledge production have evolved especially over the last five decades when science has been facing the growing complexity of real-world problems, social relevance and demand for collaboration between researchers, new research questions going beyond one discipline (Klein, 2015). A new social distribution of knowledge is occurring as a wider range of organizations and stakeholders contribute skills and expertise to problem-solving (Fig[●1]).

In 1994 Gibbons and colleagues (Gibbons et al., 1994) proposed that a new mode of knowledge production was fostering synthetic reconfiguration and recontextualization of knowledge. The concept of "*knowledge production*" understood as academic, investigator-initiated and discipline-based (labeled "Mode 1") has been challenged by a new concept due to an urgent need for rethinking science and its relationship to society. The "old" knowledge was characterized by theory-building and testing within a discipline toward the aim of universal knowledge, while the "new" knowledge (labeled as Mode 2) is generated in the context of application, much greater diversity of the sites and types of knowledge produced. In the discourse of knowledge production, the complementarity of Mode 2 transdisciplinarity develops a distinct but evolving framework to guide problem-solving efforts beyond disciplines. Though it has emerged from a particular context of application, transdisciplinary knowledge develops its own distinctly theoretical structures, research methods and modes of practice. In 2001, however, Nowotny, Gibbons and Scott extended Mode 2 theory in arguing that contextualization of problems requires participation in the agora of public debate (Nowotny et al., 2003).

Cooper (2002) after Nowotny et al. (2001) argued that science had become central to the generation of wealth and well-being, resulting even more than in the past in the production of knowledge becoming a social activity, both highly disseminated and very reflexive. Cooper after Gibbons et al. distinguished old vs. new knowledge production in the context of new global trends influencing research, like sustainable development, virtual organizations and the rise of "e-science" as well as public (including media) involvement in knowledge production.

The discourse of knowledge production for problem-solving is not new. It was fundamental to conceptions of interdisciplinarity in the first half of the 20th century (Klein, 2015). There was a growing pressure to solve problems raised from society and a more important position of transdisciplinarity (TD) with solving complex problems, "trans-sector participation" of stakeholders in society and "team-based science." Demands for TD arrived along with a wider crisis in the benefiting of dominant forms of knowledge, responsiveness to human rights accountability, and democratic participation.

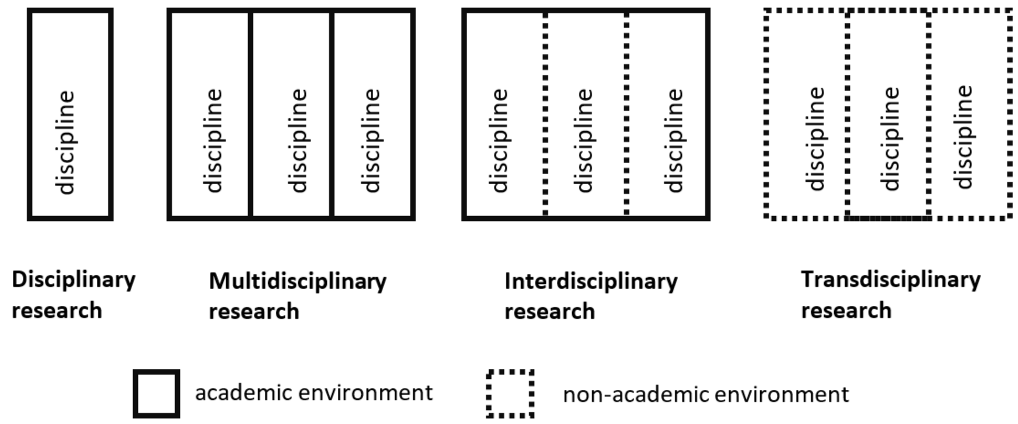
As a consequence, a shift is observed today from solely "reliable scientific knowledge" to inclusion of "socially robust knowledge" that transgresses the expert/lay dichotomy.



Fig[● 1] View of different processes involved in knowledge production (based on Klein et al., 2001, and Cooper, 2002, and modified by A. Kaczorowska).

The new trends in knowledge production include fostering new collaborations not only between disciplines in the academic context, but also partnerships between the academy and society, including non-academic partners. A distinction between disciplinary, multidisciplinary, interdisciplinary and transdisciplinary research is shown in Fig[● 2] (HafenCity University, 2018).

Multidisciplinary and interdisciplinary research can be seen as continuum between monodisciplinary research and transdisciplinary research. Transdisciplinary research developed mainly during the 1980s and early 1990s (Bunders et al., 2010). Klein (2001) defines transdisciplinarity as: *"a new form of learning and*



Fig[● 2] Visualization of different types of research in relation to disciplines involved in the academic and non-academic context (HafenCity University, 2018).

problem-solving involving co-operation between different parts of society and science to meet complex challenges of society. Transdisciplinary research starts from tangible, real-world problems. Solutions are devised in collaboration with multiple stakeholders." Transdisciplinary research is rooted in local scientific, cultural, and political practices that differ for each country.

The notion of hybridization of knowledge production and modes of inquiry in architecture and urban planning became a widespread and intensively debated issue within the scientific and academic communities at the beginning of the millennium (Doucet & Janssens, 2011). Transdisciplinarity explores new fields of investigation and research. So-called "hybrids" of knowledge production are often formed in gaps between sub-disciplines. Doucet and Janssen argue that new hybrid modes of inquiry, practice and learning have the capacity to overcome past splits of theory, history, and practice. Transdisciplinarity in architectural or urban design involves ethics, aesthetics and creativity inside of disciplinary and professional work, incorporated with social and political, normative, and ethical questions. New objects are brought into view in knowledge production, like practices in new configurations that contextualize and reassess both theory and learning, including the understanding of the general public. Klein (2014) argues that a transdisciplinary vision of architecture, urbanism and design according to Doucet & Janssens (2011) joins the epistemological perspective of systems theory with an "in-practice model" of design and learning. "Hybridization" also recognizes the greater relationality of knowledge today. Tasks lie at the boundaries and in the spaces between systems and sub-systems, requiring collaboration among a mix of actors.

Bunders et al. (2010) provides a foundation for "*knowledge democracy*," when ideal conditions allow dominant and non-dominant actors to have equal access and the ability to bring this knowledge forward to contribute to solutions for societal problems. He distinguishes different approaches to knowledge production:

1. **The self-referential knowledge production style** (mono-, multi- and interdisciplinary academic research) – might consider questionnaires or polls from the stakeholder groups related to the issue. These research projects certainly develop the academic expert's view on the issue.
2. **The knowledge dissemination style** – can be described as a process in which knowledge is transferred to the wider public and disseminated in relation to different activities, for example by promoting improvements in lifestyle.
3. **The mutual learning for knowledge production between scientists and societal actors' style** – allows a joint analysis by societal decision-makers and the public with academic researchers to tackle complex multi-stakeholder problems.
4. **The knowledge co-creation between scientists and societal actors, with specific focus on non-dominant actors' style** – is captured in the Interactive Learning and Action (ILA) approach that covers cyclic multi-phase programs often over a longer period with dominant and non-dominant actors supported by the transdisciplinary researchers.

The new knowledge production requires diverse types of action. Building on Cooper (2002), Bunders et al. (2010), and Klein (2015) after Gibbons et al. (1994), it is possible to characterize new knowledge production in comparison to the old way (Table[● 1]). New features include, for example, collaboration of at least two or more disciplines, dissemination and partnerships through networks, e-science and interaction electronically mediated, application-based problem-solving, consensual and negotiated knowledge production, innovation predominantly through reconfiguring existing knowledge. While Cooper (2002) addresses interdisciplinary knowledge production, Bunders et al. (2010) and Klein (2015) refer to transdisciplinary work, building on Gibbons et al. and Mode 2 (1994).

The context of knowledge production includes for example the commercialization of research, the development of mass higher education, the growing role of the humanities in the production of knowledge, globalization (world brands and massive data flows), etc. (Nowotny et al., 2003). "Knowledge" is sometimes viewed not as a public good, but rather as "intellectual property." Knowledge is often produced, accumulated and traded like other goods and services in the knowledge society. In the process, a new language has been invented – a language of knowledge application, relevance, contextualization, reach-out, transfer and management.

3.2.3 Knowledge management

Approach 2 for knowledge production

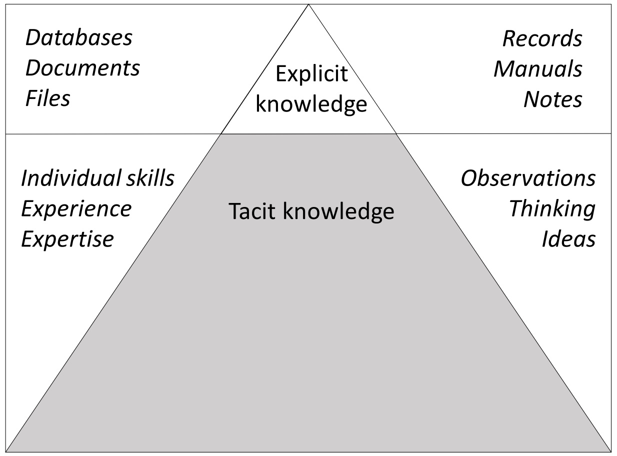
Knowledge management (also used as a term for knowledge exchange) is the process of creating, sharing, using and managing knowledge (Smith & Hairstans, 2017, after Girard & Girard, 2015). This process requires different approaches when including different types of knowledge. There is a lot of explicit knowledge to be found in codes, publications, in people and organizations. Still, the majority of knowledge regarding the built environment, including construction, is implicit and tacit.

Explicit knowledge in form of data, records, and documents, for example (in academia: journal publications, databases, books, websites and videos) is relatively easy to disseminate. On the contrary, tacit knowledge is difficult to transfer by means of writing or speaking. It is embedded in people, organizations, societies, and cultures. It comes from experience, thinking, competence, and commitment. In academia, tacit knowledge is found in workshops, conference discussions, internships, and exchanges. Fig[●3]

Table [●1] Old vs. new knowledge adopted from Cooper (2002), after Bunders et al. (2010) and Klein (2015) after Gibbons et al. (1994).

Old knowledge production	New knowledge production in the digital era
Disciplines and dissemination	
Single discipline-based	Inter-/transdisciplinary, involving a diverse range of specialists, academics and non-academics, self-referential knowledge production style, incorporates ethics, aesthetics and creativity inside of disciplinary and professional work, transdisciplinary closely involves design professions
Problem formulation governed by interests of specific community	Problem formulation governed not only by interests of actors involved in application but also broader interests of society, incorporated with social and political, normative and ethical questions
Dissemination discipline-based through institutional channels	Dissemination through collaborating partners and social networks; public debate encouraging improvements in lifestyle and behavior
Organizations and interaction	
Mediated through face-to-face or paper-based communications	The rise of "e-science," interaction electronically mediated over the Internet and digital platforms
Quasi-permanent, institutionally-based teams	Short-lived, problem-defined, changing participants, non-institutional or mixed teams
Hierarchical and conservative team organization	(Non-) hierarchical and temporary team organization
Static research practitioners operating within discipline/institution	Mobile research practitioners operating through networks, institutional and non-institutional channels
Problem-solving, science model, knowledge production and application	
Problems set and solved in (largely) academic context	Problems set and solved in application-based context
Newtonian model of science specific to field of inquiry	Emergent theoretical/conceptual framework not reducible to single discipline, knowledge co-creation between scientists and societal actors, hybridization
Separate knowledge production and application	Integrated knowledge production and application via testing, building models, places practices in new configurations, contextualizes and repositions both theory and learning
Research practice and approach to innovation	
Research practice conforms to norms of discipline's definition of scientific accountability	Research practice reflexive and socially accountable, mutual learning for knowledge production between scientists and societal actors
Static research practice defined by "good science"	Dynamic research practice characterized by on the move problem-solving, joint problem formulation between scientific and societal actors
Normative, rule-based, "scientific" knowledge produced	Consensual, continuously negotiated knowledge, produced "experience"
"Innovation" seen as production of "new" knowledge	"Innovation" also seen as reconfiguration of existing knowledge for new contexts, scientifically certified and action-oriented knowledge, hybridization of knowledge production, entrepreneurship

shows that explicit knowledge, knowing the that, what and why, constitutes an estimated 10 percent of our knowledge repository as humans, while tacit knowledge, knowing who and how, makes up 90 percent of our total knowledge base (Smith & Hairstans, 2017, after Wah, 1999; Bonner, 2000; Lee, 2000).



Fig[● 3] Shares of types of knowledge: explicit and tacit /implicit (drawn after Smith & Hairstans, 2017).

Explicit and tacit are not separate modes of knowledge but function as a continuum (Smith & Hairstans, 2017). It is necessary to explore the concept of knowledge conversion, sometimes referred to as knowledge transfer, where knowledge is exchanged from one type to another. Explicit knowledge can be transferred to other explicit knowledge – this is called a "combination." Knowledge is a human function and when people internalize the knowledge, making it part of their activity, they contribute to "internalization" when explicit knowledge is transferred to tacit conversion. Communicating knowledge in spoken or written form is to converse tacit knowledge to explicit knowledge and is called "externalization." Lastly, tacit to tacit forms of transfer are referred to as "socialization" and tend to be informal – experienced in the very act of doing (Table[● 2]).

The contemporary role of academia has changed as it serves as a facilitator of emerging modes of learning, knowledge production and knowledge exchange as described by Smith & Hairstans (2017) after Youtie and Shapira (2008). The new role of universities to advance technological

Table [● 2] Knowledge conversion scenarios and terms (drawn after Smith & Hairstans, 2017).

KNOWLEDGE CONVERSION	TERM
EXPLICIT TO EXPLICIT	COMBINATION
EXPLICIT TO TACIT	INTERNALIZATION
TACIT TO EXPLICIT	EXTERNALIZATION
TAICIT TO TACIT	SOCIALIZATION

innovation and economic development as "knowledge hub" defines a change for many universities from the late 20th century until now. It seeks to animate indigenous development and innovation, spanning between industry, the government and society. High-performing institutions are those which effectively advance, distribute and recombine tacit knowledge. Some universities in parallel also serve like a 19th century "storehouse of knowledge," or a "knowledge factory" for research, training and commercialization (late 19th century to the end of the 20th century).

APPROACH	TIME & CONTEXT	ROLE OF THE UNIVERSITY IN SOCIETY
TRADITIONAL	Prior to XIX C. / CRAFT PRODUCTION	Storehouse of existing historic knowledge by elitist group above society.
SUPLIER	XIX C.- late XX C. / INDUSTRIAL MASS PRODUCTION	University seen as a factory of knowledge that supplies research, education, fulfils commercial purposes, and contributes to development of new technologies.
HUB	Late XX C. – present /POST-INDUSTRIAL ECONOMY	Integrated institution in the region creating synergies with industry, government and society.

Table [● 3] Transformation of the university's role in society (drawn after Smith & Hairstans, 2017).

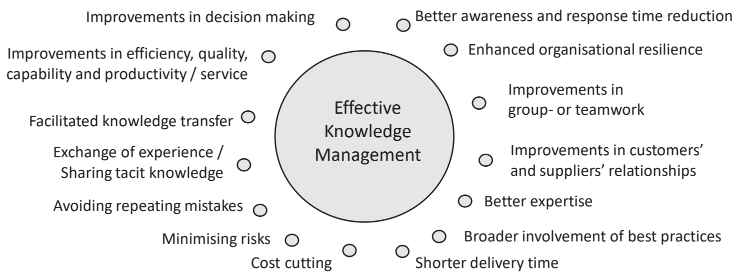
Community and non-governmental organizations (NGOs) play a special role in knowledge exchange fostering innovation in a particular sector or interest area. The contemporary role of academia has changed as it serves as a facilitator of emerging modes of learning, knowledge production and knowledge exchange.

Effective knowledge management can be seen as a key driver to increase organizational competitiveness. The future will value effective knowledge management (transfer of knowledge) if it becomes a key survival aspect for an organization to keep its competitiveness. It has been shown by various studies that poor project (activity)

B1	Efficiency improvement
B2	Quality improvement
B3	Time reduction (response time reduction)
B4	Delivery time reduction
B5	Decision-making improvement
B6	Employees' experience exchange/facilitate transfer of knowledge
B7	Product/service improvement
B8	Customers' and suppliers' relationship improvement
B9	Costs cuts/reduced costs
B10	Group/teamwork improvement
B11	Reducing rework
B12	Improve capability and productivity
B13	Better expert judgement
B14	Continuous improvement
B15	Reducing the cost of poor quality
B16	Avoid repeating past mistakes
B17	Retain tacit knowledge
B18	Minimise risk
B19	Better response to organisation changes
B20	Better sharing of best practices

Fig[● 4] Sample benefits from effective knowledge management as provided by Yap et al., 2022.

performance is linked with a lack of knowledge and/or ineffective learning. When single project failures are combined, low productivity, capability gaps, poor performance, higher learning costs are the result. By applying knowledge management at the appropriate moment (not in the distant future), that kind of loss can be avoided. Several benefits can be named that are dependent on effective knowledge management as provided by Yap et al. (2022, see Fig[● 4]).



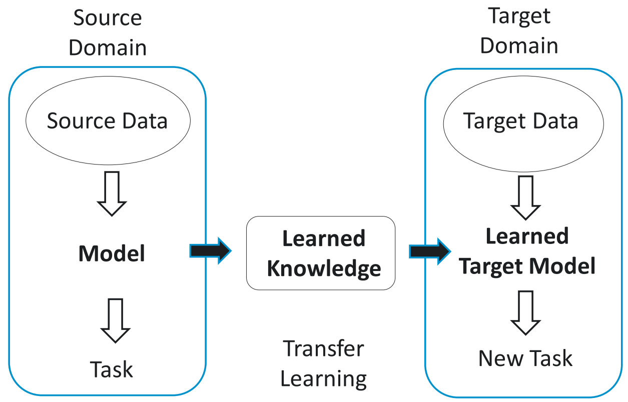
Fig[● 5] Sample benefits from effective knowledge management (drawn after Yap et al., 2022).

3.2.4 Up-to-date approach to data collection, transfer and data analysis in knowledge generation

Approach 3 for knowledge production)

To be able to use the collected knowledge, we need to find the right methods and tools to be able to transfer it. Knowledge transfer is not a copy and paste approach, you need to take account of new perspectives, mapping technologies, assumptions. It is especially important when new knowledge is based on big data analytics: how to reuse the knowledge acquired and how current knowledge can be extended. Fig[● 6] by Xu et al (2022) shows the basic transfer process of knowledge (learning). In the construction sector, there are project-based workflows; knowledge transfer rarely happens in between projects.

Collecting large amounts of qualitative data and working with different data sets involves several aspects of research,



Fig[● 6] Transferring learning from source domain into target domain (drawn after Xu et al, 2022).

such as comparison and generalization. The merging of data from several qualitative studies offers opportunities to address new research issues by comparing research differences. This comparison can be achieved using metadata, for example, about the focus of research. Some sets allow comparing differences in disciplines. Researchers can ask questions that individual projects would not be able to answer.

Knowledge production in the digital era can be a tacit experience. Knowledge and skills are considered to be key human capital elements of transforming and building a sustainable environment (Modesitt, 2016). Due to the growing complexity and digitalization in disciplines involved in shaping the built environment there is a need to rethink knowledge production in relation to craftsmanship and contemporary challenges. Digital technology (software of immaterial design with immaterial making) is eliminating the separation between design and making that had existed since Leon Battista Alberti and the renaissance. Knowledge production in architecture is often linked to seamlessly produced "experience" rather than just artefacts. Here, architects have been turning to software developed for other fields. Modesitt argues that digital workflows can re-engage craftsmanship and connect design intelligence with material intelligence.

4.0 Knowledge in the BuildDigiCraft project

Knowledge in the **BuildDigiCraft** project has been identified as one of three major elements of high-quality Baukultur together with Process and Material. Planning, design and maintenance of our built environment is driven by knowledge gained through experience, facts and perception and is available as explicit and implicit knowledge. It also includes tacit knowledge, which encompasses work by hand as well as mind. Therefore, Knowledge was integrated as a major subject in the **BuildDigiCraft** structure. The concept of Knowledge in relation to Baukultur was explored during the project from different perspectives – through input from various lecturers to individual and joint exercises where the participating PhD students elaborated and reflected upon what knowledge, knowledge production and knowledge transfer is and could be. Special attention was paid to craftsmanship in a digital environment; how digital tools can support the integration of implicit knowledge into explicit knowledge, including the aim of transfer and creation of cultural values. Three perspectives of knowledge, gained from the **BuildDigiCraft** project, will in the following be presented. They are chosen with the aim to shape a picture of the **BuildDigiCraft** process as well as to provide a basis for final reflections and guidelines.

The first view shows examples of students' work that relate to questions of what and why knowledge is produced and how this work contributes to knowledge production. As the participating students came from different research discourses, mainly from research groups in architecture and in engineering in the Nordic/Baltic context, the discussions during the smaller workshops and the common seminars covered quite a broad spectrum. This broad output was organized in terms of what, how, and why knowledge is produced and is relevant for a sustainable Baukultur. The second view exemplifies how students approach knowledge management and conversion of knowledge (explicit, tacit, implicit). The third perspective specifically points at the difficulties in distinguishing knowledge from information, especially in a digital context where the data and digital information is perceived by many as knowledge. Here, a demand for future knowledge is presented by students and exemplified. A fourth view is related to the concept of knowledge and learning by students. Finally, a fifth view, formulated by the invited lecturer Claes Caldenby, professor emeritus in Theory and History of Architecture at Chalmers, looks ahead and discusses the concept knowledge in relation to the design situations in which the wise decisions that shape our built environment are taken.

4.1 Views of knowledge production

Analysis by Anna Kaczorowska, Chalmers

This analysis is based on material collected during the Intensive Study Programs (ISPs) that includes individual students' pre-tasks, lectures, group works and seminars, and work with a compiled glossary. A framework of criteria of new knowledge production after Cooper (2002), Bunders (2010) and Klein (2015) has been used to organize the material. The aim was to answer the questions what, why and how with regards to students' approaches to knowledge production, represented in the project material and addressing following trends:

1. Applied knowledge production with a focus on innovation (application-based problem-solving, emergent conceptual frameworks, innovation through reconfiguring existing knowledge) – **WHAT knowledge is produced**?
2. Multi-/inter-/transdisciplinary knowledge production in transient and problem-defined teams, virtual organizations and platforms (dissemination through partners and networks, development of "e-science" and e-knowledge production, interaction electronically mediated over the Internet) – **HOW knowledge is produced?**
3. Socially consensual and negotiated knowledge production, co-production (public realm, knowledge production highly disseminated and very reflexive) – **WHY knowledge production is important or relevant?**

Special attention has been paid to material from three explicit tasks given to the students (PhD students and a minor group of M.Sc. students):

- **ISP2**: Reflections on *Knowledge transfer* after the keynote lecture: *"Big or small data for big and small problems?"* by Helle Rootzen. (16 students)
- **ISP2**: Reflections on *Knowledge & Data Analysis*. (16 students, four groups)
- **ISP3**: Reflections on the relation *Process, Knowledge, and Material* in relation to own PhD/M.Sc. projects. (15 students)

The content of the tasks was provided to students as follows:

"Knowledge Transfer and Data Analysis"

Pre-task 4: Assignment (ISP2)

Keynote lecture: *"Big or small data for big and small problems?"*
by Helle Rootzen, Feb. 18, 9:00–10:00 a.m.

1. Think on a situation where you are aware of how data analysis made a project better. Why was it better? Please look at different sources like papers, books, the Internet to find a good example.
2. In the context of your own projects: what is the data you use? How do you identify and acquire this data? How do you use it? How do you (plan to) interpret/evaluate it?
3. During the keynote lecture by Helle Rootzen have in mind the following question: how can you see that the principles and ideas that Helle talks about could be used in your own project, and what would be the benefits?

ISP 2, Day 4 Knowledge, Group work and presentation of the Preparatory task 1 *"Knowledge Transfer and Data Analysis"*

Mapping Guidelines:

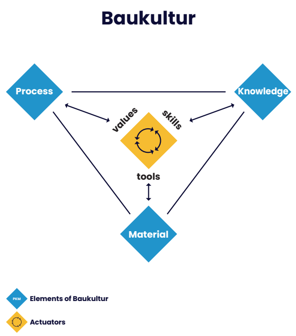
1. Present to each other your Preparatory task *"Knowledge Transfer and Data Analysis."*
2. Group work: collect and categorize together as a group the advantages and disadvantages identified by your examples on how data analysis made a project better.
3. Contribution to the Glossary: focus on the concepts of *Knowledge, Data and Data Analysis.*
4. The group speakers present the outcomes of the Group work task to the audience.

"Process—Knowledge—Material—Reflection"

Pre-task 1: Assignment (ISP3)

Reflect on your individual project (PhD project/Master's thesis/project of personal interest) in respect to the **BuildDigiCraft** graph model (Fig[● 7]).

Analyze and reflect on your individual project by answering the following questions:



Fig[● 7] **BuildDigiCraft** graph model.

1. What is the Process, what is the Material and what is the Knowledge that you are addressing and using in your (PhD) project, and what is the Process, Knowledge, and Material that you would like to derive from it?
2. How do you see the relation between the Process, Knowledge, and Material in the context of your work?
3. What are the values you are following/addressing in your project?
4. Which skills are you applying and which are the new skills that you are developing within your project?
5. What tools do you use and plan to use?
6. Try to define the term Baukultur in your own words and in respect to your individual project.

Table[● 4] exemplifies how the students responded to the questions: WHAT was the knowledge production, HOW was knowledge produced and WHY was knowledge production important and relevant?

WHAT – knowledge is produced?

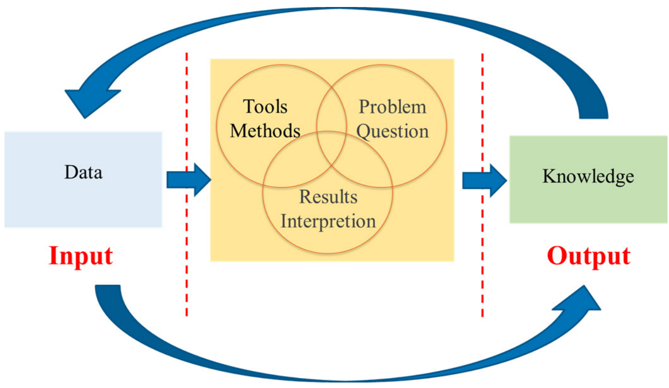
The exemplified students' projects (PhD or advanced Master's thesis) showed a variety of approaches to knowledge production. For most of the students, the aim for knowledge production had a strong link to a possible application. In answer to the question "WHAT knowledge production?", the students' projects addressed emergent, not sufficiently discussed or recently debated topics, often calling for innovation through reconfiguring existing knowledge. Their projects adopted the relation between the physical and the digital world easily and there doesn't seem to be anything questionable in knowledge production. Debatable was what kind of knowledge was able to be

Table [● 4] Evaluation of the material from Preparatory tasks in relation to knowledge production and questions: what, how, and why?

ISP/Tasks	WHAT – knowledge is produced?	HOW – knowledge is produced?	WHY – knowledge production is important and relevant?
	(E.g.: applied knowledge production with a focus on innovation/application-based problem-solving, emergent conceptual frameworks, innovation through reconfiguring existing knowledge)	(E.g.: multi-/inter-/transdisciplinary knowledge production in transient and problem-defined teams, virtual organizations and platforms/ dissemination through partners and networks, development of "e-science" and e-knowledge production, interaction electronically mediated over the Internet)	(E.g.: socially consensual and negotiated knowledge production, co-production/public realm, knowledge production highly disseminated and very reflexive)
ISP 2 / Pre-task 4 *"Knowledge Transfer"*	Knowledge from data analysis: digital analysis of data in *"Survey, construction, conservation, and restoration," "The possibility of recording current state of construction of building with efficient, fast, non-invasive techniques,"* this knowledge *"enables more complete studies and accurate interventions"* – **PhD student 1**, Gdańsk *"2D image analysis"* – **PhD student 2**, Riga *"The essential geometrical, structural, and architectural potentials, limits, and qualities"* of *"the behavior of phenomenon of concaved paper and blade of measuring meter"* – **M.Sc. student**, Helsinki Reconfiguring existing knowledge from data analysis *"GIS with remote sensing"* to get the data from the existing situations – **PhD student 1**, Helsinki Modeling impact of scenarios in urban planning – **PhD student 2**, Gdańsk *"Applying machine-learning to optimize architectural design"* – **PhD student**, Tallinn Digital modeling "To understand the real-world problems" – **PhD student 3**, Gdańsk & **PhD student 1 DTU**, Copenhagen	*"Devising new hybrid disciplines and operations between design and science that advance the prospect of establishing future biophilic environments"* – **PhD student 1**, Gdańsk Elaborated *"physical and digital studies"* – **M.Sc. student**, Helsinki *"Generating new physical or digital prototypes"* – **PhD student 1**, Helsinki e-data from sensors collected and analyzed – **PhD student 1**, Helsinki *"Provide quantitative analysis"* – **PhD student 1**, Gdańsk Modeling and simulations – **PhD student**, Tallinn *"BIM modeling"* – **PhD student 1**, Gdańsk *"Assessment of sustainability performance"* of buildings – **PhD student 1 DTU**, Copenhagen *"Data analysis from design to build"* – **PhD student 2**, Helsinki	*"To optimize the performance of form, material and cost"* – **PhD student 1**, Gdańsk *"The bind between making digital architecture and making resilient architecture must be secured for holistic and sustainable outcomes"* – **PhD student 1**, Gdańsk *"To simplify"* – **PhD student 2**, Riga *"To collect (data) and evaluate (...) in possible outputs"* – **PhD student 1**, Helsinki & **PhD student 1 DTU**, Copenhagen *"To evaluate behavior"* – **PhD student 1**, Helsinki *"Demonstrations of the impact of scenarios and Informing decision-makers"* – **PhD student 2**, Gdańsk *"Designing measurable, clear and concise questions/qualify or disqualify potential solutions to specific problem or opportunity"* – **PhD student**, Tallinn To diagnose *"Find the most problematic areas"* – **PhD student 3**, Gdańsk *"To understand state of the art"* – **PhD student 2**, Tallinn

ISP/Tasks	WHAT – knowledge is produced?	HOW – knowledge is produced?	WHY – knowledge production is important and relevant?
ISP 2 / Day 4 Knowledge, Group work and presentation of the Preparatory task 4 (ISP2) *"Knowledge and Data Analysis"*	Group 1, Specific research questions: *"How to improve the buildings? How to analyze the proposed change without the actual building?"* Group 3: *"Design specific solution with only required data about form, cost and material"* Group 4: *"Gathering knowledge about addressing wicked issues," "Data vs. Knowledge"* Group 5: what knowledge from e-data? *"The acquired data needs to be interpreted by the skilled researcher who with his/her knowledge will discover, read, research the object"*	Group 1: "Model of variables and its impact on future energy consumption and spending based on previous data collected Group 3: experiments: *"Optimization, testing hypothesis vs. theory", "Forming a hypothesis before testing, then analyzing data and forming a conclusion"* Group 4: *"Statistical models and solutions, applying machines (artificial intelligence, machine learning, deep learning)"*	Group 1: *"Minimizing energy consumption in a building"* Group 3: *"New specializations and new collaborations"* Group 4: *"Knowledge = Wisdom"* Group 4: *"Data vs. Knowledge"*
ISP3 / Pre-task 1: *"Process – Knowledge – Material – Reflection"* in relation to individual project (PhD project / Master's thesis)	*"How to deal with rising water level"* – **PhD student**, Gdańsk *"Local knowledge on adaptation of digital paradigm and local craft"* – **M.Sc. student**, Hamburg *"Finding principles for design and fabrication of timber active bending structures using material behavior"* – **PhD student 1**, Innsbruck *"Wood science and structural engineering"* – **PhD student 1**, Helsinki *"Adaptability"* – **PhD student 2**, Innsbruck *"Achievability of adopting a circular economy in the built environment"* – **PhD student 2**, Helsinki	*"New tools are very helpful for researching how cultural landscape is being re-modelled"* – **PhD student**, Gdańsk *"Community-oriented"* exploration of *"off-grid housing scalable solutions"* – **M.Sc**, student, Hamburg Exploration and testing different joints, patterns, on form and placement, dimensions, literature study, *"Computational tools and programming (simulation tools, structural analysis applications) and physical tests"* – **PhD student 1**, Innsbruck *"Material selection, experimental investigation, Design" "Structural analysis, architectural design (integrated design concept), sustainable design, parametric design."* – **PhD student 1**, Helsinki *"Negotiations between disciplines"* – **PhD student 2**, Innsbruck *"To evolve and develop the existing models and framework; to come up with new frameworks or models," "Case-studying, field-studying and investigating the current, construction and architecture practices and projects"* – **PhD student 2**, Helsinki	*"Resilience = modern water society"* – **PhD student**, Gdańsk *"Bridging vernacular architecture with more technological systems," "Baukultur = standardization of best practices in construction by balancing social, ecological and economical aspects boosting a culture of continuous improvement"* – **M.Sc. student**, Hamburg *"Reducing the cost and energy for making forms using designed elements, assembled and dissembled, and shaping different forms"* – **PhD student 1**, Innsbruck *"Value: sustainability, structural efficiency, integrated architectural and structural design concept, wood-only connection"* – **PhD student 1**, Helsinki *"Adaptability refers to the need to reach balance between the selection of a specific behavior and the consideration of a large variety of behaviors"* – **PhD student 2**, Innsbruck

obtained from digital data ("What knowledge from e-data?", Group 5, Workshop on Day 4, ISP2, Fig[● 8]). Fig[● 8] showed the students' awareness of the distinction between data and knowledge and how data through a scientific craftsmanship can be transformed into knowledge.

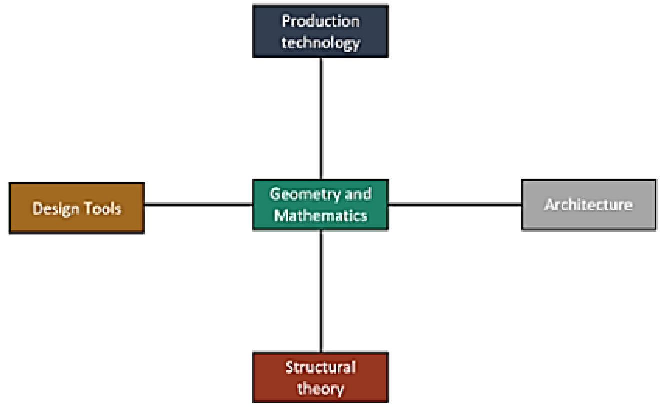


Fig[● 8] "Data vs. Knowledge" (source: Group 4, ISP2 Workshop, Task 1).

The debatable aspects of e-data related to the importance of qualities building digital work and decisions creating possibly the most reliable implications for the physical objects and places. The problem formulation is governed by broader interests of society. Projects addressed multidisciplinary, inter-/transdisciplinary aspects.

One PhD work discussed the mathematical breakthrough in geometry and how it had led to new opportunities to understand the physical world surrounding us. With inspiration from history, where geometry was a main precondition for many of our historic built masterpieces, he wished to resurrect geometry in architecture and engineering, and specifically for the use of accessible simple building blocks. Different mathematical representations have advantages and disadvantages in different situations since their underlying mathematical foundation allow for different types of manipulation, flexibility, and relaxation of physical constraints in the structural assembly, for example.

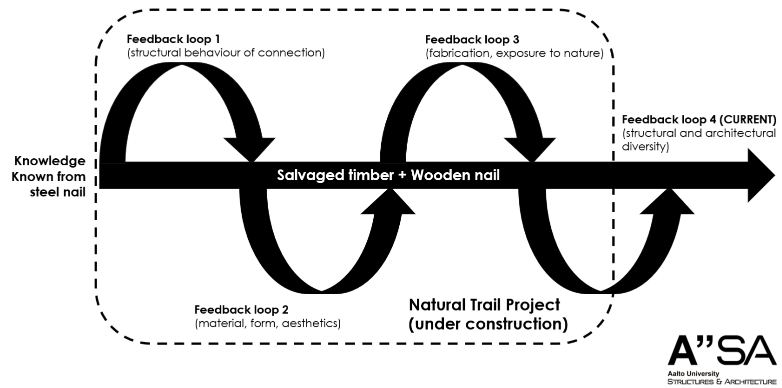
The concept of Knowledge in the PhD project was organized by seeing geometry as the basis connecting the different areas of knowledge and expertise (Fig[● 9]).



Fig[● 9] Areas of knowledge development and expertise selected for PhD project (author E. Adiels).

HOW – knowledge is produced?

Knowledge production was observed as being highly integrated and applied. The HOW was achieved by testing, building models, placing practices in new configurations, contextualizing, and repositioning both theory and learning. Digital tools were used in every project and included a variety of approaches for analysis, modeling, simulation, etc. The level of digitalization considered to be applied in projects seems to be very high and inspiring. Much work is still based on testing and experiments, where visualization plays an important role (Fig[● 10]). Additionally, knowledge production is based on "*negotiations between disciplines*" (PhD student 2, Innsbruck, ISP3, Pre-task 1).

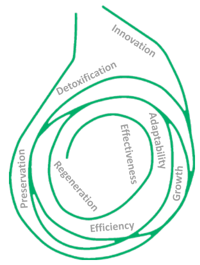


Fig[● 10] Optimization, testing hypothesis vs. theory (source: PhD student, Helsinki, ISP4, Preparatory task 1).

Table [● 5] Knowledge and digital futures: correlation between data, questions and models (source: students' work at the Workshop ISP2, Day 4: Knowledge, Group 1).

Data	Data	Questions	Models
Ilirjana	Spatial data User-generated data	1. How do we examine the changes of the urban morphology? 2. How are digital tools/data shaping policies and development strategies for the built environment?	Urban scenarios Digital modeling to address challenges and predict social, economic, environmental and sustainability performance of the built environment
Theo	More of qualitative data than quantitative (mixed methods). From interviews, focus groups and questionnaire questions (mostly open-ended)	Main: how can BIM be leveraged for construction management education?	Model 1: search engine query to identify relevant literature. Model 2 (theory): existing BIM-enabled strategies
Sepideh	Data derived from structural analysis Force flows in the structure	How could structural analysis help in improving the structural function and optimizing the material usage in designing a building? What are the limitations in using this approach?	Structural digital modeling/simulation Finite Element Modeling as the method
Paulina	1. Thermal imagining 2. Meters readings 3. Previous refurbishment works 4. User opinions	1. How to improve the buildings? 2. How to analyze the proposed change without actual building 3. How to reduce the risk of misinterpretation	Model of variables and their impact on future energy consumption and spending based on previous data collected
Egils	2D data to generate 3D spatial model	How can a 3D model of a city/city block can be helpful in planning? How to justify the cost of a digital twin city model? What sort of data is needed to add higher value to the 3D model?	Spatial model with the opportunity to add multiple layers and run different analyses and scenarios

There was broad understanding among students that future building cultures will work on building models in the virtual world to gather greater knowledge about the real world from simulations of data variables in these models. The most highlighted aspect of the workshop session: "Knowledge and Digital Futures" in the ISP2 workshop on Day 4 was related to data and models. Group 1 presented a table framing the connections in students' research work between data, questions and models. Students examined how it is feasible to answer key research questions with designed models based on available data (Table[● 5]).



Fig[● 11] Principles of knowledge production (source: PhD student 2, Helsinki, ISP3, Pre-task 1).

WHY – is knowledge production important and relevant?

A visible ambition in students' projects was to solve/address existing problems within a framework of sustainability, regeneration, efficiency, resilience, socially consensual and negotiated knowledge production/co-production. Moreover, by answering a question WHY? (Fig[● 11]), knowledge production was often highly disseminated and very reflexive ("*Knowledge–Wisdom*" source: Group 4, ISP2 Workshop) when facing social, normative, and ethical questions.

4.2 Views of knowledge management

Reflecting on question 3 in relation to BuildDigiCraft

The focus of the pre-tasks and group work in the ISPs was set on identity – creating a distinguishing character of a building or structure through architecture; being alive – through the use of a *Baukultur* approach in the design; social issues – in some way informal, organized by members of a club or a group of people; aesthetics – concerned with beauty and appreciation of beauty; emotional issues – openly displayed and invoking a feeling and being future-oriented – an investment in the living spaces for a vibrant future.

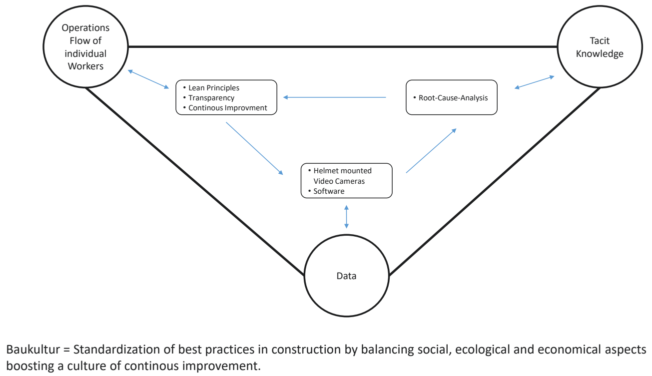
> *"Built environment should honor life which is in balance with nature and human knowledge."*

Fig[● 12] Presented aspects of knowledge and Baukultur in Master's students' work at HafenCity University.

Students were familiar with the terms "tacit, explicit, implicit knowledge" and referred to them often in their work. In Pre-task 1 (ISP3): ***"Process–Knowledge–Material–Reflection,"*** Master's students at the HafenCity University described the topic of community-based digital design and fabrication, arguing for high-quality Baukultur (Fig[● 12]) that respected local knowledge and adapted local craft.

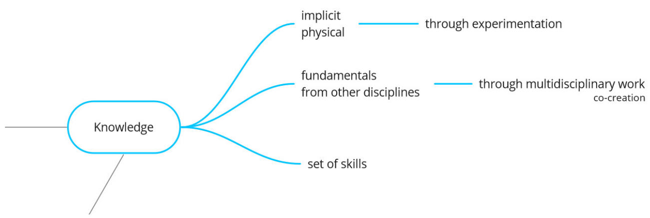
In discussing the topic of Baukultur, Master's students presented *"tacit knowledge"* as an important component of their own project work (Fig[● 13]). Here, tacit knowledge is linked to best practices in construction in relation to work of individual workers, operations, and data in community-based digital design and fabrication.

Fig[● 13] The subject of tacit knowledge for high-quality Baukultur in the Master's students' work at HafenCity University.



Fig[● 14] Process–Knowledge–Material–Reflection (source: PhD student 3, Helsinki, ISP3, Pre-task 1).

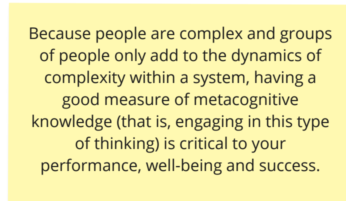
Another student indicated the importance of *"implicit knowledge"* applied via experimentation, calling it physically embodied in craftsmanship and materiality (Fig[● 14]).



For another student, a PhD student from Riga Technical University, *"learning by doing"* in research and design work was a way of knowledge production. This showed the importance of "knowledge conversion," sometimes referred to as knowledge transfer as a key aspect of learning, where knowledge is exchanged from one type to another (chapter *3.2.3. Knowledge management*, source: Smith & Hairstans, 2017). Here, research and design work enabled all types of knowledge. Implicit knowledge became the practical application of explicit knowledge. A transfer of explicit knowledge to another explicit is called "combination," and "internalization" of the knowledge when students transferred explicit to tacit individual knowledge, garnered from personal experience and context. When students communicated this tacit knowledge to spoken or written form explicitly, it was called "externalization." "Socialization" tended to be informal, experienced in the very act of doing, where one tacit form of knowledge was converted to another tacit form.

4.3 Students' perception of learning

Students from Group 2 at the ISP2 workshop highlighted aspects of knowledge in the learning process as introduced by Krathwohl (2002). The new dimension of knowledge according to the revised taxonomy by Krathwohl brought a perspective of knowledge into the field of education and learning as a cognitive process, categorized into four dimensions: (1) factual knowledge, (2) conceptual knowledge, (3) procedural knowledge, and (4) metacognitive knowledge (Table[● 6]). Interestingly, students discovered a link between their own learning in research and design work and discipline-based knowledge. They reflected on *"metacognitive knowledge"* as *"knowledge of cognition in general as well as awareness and knowledge of one's own cognition"* (Fig[● 15]).



Fig[● 15] Comment on the cognitive knowledge when dealing with complexity (ISP2, Day 4, Group 2).

Knowledge taxonomy according to Krathwohl (2002) added to the discussion on individual and general learning (Table[● 6]). As students correctly pointed out, work in complex multidisciplinary built environments emphasize the assessment of learning. Education plays an important role in shaping building cultures. The challenges are linked to complex issues addressed by research but also new trends like digitalization and tools bringing new ways of approaching knowledge. The awareness of content, context, and knowledge of cognition should be an elementary part of contemporary cross-disciplinary education in complex built environments.

A. *Factual Knowledge* – The basic elements that students must know to be acquainted with a discipline or solve problems in it.
- **Aa. Knowledge of terminology**
- **Ab. Knowledge of specific details and elements**

B. *Conceptual Knowledge* – The interrelationships among the basic elements within a larger structure that enable them to function together.
- **Ba. Knowledge of classifications and categories**
- **Bb. Knowledge of principles and generalizations**
- **Bc. Knowledge of theories, models, and structures**

C. *Procedural Knowledge* – How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods.
- **Ca. Knowledge of subject-specific skills and algorithms**
- **Cb. Knowledge of subject-specific techniques and methods**
- **Cc. Knowledge of criteria for determining when to use appropriate procedures**

D. *Metacognitive Knowledge* – Knowledge of cognition in general as well as awareness and knowledge of one's own cognition.
- **Da. Strategic knowledge**
- **Db. Knowledge about cognitive tasks, including appropriate contextual and conditional knowledge**
- **Dc. Self-knowledge**

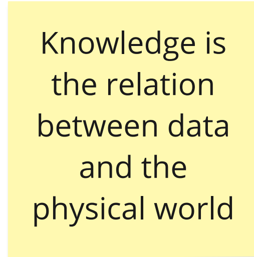
Table [● 6] Structure of knowledge dimension of the revised taxonomy (Krathwohl, 2002)

Another example was the scope of different forms of knowledge represented by different participants in the process of decision-making and inter-/transdisciplinary projects. Depending on the pedagogical curriculum of the school and program in the built environment, students from early education can learn how to integrate different forms of knowledge in projects by reflecting on the interplay of actors in the real world. They learn how to integrate knowledge from different disciplines (expert knowledge), from civil servants and decision-makers (institutional/bureaucratic knowledge) and stakeholders (stakeholders' knowledge). According to Bunders et al. (2010), this integration of different forms of knowledge in decision-making processes requires in parallel organizational and social integration, communicative integration and technical integration. If students work in application projects outside their own discipline and linked to stakeholders outside academia, they may have an opportunity to learn about different methods, processes and instruments to develop knowledge and understand the challenges. This inter-/transdisciplinary knowledge construction demands from students to learn skills and accommodate values in a context of complex built environment and sustainability in decision-making.

4.4 Future demand of knowledge and digitalization

Reflecting on research question 4 in relation to BuildDigiCraft

Students identified a demand of knowledge as a need for better know-how and a need to recognize future conditions that are not always presently known. It was easy to see from the group studies that "digitalization," "automation" and "data analysis" are clear examples of understanding that technology in the future may help to solve current issues or simply enhance current knowledge. Fig[● 16] shows one student's approach to knowledge seen as related to a large extent on available data. A conclusion was that it was a narrow but popular way of perceiving the physical world through the analyzed available data. In this respect the knowledge gap lay in a lack of data and the future demand for knowledge will depend to a large extent on reliable sources of data.

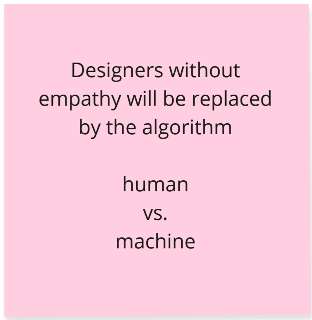


Fig[● 16] What is Knowledge? (Source: students' work at the Workshop ISP2, Day 4: Knowledge, Group 2).

Artificial intelligence, for example, can analyze the current collected data from various perspectives. This includes the possibility of filling in the gaps in data that might otherwise obscure the creation of meaningful new knowledge. Automation as a key part in data analysis helped to introduce new data at any given moment and therefore carried out integrated analysis to get better perspectives on current knowledge. Still, a question was raised of knowledge gaps that need to be addressed first by humans before relying completely on digital tools. The student asked: *"Will AI make sense of what we don't understand?"* (ISP2, Day 4: Knowledge, Group 3).

In the analysis of the **BuildDigiCraft** project, material was mainly seen as "knowledge reuse" and "new materiality" sub-topics. But also how the physical world could be described or accounted for in a digital world to help to design better products for the future. Examples of knowledge reuse that emerged from analysing the project included the reuse of materials and how more sustainable materials can be used in future. Sustainability itself could be defined through various aspects (environmental, social, economic) that would be valued more in future than those currently. This knowledge might change, especially through various knowledge transfer processes (individual > organizational) which simply takes time when we see it at different scales (local, global scales). In addition to "reuse," students argued that the future demand of knowledge might help to develop better materials that can originate from extensive analyses from current knowledge (as elaborated in the previous section), due to the fact that knowledge gaps can be filled with fresh data.

Development of artificial intelligence, computer learning, algorithms applied in the built environment raised a question about future knowledge demands, ethics and the role of the designer in securing qualities in future relations *"human vs. machine"* (Fig[● 17]).



Fig[● 17] *Human vs. machine* (Source: students' work at the workshop ISP2, day 4: Knowledge, Group 3).

As a reflection from the material referring to "Knowledge production," the future demand of knowledge would need to address the growing complexity of topics rooted in an urbanized world better, along with the decision-making and ambition to respond to urgent issues within a framework of sustainability, regeneration, efficiency, resilience as well as socially consensual and negotiated knowledge production and co-production.

Another perspective on the future demand of knowledge was to address contemporary problems and questions rooted in society, behaviors, and quality of life. Trends showed that there was a changing paradigm in how knowledge production was held due to growing demand and use of digital technologies. New opportunities were observed that were emerging in knowledge production of future building cultures that may lead to greater use and dependence on the virtual world and AI.

4.5 Knowledge and the design profession in the digital era

Preparatory input and lecture by
Claes Caldenby, Professor emeritus at Chalmers

"We are in the midst of a tremendous social and economic transformation, as sweeping in its impact as the Industrial Revolution was some 150 to 200 years ago" (Fisher, 2000).

The changes around the turn of the millennium have been described by many and been given different labels: post-industrialism, globalization, information revolution, network society, world of flows. It is all too easy to get lost in the midst of all the overwhelming opportunities and threats. The longer historical perspective could however, it could be argued, give a structure to the changes that offer us some clues about how to handle them.

Techne is a Greek word for knowledge, often used in the sense of the craftsman's practical knowledge of making things. Techne is obviously the knowledge of the technician but traditionally it is also the knowledge of the artist. Art and technology were one and the same in pre-modern, pre-industrial societies. With modernization and industrialization, they begin to go their separate ways, ending up being each other's opposites: the spontaneous artist versus the rational engineer. Today, they seem to be merging again with computer technology as a design tool (Liedman, 1997). A new concept of techne could be understood to combine the knowledge of the artist with that of the technician. The tasks put to us in a *"world of flows"* could be described as *"from an urge to dominate nature to one that seeks balance with it; from mass production to mass customization; from large bureaucratic organizations to smaller project-based operations; from specialized jobs to versatility; and from professional autonomy to participatory teamwork"* (Fisher, 2000). There is a possible flipside to the project-based operations and the versatility in loss of long-term job security that must be dealt with. But basically, this is an optimistic view of the role of the designer in a world constituted by "fuzzy" problems. This could even, somewhat provocatively, be stated as a belief "that design may have as central a place in a world of flows as science and technology had in the industrial revolution." Here again we could see the designer combining the roles of artist and technician.

Essential in this development is the trust in and pride of one's own work as a professional. New Public Management has meant a transfer of control from professionals to economists and politicians and *"a world domination of the petty"* (Bornemark, 2018). *"Evidence-based design"* is important but not always the right answer to fuzzy problems. It seems more to belong to an industrial society than to a world of flows which arguably should celebrate the knowledge of the designer. Again, we could return to the craftsman's practical knowledge. The craftsman is not only the skilled manual laborer who disappeared with industrialization. The value of good craftsmanship is important for the computer programmer, the doctor, the parent, the citizen as well as for the designer. Pride in one's work includes reflection in and on the making (Sennett, 2008).

Qualities of craftsmanship that need to be sustained in the digital era:[1]

1. Materiality (being real not virtual)
2. Location (being grounded)
3. Sustainability (being adapted to nature)
4. Diligence (being passive and professional)
5. Openness (being vague)
6. Good life (being human)

[1] (Source: lecture by Claes Caldenby in the project **BuildDigiCraft**: *"Craft in a Digital Era. A Search for Earthly Paradise?"*: https://www.youtube.com/watch?v=pLL1ZR5Uvk0

4.6 Connection to the Davos Declaration

"There is an urgent need for a holistic, culture-centred approach to build environment and for a humanistic view of the way we collectively shape the places we live in and the legacy we leave behind."

(**Davos Declaration**, 2018, *"The central role of culture in the build environment,"* §3)

The Davos Declaration (2018) stresses the central role of culture for the quality of the built environment and incorporates all activities with spatial impact, from craftsmanship details to large-scale urban planning and development of landscapes. "The Davos Baukultur Quality System" (2021) is a contribution to the ongoing Davos process and proposes eight criteria for making the evidence-based assessment of the Baukultur quality of places. These criteria include governance, functionality, environment, economy, diversity, context, sense of place and beauty.

The connection to the Davos Declaration in the **BuildDigiCraft** project is in the sense that knowledge production, transfer, sharing for high-quality places in both the built environment and open landscapes is essential for education. This knowledge can help cultures to consider and recognize preconditions and challenges, it can help to raise awareness about past, present and future values. The importance of knowledge production, management, exchange in the field of Baukultur for the quality of the built environment, stresses the central role of culture in the context of all activities trained by students in higher education. These activities require gaining individual knowledge about inventory, design, planning and construction, as well as knowledge democracy for cross-disciplinary discourse and through multi-level and cross-sectoral cooperation between different actors, participation of civil society, and an informed public.

Evidence-based learning is only a part of knowledge generation in higher education; the other involves individual learning.

In reference to Jonna Bornemark:

In the knowledge transfer process, knowledge has to be redeveloped by each individual (Dan Paulin and Kaj Suneson, 2011). Consequently, the knowledge barrier cannot be overcome simply by providing access to a knowledge repository. In this case, a distinction is made between information and knowledge if the information is an objective unit that is presented to the person. Whether an individual will transform it into knowledge depends on a number of factors such as previous experience, background and "sense-making." The important factor is the choice of methods used in the process of knowledge transfer. Breaking down hierarchies enables knowledge transfer, where the development of horizontal communication flows promotes the efficiency of the process. As the complexity of today's challenges often requires interdisciplinary research and solutions, the inclusion of the principle of multidisciplinary promises to provide the necessary competencies.

The concept of high-quality *Baukultur* manifests itself in a multidisciplinary approach, encompassing notions such as built environment, cultural heritage, quality of life, social cohesion, well-being, resilience and others. The impact factors, the areas affected and the people involved form a complex set of units, the development into a holistic targeted system of which is directly linked to the transfer of knowledge in a multidisciplinary environment. Principles defined for successful knowledge transfer – i.e., the provision of the horizontal flow of information, the rating and feedback, the time resource factor – can form the basis of an approach to building a high-quality Baukultur process.

Project results show that concepts of knowledge and approaches to knowledge production, management, transfer/exchange or sharing are diversely represented in the academic, institutional, expert, public and individual discourse. Reviewed material from the project confirms the diversity of aims, questions, methods and tools applied to address socially relevant important issues raised in the students' projects.

Despite the different topics and methodology, students chose to work with the high complexity of problems. There are common "red threads" when analyzing knowledge in relation to Baukultur in higher education. First, the importance of knowing more and/or exploring the craft, art/design and digitalization in the diverse context of the built environment. This is often to gain new skills in connection with the rapid development of new digital tools for design and production. Others are to share common values like ethics and knowledge democracy, to apply knowledge and approach multi-actor society, aiming for the quality of the space and sustainable lifestyle in the built environment.

Finally, there is an "education" component, which plays an important role in how knowledge is generated and enhanced under future conditions – especially how the educational system must change in the digital age. This is an open question and depends heavily on the afore-mentioned components, like on how to minimize knowledge gaps where physical and digital worlds are seen to be merging closer together than ever before.

5.0 Final reflections and guidelines

The results from the **BuildDigiCraft** project show that the complex concept of knowledge related to the shaping of built environment has evolved meaningfully due to the necessity of rethinking the role of science and its relationship to society and building cultures. This was due to serious challenges involved in achieving sustainable development, when science faced growing complexity of real-world problems, social relevance and the demand for collaboration between academic and non-academic actors, research questions going beyond one discipline. A new social distribution of knowledge is occurring as a wider range of organizations and stakeholders contribute skills and expertise to problem-solving.

Results from the project show that knowledge production and management in higher education can support transfer and creation of cultural values expressed in the Davos Declaration and includes the contribution of universities to educate students toward the vision of high-quality Baukultur. This involves learning how to apply conscious and well-debated design, maintain and improve the qualities of places by construction, build social cohesion, promote environmental sustainability or maintain and protect our cultural heritage. Eight quality criteria proposed in the Davos Baukultur Quality System derived from the Davos Declaration highlights important aspects of shaping built environment linked to governance, functionality, environment, economy, diversity, spatial context, sense of place and sense of high quality responding to the human need for beauty. The teaching curriculum in higher education needs to address these; education and research should train future professionals and designers how to integrate best practices and applied knowledge (implicit knowledge) into documented and written means (explicit knowledge) for a high-quality Baukultur:

- Shifting the focus from preservation of knowledge to its dissemination via education. For high-quality Baukultur it is necessary to create and grow learning communities. Higher education plays a vital role in active participation in community-based learning, being driven by the recognition that the most valuable knowledge in any group or organization in the society is "tacit" and that people need to share their knowledge and collectively bring their intelligence to bear to solve important problems.

- Knowledge democracy should be safeguarded – it is necessary to provide conditions that allow dominant and non-dominant actors to have equal access and ability to bring this knowledge forward to contribute to solutions for societal problems (self-referential knowledge production, knowledge dissemination, mutual learning for knowledge production between scientists and societal actors' style, knowledge co-creation between scientists and societal actors).

"A place is determined by Governance, based on participatory democracy with good processes and management of places. Diversity ensures vibrancy and social inclusion."

(**Governance & Diversity: Davos Baukultur Quality System**, 2021).

- The inter-/transdisciplinary approach involves a diverse range of specialists, academics and non-academics and therefore creates opportunities for self-referential knowledge and production style. Recognizing human needs and purposes should involve individual and unique approaches to knowledge production. For example, transdisciplinarity in architectural or urban design involves ethics, aesthetics and creativity inside of disciplinary and professional work, incorporated with social and political, normative and ethical questions. It contextualizes and repositions both theory and learning, including the understanding of everyday people. This requires an "in-practice model" of design and learning, greater relationality of knowledge today, which in turn requires a collaboration among a mix of actors.

"Functionality addresses the level of satisfaction of human needs and purposes."

(**Functionality: Davos Baukultur Quality System**, 2021.)

- Research and education within higher education contributes to decision-making, development projects, planning, design or construction to solve/address existing problems within a framework of sustainability, regeneration, efficiency, resilience, even affordability and vitality. It should involve the generation, exchange and use of cross-disciplinary knowledge.

"Respect for the natural Environment with mitigation of climate change contributes to the sustainability of a place. Economy with long lifecycles and long-term viability of places is an important component of Baukultur quality.

(**Environment and Economy: Davos Baukultur Quality System**, 2021.)

- Academia is open for collaboration and knowledge production within society. It has been acknowledged that not only new knowledge but also skills are indirectly produced and disseminated in conversations and networking activities. Context and sense of place should involve more than evidence records about the places (explicit knowledge), but rather demand collection and sharing of the memories or stories people tell about places or implicit knowledge in applied best practices. Therefore, one way to help people share and internalize tacit knowledge is to allow them to talk about their experiences and to exchange their knowledge while working on specific problems.

"The particular spatial Context of a place with its physical and temporal characteristics, such as the shape and design of buildings, neighbourhoods, villages and landscapes and respect for built heritage has a great impact on the quality of a place. A specific Sense of place is created through social fabric, history, memories, colours, and odours of a place producing its identity and the attachment of people to it."

(**Context & Sense of place: Davos Baukultur Quality System**, 2021.)

- Education about high-quality built environment with regards to making places needs to contextualize and reposition both theory (explicit knowledge) and learning (tacit, implicit knowledge), aesthetics and understanding of needs of everyday people.

"Places of high quality are authentic and respond to the human need for Beauty."

(**Beauty: Davos Baukultur Quality System**, 2021).

Results from the project show that today the university in the up-to-date complex environment of information transfer plays a role as "**knowledge hub**," animating indigenous development and innovation spanning between industry, government, and society. The contemporary role of academia has changed as it serves as a facilitator of emerging modes of learning, knowledge production and knowledge exchange. The new role of universities is to advance technological innovation and economic development.

The role and purpose of higher education has increasingly come to be the preparation of young people across society to take on highly skilled positions in industry and society.

The perspectives on knowledge production have evolved a lot, especially over the last decades when science faced growing demands for collaboration between researchers, new research questions going beyond one discipline. Here more than ever, collaborating communities, researchers and decision-makers seek to tackle problems that require both specialized knowledge and integrative skills to cope with complexity.

Knowledge and skills are key human capital elements of building sustainable environment. This project guides and reflects on the important role of higher education in preparing the future generation of designers to take responsibility for shaping high-quality built environment, sharing knowledge and values of good craftsmanship. Moreover, exemplified results from the project show that in the age of digitalization and globalization, there is an opportunity to use a wide set of digital tools for knowledge production and exchange.

1. In higher education, individuals should learn to grow in one's own work as professionals. Education and research should be directed toward how we can prepare individuals to grow in all of **Aristotle's three categories of knowledge** – episteme (scientific knowledge), techne (knowledge of craft) and phronesis (ethical knowledge). "Evidence-based design" is important but not always the right answer to wicked design problems in the built environment. The knowledge of the designer needs training to learn and implement the craftsman's practical knowledge: *techne* and evidence-based assessment related to *episteme*. Evidence-based learning is only a part of knowledge generation in higher education – the other involves individual learning.
2. The ultimate goal of the university is to create opportunities for students to make **informed design decisions** and **explore phenomena-based knowledge**. This includes learning about cultural values like the history of architecture and built environment (old and contemporary), humanistic understanding of design questions, state of the art and an awareness that every problem is unique involving

phronesis. Students reflected on the "metacognitive knowledge" (Krathwohl, 2002) and learning to gain knowledge of general cognition as well as self-knowledge and awareness.

3. High-performing higher education institutions are those that effectively advance, distribute, and recombine tacit knowledge. The current role of the university as a facilitator of emerging modes of learning, knowledge production and information transfer embody the necessity to combine **all types of knowledge: explicit, implicit and tacit** into the formal, semi-formal, and non-formal tools of education, including the shift from teaching to learning. There is much explicit knowledge found in codes, publications embedded within people and organizations. Still, the majority of knowledge regarding built environment, including construction, is tacit or implicit. In academia, explicit knowledge in form of data, records, and documents (present in journal publications, databases, books, websites, and videos) is relatively easy to disseminate. On the contrary, tacit knowledge is difficult to transfer by means of writing or speaking. It is embedded in people, organizations, societies, and cultures. It comes from experience, thinking, competence and commitment. In academia, tacit knowledge can be found in workshops, conference discussions, internships, and exchanges.

4. Universities play an important role in the **generation and dissemination of knowledge** in the process of learning. Students need to be trained in understanding and making the complex and massive knowledge explicit that is required for professional practice and identifying ways in which this knowledge can best be initially learnt and developed further throughout professional life. Understanding how learning experiences and educational processes might best be aligned or integrated to support professional learning is to let students learn how to exchange knowledge from one type to another. This is referred to as **knowledge conversion** and knowledge transfer. Students can study to externalize knowledge communicated to spoken or written form, supporting knowledge conversion from tacit/implicit to explicit. Here, students learn to reconfigure existing knowledge inside and outside university in connection with the rapid development of new digital tools for design and production. This calls for training selective approaches to gather data, information and knowledge.

5. From early education onwards, students need to train creativity and develop **skills to communicate design work**. ISPs presented different research ideas and approaches to design where thematic group work and discussion panels created opportunities for students to present their work. Activities promoted in academia, such as workshops, public presentations and competitions, allow students to learn from each other and develop skills of creativity, argumentation, and communication.

6. **Practice-based learning** is used in higher education and enables theory–practice bridging there. An engineering curriculum represents the "epistemic transition" from the natural (and mathematical) sciences to the engineering sciences through to the sciences of design and the practice of application. Students can gain new knowledge in practice, while working and collaborating with professionals in practice. Practice-based knowledge is recognized to be personal, disputed, conditional, and dependent on individual meaning-making, when often university traditions have built on the assumption that knowledge exists as discrete facts developed, distributed, and institutionalized in good research by expert authorities.

7. Education and research play an essential role in the information transfer **fostering innovation** in a particular sector or interest area. Sharing different types of knowledge in higher education can be carried out with the help of effective involvement of interested sides in the educational process – municipalities, communities, non-governmental organizations (NGOs), and other actors in society. Students from the early stage of studies up to the advanced level of education gradually learn to select the appropriate tools and integrate different

forms of knowledge into the study and research projects. They learn to reflect on the interests of various actors in multidisciplinary projects and evaluate the challenges of the decision-making process.

8. Digitalization may create opportunities for knowledge generation and exchange. The advent of the Internet has become one of the reasons why a lot of face-to-face universities started developing online courses. By encouraging the formation of **virtual learning communities**, face-to-face universities can create a competitive sustainable advantage for themselves, the same as benefiting from using digital tools for knowledge production and sharing – this should be the way forward in the 21st century. Since the opportunities for face-to-face interactions are rather limited in universities of today (e.g., pandemic due to COVID19, 2020–2021), virtual learning communities supported by Internet technologies are viable alternatives to live conversations and knowledge exchange.

9. Digitalization enables developing new skills working with the complexity of data in the built environment and can provide **efficient digital tools** for seeking new research issues. Digital tools allow collecting large amounts of qualitative data and working with different data sets. By merging data from several qualitative studies (meta-data), research is able to pose questions that individual projects cannot raise.

10. Results from the project show that knowledge production in the digital era can be tacit and in architecture is often linked to the seamlessly produced **virtual "experience"** rather than just artefacts. Tacit knowledge is non-articulated and experience-based knowledge linked to best practices and making. It is the application of implicit knowledge specific to a student's needs. The modern world is constantly providing us with new challenges, though, and to meet these challenges, we need conscious methods for evaluating knowledge and experience. Due to growing complexity and digitalization in disciplines involved in shaping built environment, digital technology (software of immaterial design with immaterial making) is eliminating the separation between design and the making. Here, students have been turning to software developed for other fields. Digital workflows can re-engage craftsmanship and connect **design intelligence with material intelligence**.

11. There is a necessity of re-identification of the designer's work with the work of a craftsperson in the digital era. Digitalization highlights the importance of data and evidence-based knowledge, where the experience and place-based work of the designer needs to be promoted. In **the digital era the qualities of craftsmanship** that need to be sustained should include: *"Materiality"* (being real, not virtual), *"Location"* (being grounded), *"Sustainability"* (being adapted to nature), *"Diligence"* (being passive and professional), *"Openness"* (being vague), *"Good life"* (being human).[2]

[2] (Source: lecture by Claes Caldenby in the project **BuildDigiCraft**: *"Craft in a Digital Era. A Search for Earthly Paradise?"*: https://www.youtube.com/watch?v=pLL1ZR5Uvk0

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2.5 Material
Intellectual Output 4

The meaning of Material, Materiality and the Digital for Baukultur

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Olga Popovic Larsen, Günther H. Filz

Contents

1.0 Material knowledge and the ancient Master builder

The dome of Florence Cathedral, Italy, represents both a milestone and turning point in the art of design, constructing and building, respectively the history of architecture. Until then, there was no clear separation of professions, such as architects and engineers. In ancient times, the person who worked with specific building materials and mastered building skills was responsible for the entire building process from the early design phase to the final execution and was referred to as the Master Builder. Accumulated knowledge about material, form and proportions of buildings were passed on from predecessors (Larsen and Tyas, 2003) and developed their building skills with "intimate intuitions" from nature (Torroja et al., 1958). Based on centuries-old cycles of trial and error that were the lessons learned from his predecessors, the ancient Master Builder developed material-based building technology from generation to generation and often by leaps and bounds through innovative thinking and building techniques – as was the case when building the dome of Florence Cathedral.

Similar to pottery, material knowledge and shape were inseparably embedded in and dependent on the process of making, which resulted in the final artifact. Today, we speak about these traditions, their processes, but also about the material knowledge as tacit knowledge From the Renaissance onwards the role of the Master Builder separated liberal thinkers and executors (Argan, 1969), so those whose design was based on theoretical and, for example, mathematical considerations, and those who assembled the buildings. While this new approach allowed for the early incorporation of materials and material technology into the design and pre-planned construction process, the earlier feedback loops were broken and the executors lost their involvement in these processes and moreover, their importance and standing in society.

A further division of liberal thinkers into architects and engineers was triggered mainly by the emergence of architectural methodologies and later by the inventions of new building materials, such as cast iron, steel, and glass. The executors became responsible for building construction mainly (Saint, 2007). Consequently, the role of the Master Builder has been fragmented into specialized professions, where the architect's role is limited to conceptualizing the building form, and the structural engineer's role is to rationalize the structure and define the dimensions of the material (Setareh et al., 2015). Later, this fragmentation led to the specialized architect, the structural engineer, the mechanical engineer, the construction manager, etc. Certainly, there are several advantages resulting from the fragmentation into individual specialized professions, especially for complex projects. However, the fragmentation may result in a lack of efficiency due to the difficulty of collaboration between the different professions where different methodologies and different thinking modes are applied. The separation may also result in inefficiencies such as excessive use of material, inappropriate selection of structural form and high costs (Larsen, 2016) as a consequence.

The history of architecture proves that architects have very often invented their own tools in the context of the material. The dome of Santa Maria del Fiore would not have been built the way it was if Brunelleschi in his time had not also thought about the tools and machines to produce the structure. This relationship, however, has changed over the centuries in that it has become somewhat more passive. Historically, it is also interesting to observe how this relationship has evolved in terms of design, planning and implementation. It is perhaps less well known that in the 1940s and 1950s in the aerospace industry, in mechanical engineering and in the automotive industry, the machines used for manufacturing were controlled numerically. These so-called NC machines were controlled by punched cards that guided a specific tool to produce certain components or machine parts. In a later step, these machines became computer-controlled so-called CNC machines. For this purpose, programming languages were developed to feed the machines with appropriate information, while at the time the designs were still made conventionally on paper. This issue then led to the conception of the first CAD programs. The first versions worked with relatively primitive primary shapes and geometries. The conversion of increasingly complex geometries into mathematical formulas enabled their programability. Among the pioneers of the 60s of the 20th century were Citroen and Renault in devising the Bezier and NURBS curves. At the same time, methods were developed for finite element analysis, which nevertheless required a resolution of the geometry as three-dimensional meshes. Especially in the entertainment industry, important advances were made in computer graphics for animation and visualization.

In summary, many of the tools we use in architecture today have their very origins in other industries and disciplines. This in turn means that very often innovations in architecture have been achieved through appropriation of tools from other fields. Although fragmentation into individual specialized professions has several advantages, it can lead to a lack of efficiency in many respects, especially for very complex projects. As a possible way to bridge the gap between architects and civil engineers, the model of the new Master Builder has been mentioned repeatedly in the last decades. Alternative approaches, such as the design-build philosophy (Nicholas and Oak, 2020), architectural or civil engineering as an educational program and profession (Parasonis and Jodko, 2013), the idea of structural arts (Billington, 1985) or the development of robots as modern master builders (Sweet, 2016) have been explored. Few exemplary projects can be found in the recent past (Billington and Garlock, 2004). However, today's technologies offer architecture the opportunity to develop and establish its own systems, tools and processes for both the collaborative and individual discipline.

2.0 Materiality in architecture, engineering, and material sciences

Material understanding and materiality are closely connected to architecture and building design. The history of construction of the pyramids in Egypt shows a great understanding of material properties, load transfer and the art of building. With every "new" material a whole world of development around its properties and performance is developed – one that affects how it is used, applied and constructed with. A common recurrence throughout the history of architecture is that design and construction methods lagged behind the newly discovered/created materials. The Parthenon in Athens built in stone using timber post and beam structural principles or the Iron Bridge in the UK that utilized Dovedale timber-like connections are classic examples of designing and building with the knowledge of the "old" material. This also emphasizes the role of tacit material knowledge, one that was learned by doing – participating in projects, learning through the gained practice experience. This was then transferred further into the trade (of timber construction, glass or any other old or new material technology). However, with each new step in the development of new materials, the design language and the craft of making in the material was lagging behind. With this in mind it is not surprising that the Iron Bridge or the Parthenon were using old material technologies. This is also equally present today. The science of new materials often precedes the design and the crafting language and practice.

At present we live in a time characterized by highly developed scientific methods that enable us to understand and describe materials both old and new on micro and macro scale. It is also fair to state that material understanding has never been more important than today, on the one hand with the great development in material science and engineering leading to an explosion in the development of new materials, and on the other – our performative requirements of materials have become higher and much more specific than ever before. We design buildings with requirements for internal climate, acoustics, energy use, etc. And the materials we choose need to live up to these high requirements. Often in order to live up to the performative requirements, the materials are purpose-developed. Many of these requirements are related to and try to give answers posed by the climate emergency we are facing. More often than not, we wish for low-impact materials that are high-performing, have low maintenance requirements, yet offer longevity to the building and which are biodegradable at their end-of-life.

But what about tacit material knowledge? It is the type of knowledge that connects the "material" with the "maker." In the case of "old" known materials, the knowledge development followed the material. The more we "knew" about the material (its properties, applications, durability, etc.) the more we "knew" about how to work with it, how to craft it (to cut it, or cast and fabricate elements). At present, tacit material knowledge is as important as ever, even more so because the act of making exceeds the physical only, but goes beyond that and into the digital realm, as the **BuildDigiCraft** project has shown. If we go back into history, material understanding both in a physical, performative sense as well as sensual, tactile, and experiential sense has always been very important. Not surprisingly, it continues to shape the design and construction of our buildings, structures, and cities today. Within the realm of building design, one can discuss material and materiality across scales: from nano-scale for material additives and surface treatments, to material understanding affecting element and structural design and all the way to building scale and finally – to urban scale affecting the creation of cities and large complexes across the globe. Understanding material and materiality is as crucial today as it was in the early days of human society.

To define, understand, and model material and materiality, physical modeling has been used as a tool as early as during the construction of the Pyramids in Egypt, throughout the history of architecture, and is still being used today. The book *Physical Modelling for Architecture and Building Design* (Popovic Larsen, 2020) maps the roles physical models have had:

- To **create**: physical models as an exploration and conceptualization tool
- To **see**: physical models enabling visualization, representation, and communication
- To **understand**: physical models aiding understanding through testing and verification
- To **guide**: physical models as a construction definition tool – guiding assembly as sequence of events
- To **link**: physical models linking physical and digital environments

Perhaps the most relevant finding in this book, especially in the context of the **BuildDigiCraft** project, is that physical and digital models are so intertwined and inseparable that they are representation – a model that is neither only physical nor only digital, but often both digital and physical at the same time. And then within this context, when we discuss the notion of material and materiality – it would be difficult to talk about material in a pure and only physical form. Typically, physical material with all its characteristics/performance is described through data that is detailed, complex, and derived and presented in digital form. Whereas the (physical) material possesses the workability and formability that has historically been developed through tacit knowledge and the craft of making, currently, this is supplemented by material as data (data about the material) that facilitates better/more sustainable/higher-quality design, architecture and building design. The two – the physical material and the digital material – are inseparable and without either of them we would not be able to discuss material and materiality.

In the context of architecture, it seems sometimes more appropriate to speak of materiality rather than material. By definition "materiality" means the opposite of "immateriality" and aims at describing the materiality or existence of corporeality. However, materiality incorporates the material with its meaning and effect on people and the environment. Consequently, context and the interactions it contains come into focus: materiality is thus consciously designed and located material. Since materiality simultaneously conveys corporeality and its properties, and thus ultimately seeks to provoke emotions, the duality of the noun – often even in the plural "materialities" – in its use as an attribute seems logical. The material as a natural or artificial raw material enters the material culture through conscious use and design. Through knowledge, processes and technology, it becomes a refined material. Materiality encompasses all material and cultural aspects and meanings. Thus, within materiality, material and immaterial conditions can be seen as having equal value, but since the sensual perception significantly complements the analytical comprehension of materials, the intangibles may ultimately prevail. Therefore, design culture leads to the creation of meaningful work transforming material culture into a holistic effect. Over time, materials change their properties and meanings. Machining processes and use shape, transforming material and environment in a dynamic way and creating new valences. Material thus manifests and stores knowledge and processes. Both industrial and craft processing steps expose their specific potentials and lead to different material qualities.

In the recent past, integrated design concepts have been identified as beneficial for contemporary architectural design (Moe 2008), where material, structure, and architecture (form) and their sequence are essential in the discussion (Oxman & Oxman 2010). Throughout many decades, a "form-structure-material" sequence was adopted. However, different sequences of the three elements are also possible and have been explored and practiced. For example, Oxman (2010a; 2010b) proposed a material-based design concept that computationally links the three elements in a "material-structure-form" order.

This material-first order in integrated design concepts was also practiced by the ancient Master Builder (Ruan et al., 2021). One example shows in the origin of tectonic expression in vernacular architecture where the selection of material informs the expression of form and structure (Oxman 2012). Many of these highly important problems in practical terms are actually of a geometric nature and thus the architectural application attracted the attention of the geometric modeling and geometry processing community. This research area, which is closely connected to digital toolmaking and digital fabrication, is now called Architectural Geometry (Bentley, 2007; Pottmann et al., 2008). Together with the knowledge of material properties, the field of architectural geometry not only links architectural shapes with the making, which means physical realization, but also with the fields of structural mechanics and structural engineering. Material science deals with research on, or techniques for studying, the relationships between the structure, processing, properties and performance of materials. Topics include materials of all sorts and scales such as metals, ceramics, glasses, polymers, electrical, and electronic materials, composite materials, fibers, nano-structured materials, and materials for application in the life sciences. This knowledge of material properties and the development of new materials form the essential basis of structural engineering, where digital and numerical simulation and analysis becomes increasingly important. Latest approaches aim at increasing the complexity of design by overcoming a pure geometric modeling by connecting and exchanging data, by using rule-based processes such as parametric design, by computationally assisted information-based explorations, and by AI approaches that are data-based and in some cases even "unmodeled."

3.0 The Davos Convention and material in the context of Baukultur

An important reference and point of departure for the overall **BuildDigiCraft** project is the Davos Convention, that both defines Baukultur, and also sets the ambitions for creating a new high-quality Baukultur. Material is a crucial element in achieving this.

The Davos Convention describes Baukultur as:

"… Baukultur embraces every human activity that changes the built environment. The whole built environment, including every designed and built asset that is embedded in and relates to the natural environment, is to be understood as a single entity. Baukultur encompasses existing buildings, including monuments and other elements of cultural heritage, as well as the design and construction of contemporary buildings, infrastructure, public spaces and landscapes."

(**Davos Declaration Community**, 2020).

Material is mentioned 57 times in all contexts of the quality criteria defined by The Davos Baukultur Quality System. (Eight criteria for a high-quality Baukultur – the whole story, in 2020.) The eight criteria are Governance, Functionality, Environment, Economy, Diversity, Context, Sense of Place, and Beauty.

Material in the **BuildDigiCraft** project is investigated through the lenses of craft, through the digital and finally Baukultur. In this context, as mentioned earlier, material needs to be understood not only in a physical but also in a digital context, where craft allows addressing the gap between the actual situation of digitalization and its potential. The digital will influence the shape of a building and Baukultur is binding all of the above, based on the quality of space and acceptance through society. Materials are at the heart of innovation and development and have had such an impact that they have defined key eras in the evolution of mankind. Whether it's stone, bronze, iron, the steel of the Industrial Revolution, or the birth of silicon, materials offer the possibility (and threat) of forever changing the way we live. In our built environment, materials are intrinsically linked to technical, constructive, functional and aesthetic aspects and philosophical issues of architecture. Conversely, most will agree that architecturally designed spaces are defined and bounded by materials, but the architecture itself emerges in between, on a meta-level, to achieve what the Davos Baukultur Quality System describes as Sense of Place and Beauty. It is thus stated that *"High-quality Baukultur is more than the absence of defects."* Achieving high-quality Baukultur goes beyond fulfilling the defined technical requirements, like a desired program, volume, or material; it is equally important to reach a consensus about cultural values debated and defined by society. (Davos Declaration Community, 2020).

4.0 BuildDigiCraft: material in the context of process and knowledge

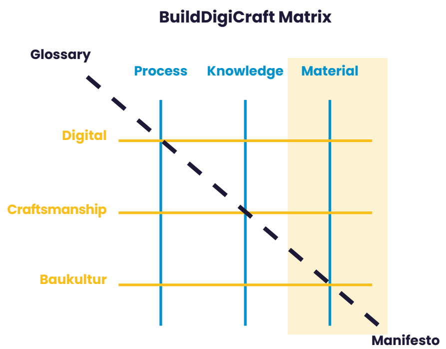
The **BuildDigiCraft** project, as described earlier, establishes a training network for young researchers, teachers, and practitioners that promotes innovative teaching approaches for shaping the built environment in the digital age. With the overall aim of contributing to the development of a high-quality Baukultur, the **BuildDigiCraft** project addresses the potential of digitalization and its effects on the built environment, with new teaching approaches aimed at enabling the introduction of an imminent and highly necessary cultural and organizational change in the planning and building sector in Europe.

The three pillars of the **BuildDigiCraft** project: material, knowledge and process are explored through a number of keynote lectures and ongoing PhD projects from the project network that through specific tasks are further developed, reflected upon, analyzed, and discussed. The **BuildDigiCraft** project reflects the understanding that the shaping of the built environment is a result of complex and diverse processes and includes design, planning, construction, and maintenance. The topics of the PhDs, the given tasks and the keynote lectures all reflect these. The organization of the **BuildDigiCraft** activities is carried out through the four Intensive Training Programs (ISPs) that are all organized around their own specific theme and content:

ISP1: Concepts and Fundamentals
ISP2: Digital Futures
ISP3: Craft and Craftsmanship
ISP4: Rethink Baukultur

The explorations with tasks closely related to the PhDs, Baukultur and the specific theme of the ISPs led to amazingly rich material. Although difficult to separate from each other, with the three perspectives of the **BuildDigiCraft** project Material, Process, and Knowledge that are present in all four ISPs, the ISP3 on Craft and Craftsmanship offers most of the data and results concerning the Material aspects.

5.0 Outcomes relating to material within the BuildDigiCraft project



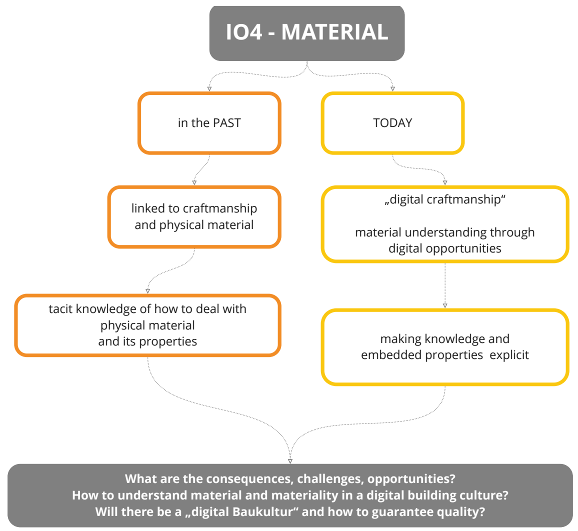
Fig[●1] The different aspects leading to high-quality Baukultur (from **BuildDigiCraft**).

Returning to the ISPs – when looking at the reflections deriving from all ISPs, on an organizational level one can describe the contents "Knowledge," "Process," and "Material" as being influenced by the "craft" and "digital" and leading to new high-quality Baukultur.

Generally speaking, through craft and the digital, (high-quality) Baukultur is influenced by the available knowledge, the processes we utilize and an understanding of materiality. The overall project outputs have been analyzed and developed in taking these perspectives into account.

ISP3, focusing on Craft and Craftsmanship, explored:

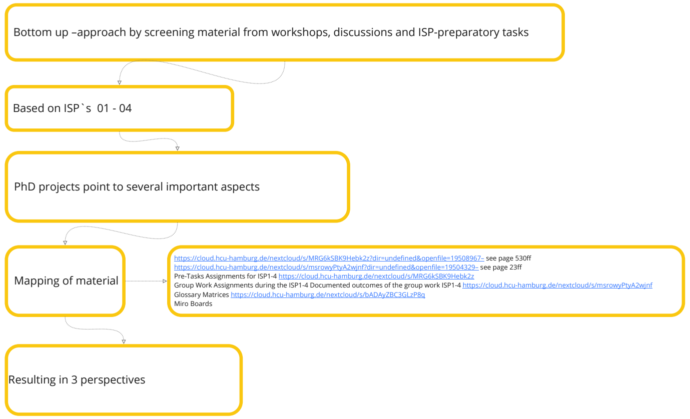
- *What is Baukultur in the digital age?*
- *What is the essence of the digital revolution in respect to the shaping of the built environment?*
- *How do we design, build, and maintain the built environment based on craftsmanship, data and algorithms?*
- *What are the qualities of craftsmanship, what is the essence of craft and craft-based production that we would like to transfer to the future digital shaping of the built environment?*



Fig[● 2] Diagram presenting a summary of outputs IO4 on Material.

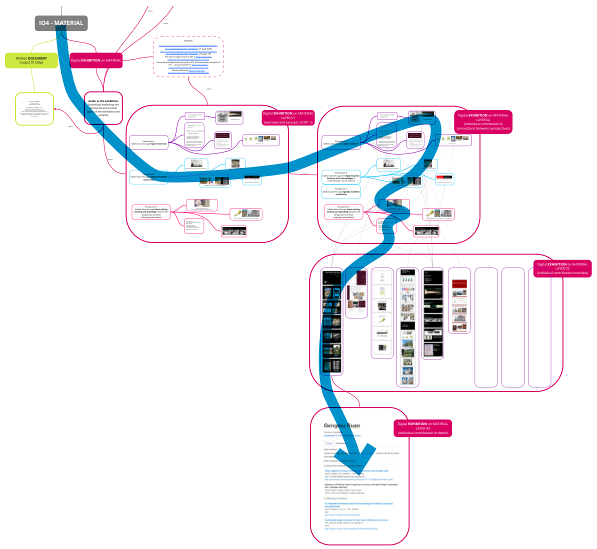
The method of analyzing the data that resulted from the ISPs – with greatest input from ISP 3 – was "bottom up," where the ISP pre-tasks, tasks, PhD presentations and keynote lectures were all mapped according to how they addressed material within the context of their work. This proved to be a good way forward although organizing the data was not always straightforward as a result of overlapping contents, questions and reflections. The mapping of the material (data) is presented in the image below with the links to the files of data from the ISPs.

Clarifying the trends and organizing the data required a long and thorough process. This was because of the richness of the created data, but also because there were more (good) ways of how the data could be read



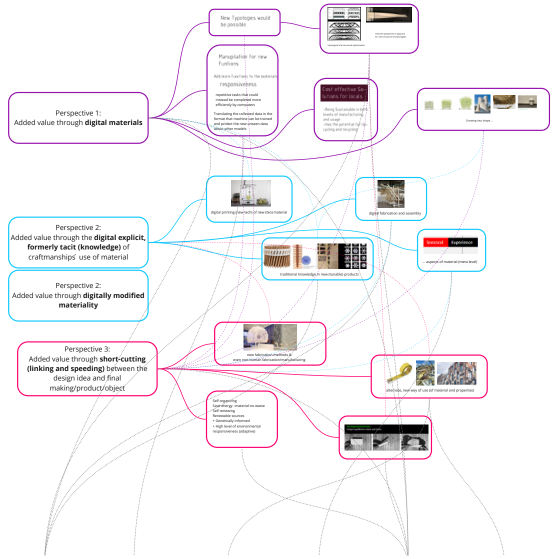
Fig[● 3] Mapping the material (data) relating to material within the overall **BuildDigiCraft** data.

and understood. In this process, it was important to look at trends, rather than search for specific answers. This required many reviews of the data, and also a challenging of the way it was presented, what the main messages were, how these should be understood, and how much the context colored the outcomes. Nevertheless, after several iterations the outcome became clearer and clearer pointing towards three perspectives that were derived by analysis of the data. The pathway through the material data is presented in the screenshot of the interactive whiteboard, with the next one presenting the complexity of the relations and interconnectivity of the ISP material that was studied, mapped, and reflected upon.



Fig[● 4] Screenshot of the interactive whiteboard presenting the mapped data related to material.

Fig[● 5] The data is complex and relates to each other in complex ways. The interconnectivity is on a multitude of scales and levels. Despite the complexity, three clear perspectives can be identified that emerge from the data.



6.0 Three perspectives – findings and discussion

Perspective 1. Added value through digital materials

*Digitally defined/created/optimized/fine-tuned **materials** will have a designed performance. This will embrace both measurable and qualitative Baukultur values.*

Perspective 2. Added value through digitally modified materiality

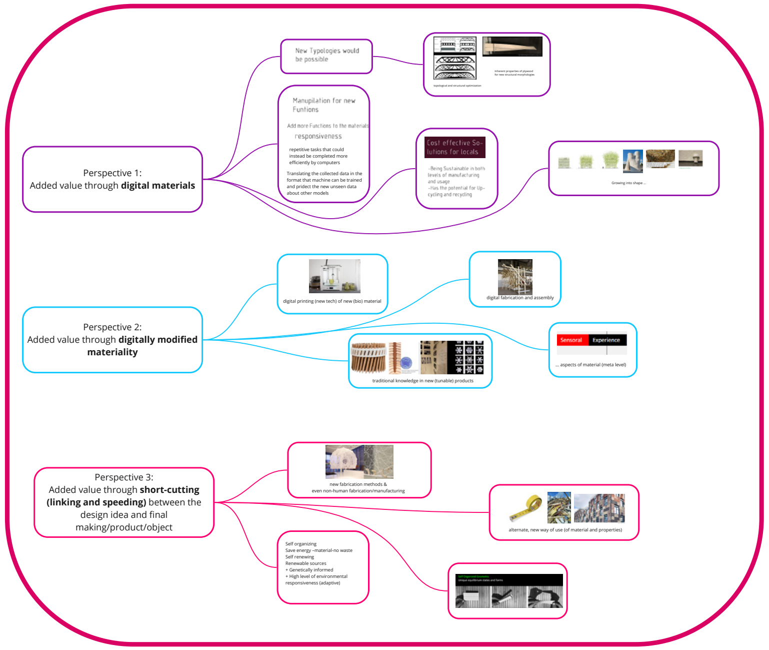
*Building longevity, good indoor climate, resources optimization can be achieved through digitally modified **materiality** – achieving values closely associated with Baukultur.*

Perspective 3. Added value through short-cutting digital workflows

Linking and speeding between the design idea and final making/product/object digital workflows enable real-time simulations and optimizations. Constructing while testing and before designing enables new workflows and opportunities that will secure quality.

The above are the three most important findings – perspectives of all the data related to material. They are organized as shown in the interactive whiteboard diagram below:

Fig[● 6] The three perspectives.



Perspective 1. Added value through digital materials

*Digitally defined/created/optimized/fine-tuned **materials** will have a designed performance. This will embrace both measurable and qualitative Baukultur values.*

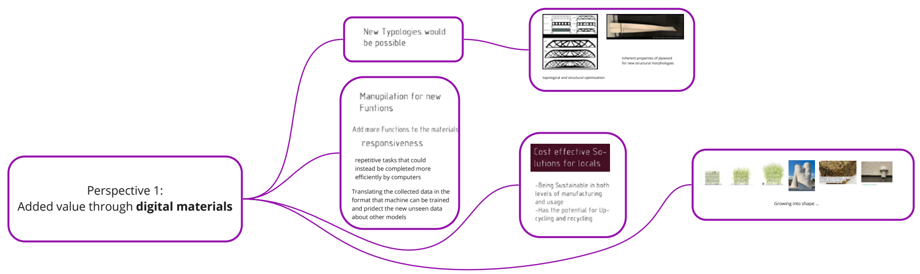
An example of this can be presented through new material technologies where material as data and material as a physical entity cannot be separated. If we look at 3D printing, it enables new, different, complex-built forms to be produced (fabricated and constructed) that are optimized. The 3D printed design of the bridge has an optimized form, performance, and buildability. Furthermore, it is constructed (3D printed) by a robot with a very high level of quality control. The construction workers are no longer exposed and dependent on weather conditions. Instead they work in a laboratory where the robotic constellation does the "physical" work. The processes ensure quality and workers' safety at the same time.

Fig[● 7] Concrete 3D printed bridge design.

Fig[● 8] 3D printing of concrete using robotic production methods.

A further advantage is that the materials can be optimized based on performative requirements (as graduated material behaviors) or with the structural elements offering the required performance using an optimized – minimal amount of material. This can contribute to optimizing resources in use and lead to a more sustainable way

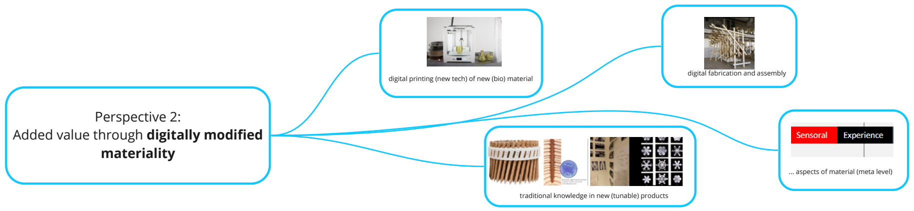
Fig[● 9] Perspective 1: added value through digital materials.



of building. One can also argue that through Perspective 1 – Added value through digital materials: digitally defined/ created/optimized/fine-tuned materials will have a designed performance – that we could contribute to a high-quality Baukultur. However, all of these technologies will have to be tested against their social acceptance and time.

Perspective 2. Added value through digitally modified materiality

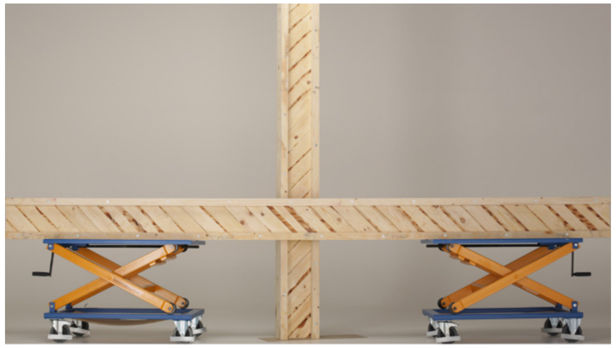
*Building longevity, good indoor climate, resources optimization can be achieved through digitally modified **materiality** – achieving values closely associated with Baukultur.*



Fig[●10] Perspective 2: Added value through digitally modified materiality.

This perspective points towards huge opportunities for working with digital technologies and material where we have the possibility to create a digitally modified materiality. An example can be working with materials that are discarded (waste/leftovers) that offer material performances that are reliable. *Material Value(s): Motivating the architectural application of waste wood*, (Browne et al., 2022) investigates the Brusenius-inspired beam topology made out of waste wood, showing performance that is reliable and comparable to a structure made out of new wood.

Timber-only structures and architecture: using salvaged timber and wooden nails only by Gengmu Ruan and *Architectural design from upcycled formwork wood: perspectives on new physical and aesthetic qualities of waste wood, computer vision and algorithm-assisted façade design* by Gabrielle Nicolas may provide further examples of how digital technologies and (salvaged) material create a digitally modified

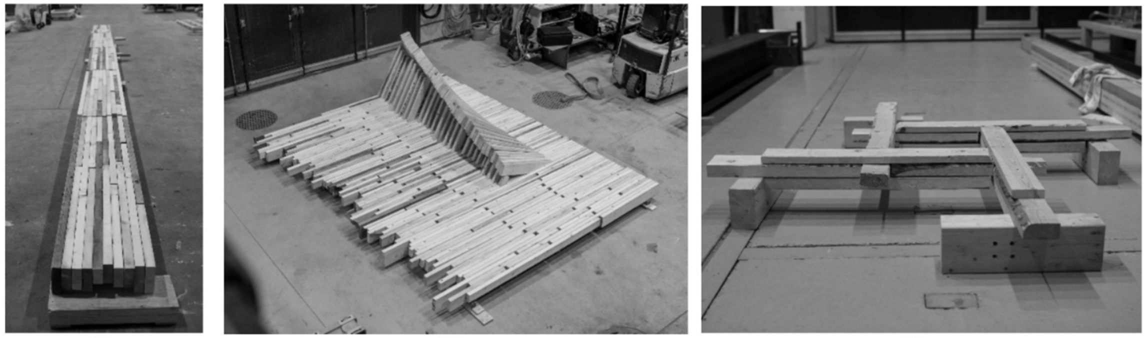


Fig[●11] Brusenius assembly – post and beam.

Fig[●12] Brusenius beam made out of reclaimed wood – close up.

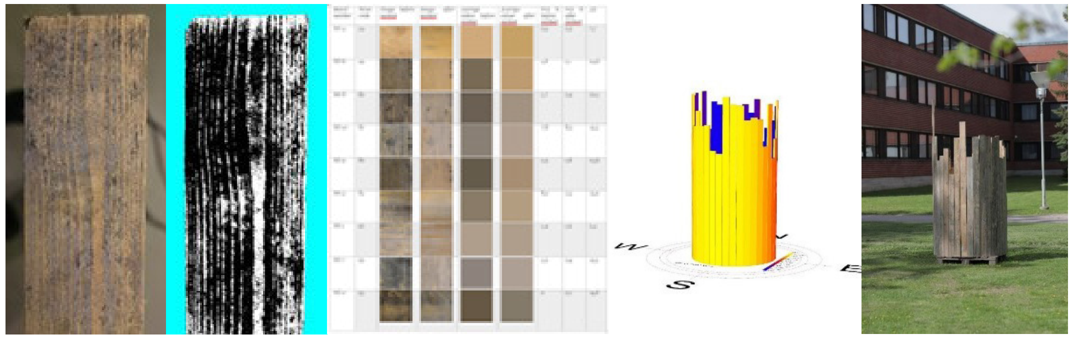
materiality. For both projects the aspect of materiality that incorporates the material as well as an effect on people and the environment is essential (Ruan et al., 2022b). The context and the interactions it contains come into focus, and materiality is thus consciously designed and located material.

Timber-only structures and architecture focuses on integrated sustainable, structural, and architectural design concepts for timber-only structures, more specifically, structures made from salvaged timber and wooden nails only (Fink et al., 2019; Ruan et al., 2021). The key elements discussed in this ongoing PhD research are connection, material, structure, and architectural form. Similar to what is suggested in Oxman and Oxman, 2010, a sequence of "Material and connection first, structure second, architecture third" is applied. Material properties, structural behaviors of possible connections and the entire structure, as well as architectural and structural benefits and limitations are explored by means and design-build-loops (Ruan et al., 2022) of physical (Ruan et al., under review) and digital exploration. Basically, the goal is to introduce salvaged-timber approaches to the field of structures and architecture as an elegant, ecological and efficient option.



Fig[●13] Design showcases: (a) modular elements for Kouvola trail project, (b) a partly curved plaza for Kouvola trail project, and (c) a planar reciprocal frame unit which consists of four beam elements.

“Architectural design from upcycled formwork wood: perspectives on new physical and aesthetic qualities of waste wood, computer vision and algorithm-assisted façade design” explores innovative façade structures from waste wood with the help of machine-learning techniques such as computer vision (Nicolas and Filz, 2022). The hypothesis of this research was driven by the main aspect that concrete remaining on the formwork wood can be considered to be given a new surface treatment/coating instead of turning the wooden boards into waste. Conversely, it can provide the material physical and aesthetic properties not previously considered. Gabrielle Nicolas combined photographic scans, image processing and computer vision, and with UV testing and water absorption tests sought to understand the performance of the new wood material and coating. Quantitative and qualitative results of the UV tests, weathering tests and grade of surface coating are used as input data to create algorithm-assisted customized architectural designs. Combined with actual weather and climate data, Gabrielle presented the showcases of façade designs in two locations – Brussels and Helsinki. In conclusion, this project deals with the opportunity of looking into future scenarios of material performance using machine-learning techniques such as computer vision to simulate and predict technical and visual effects. This takes place after digitally exploring and simulating a full-scale demonstrator of a representative façade design that was built and exhibited at Aalto University.



Fig[●14] Architectural design from upcycled formwork wood, from physical object via computer vision techniques to simulation and real-world application.

WasteWood Canopy, (Larsen, 2022) is a recent project investigating structural application of reclaimed wood, combining crafting methods, tacit material knowledge, and digital (material) data in both physical and digital workflows. The project worked with multi-objective optimization where a number of aspects such as Architecture/Aesthetics, Buildability/Ease of construction and Structural performance were continuously weighed out against each other. The comparisons, relationships, and influence between the factors were optimized so that the outcome – the inhabitable structure in architectural scale (demonstrator) could be designed to achieve a performance that is as high as possible in a holistic way and in all three spheres of influence. It is clear that by achieving a single factor, optimization would give higher results to one factor compared to the multi-objective optimization, which addresses several factors simultaneously (Popovic Larsen and Browne, 2022). However, addressing problems holistically is more beneficial as it mirrors reality in building design practice where it is very rare that we need to optimize one factor only. Furthermore, our current ability to handle complex data combining digital material knowledge with knowledge on physical material offers huge potential opportunities in dealing with the complex challenges that we are facing.

Fig[●15] WasteWood Canopy – exhibition "70% less CO2" at the Royal Danish Academy.

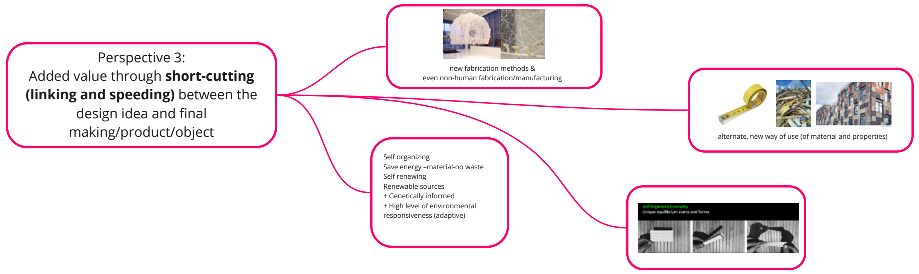
Fig[●16] Examples of façade panels made out of reclaimed wood: Nordic Waste Wood for Good project.

Added value through digitally modified materiality can lead to increasing the building's longevity, securing better indoor climate and if we use resources in an optimized way, it will be a step towards addressing the climate crisis. However, the technical aspects are not the most difficult to deal with. To use and re-use materials that we currently regard as waste, we need to develop a whole new way of approaching design. In addition, a paradigm shift about defining quality needs to happen. A recent project exploring opportunities for re-use of different wood waste streams for façade panels, Nordic Waste Wood For Good, investigated not only the material, design, and detailing aspects, but also tested the social acceptance of the designs (Popovic Larsen and Browne, 2022).

If the technical, aesthetic, and social aspects can be handled, this can also contribute to a high-quality Baukultur. However, all of these approaches and technologies will have to be tested against their social acceptance and time.

Perspective 3. Added value through short-cutting digital workflows

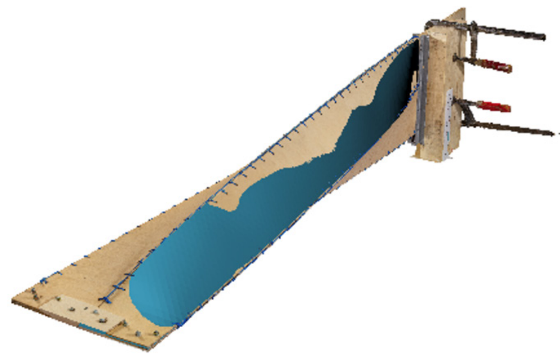
Linking and speeding between the design idea and final making/product/object digital workflows enable real-time simulations and optimizations. Constructing while testing and before designing enables new workflows and opportunities that will secure quality.



Fig[●17] Perspective 3: added value through short-cutting (linking and speeding).

Building in parallel with designing or building before having the complete design is something digital workflows enable. With this short-cutting, processes results can be optimized, all leading to improved quality and Baukultur for the future that relies on new digital opportunities but celebrates qualities of crafting and tacit knowledge brought into the new millennium.

PhD research by Serenay Elmas, who explores elastic torsion as a design driver for structures and architecture, may serve as a showcase for achieving added value through short-cutting digital workflows (Elmas et al., 2021). The main focus of this research is set on twist and torsion and in more detail on bending-active torsional structures with regard to their geometrical, structural, and architectural potentials, limits, and qualities. It looks into a method of framing a self-organized process by combining bending-active aspects (Lienhard et al., 2013) with torsion, which results in a novel typology of lightweight structures. In particular, this research investigates the advantages of such typologies in conjunction with the geometric stiffening, the generation and control of geometry itself, possible bi-stable equilibrium states through the introduction of torsion during the process of form-generation as well as fields of real-world application. The methodology for this study includes both computational and physical approaches. Multi-disciplinarity and parametric design thinking have a crucial role in addressing and solving the questions. Since this particular way of using elastic torsion results in large deformations and non-Euclidean geometries, geometric non-linearities have to be considered. However, after a phase of exploration of material properties and material parameters, the principle findings of material behavior were compared with results from the digital exploration by physics engines. Geometrical observations were evaluated and verified by photogrammetrically generated point-clouds (Filz et al., 2022). A similar procedure has been applied to the structural aspects – physical testing verifying the computational simulation and results – linking and bi-directional bridging between disciplines (Filz et al., 2021). After only a few cycles a purely digital workflow can be established, which not only takes geometrical aspects and structural performance of the single member into account, but also the process of assembly (Elmas et al.) and change of geometry, i.e., the large deformation of the material during this process. Since the exact deformed geometry is known, a wide variety of configurations of the elements can be explored in further steps and in a purely virtual environment and evaluated from different points of view. As a real-world implementation, as part of a larger architectural structure and together with other parameters such as user-structure interaction, a fully digital prototype can be designed, explored, and investigated as firstly demonstrated in the kinematic research pavilion "Zero Gravity" (Filz et al., 2019) realized by the team of ASA (Aalto University Structures and Architecture) in 2019 (Markou et al., 2021).



Fig[●18] Photogrammetric reconstruction of the beam element compared with the mesh from the computational simulation and Zero Gravity research pavilion at Väre building, Aalto University, October 2019, image credit: Lassi Savola.

7.0 Discussion

Within IO4 of the **BuildDigiCraft** project, we discussed Material and its role within the changing digital opportunities of current building research and design practice. The discussion took place on the basis of mapping the data created through the keynote lectures, pre-tasks, PhD projects, tasks and discussions. The rich data was organized, analyzed, discussed, reflected upon. The data suggested the three perspectives presented here.

Digital tools and material practice

The digitization of manufacturing tools has radically changed production. Where computers and numerically controlled machinery have introduced a high level of precision consistency and quality as well as considerable time-efficiency and the ability to deal with high levels of complexity and variance, this approach has also introduced a new category of tools that has profoundly changed the way we understand and perform not only manufacturing but also data collection, transformation, use, and application. Most of the works presented within the framework of the **BuildDigiCraft** project (**BuildDigiCraft**, 2022) have shown one or several of these aspects. This paper may refer to ISP3 (ISP3: Craft and Craftsmanship – **BuildDigiCraft**, 2022), which can be found on the **BuildDigiCraft** web page as well as in its exhibition section (Exhibition – **BuildDigiCraft**, 2022). There is also a recognizable introduction of shared digital platforms creating new interfaces between design, performance, analysis, and fabrication. The increased focus on digitally defined work processes has enabled highly precise and complex design investigations and also the linkage to production with file-to-factory technologies. Here information is directly passed from the design to the fabrication – beginning with data that is used as material, which then undergoes a process and manifests itself in physical artifacts. The used digital tools – often self-programmed – allow architects, designers, engineers, and researchers to reconsider theoretical concepts as well as material practices. Programming is used as a design tool, a new computer logic and a new source of creativity for designers, architects and engineers. In many cases, programming goes along with ready-made, digital tools, and software that is often borrowed from other disciplines and applications.

Material thinking as a design driver

The use of digital tools, digital processes, and digital technology in general shift virtual and digital material thinking into the core of design. This way, new structural, material and tectonic potentials can be explored pushing the boundaries of the disciplines. These approaches – observed within the **BuildDigiCraft** project and from the work of its contributors – can to a certain extent be understood as digital crafting (ISP2: Digital Futures – **BuildDigiCraft**, 2022). Digital crafting shifts manufacturing from a practice-based knowledge residing with the craftsman as tacit knowledge to an integrated practice that also connects with other disciplines during the design and implementation phases.

The concept of material performance

Digital fabrication necessitates a good understanding of crafts traditions and their processes. Designing within and for digital processes and fabrication means understanding the highly developed traditions of material handling, tectonics and their meaning for the design and application space. Together this leads to an enhanced interest in the material and its performance (ISP1: Concepts and Fundamentals – **BuildDigiCraft**, 2022). The creation of new digital material and possibly tuned material suggest new active material understanding also allowing them to provide feedback on the design processes. Finally, digital processes and fabrication allow the exploration of the potential of material thinking, which enables the designers to engage directly with material rather than understanding standardized, prefabricated, and out-of-the-shelf building materials. This opens up new perspectives of highly specified and customized material descriptions, manipulations and therefore material performance. These approaches can be achieved by tuning and creating new material, and by introducing these new concepts, graded material and variations thereof in direct response to their contextual and programmatic aims for a new material culture that can be highly connected to industrialization and which is at the same time questioned on a fundamental level.

The opportunities – but also challenges – in the data analysis for IO4 Material were that the:

- data was very rich – this was both an opportunity, but also a challenge as it was not easy to handle
- data could be understood, handled and analyzed in more than one (good) way, which required many iterations
- iterations gave clearer suggestions of the trends, presented through the three perspectives

By analyzing the material (data) for IO4 – Material, one should point out that the outcome and conclusions are as rich as the data that was studied. The three perspectives suggest three possible ways of how high-quality Baukultur can be achieved. It is interesting to witness whether they will prove to be on point or not. The test of time and social acceptance as well as further research will provide more answers in the future.

8.0 Conclusion

In conclusion, the **BuildDigiCraft** project reflects upon several crucial questions in relation to material:

1. ***Material vs. data = material vs. immaterial?***

The digital (data) is the new material. In the last few decades an entirely new conception of the material world has emerged, as unlike physical components, this material is invisible and intangible. What is known as Industry 4.0 also has implications on our future Baukultur and refers to the intelligent networking of machines and processes with the help of information and communication technology.

The possibilities include flexible production and manufacturing, convertible, and modular production lines, customer-oriented and customized solutions, optimized logistics, combined and analyzed use of data, resource-efficiency, and circular economy. Besides information and data-driven tuning, designing, and composing of new materials, the flow of data and the used technology is stored as an aesthetic feature and trace in the final artefact. This phenomenon is for example most visible in CNC-milled components or the surfaces of 3D-printed objects. The physical and digital are closely connected. They are actually inseparable: they flow between and are closely linked supporting each other's existence. They are truly "one." The data is the material and any material can be described as or by data. That clearly offers opportunities but also challenges.

2. ***Material and sustainability?***

With new digital material an understanding of material's behavior and performative qualities can be tuned, customized and optimized, which may lead to the development of new materials with specifically designed or bespoke performance. Furthermore, building with what we currently consider as waste becomes possible and offers new potential of resource optimization as well as a rise to a new aesthetic paradigm based on material agency.

3. ***Where are we in terms of digitalization?***

Currently, we are able to handle huge and complex forms of data. If, however, we look at the history of digitalization, it is very short in comparison to history of our civilization. The development in digital workflows, processes, and tools is extremely fast. Systems of a few years ago that at the time were presenting the height of human achievement in the field are not only obsolete, but also impossible to use. The data we use is short-lived if supporting digital systems are outdated and thus, not there any longer. A relevant challenge to address is how to store, manage, and in some cases restore data in future as systems and software are subject to constant change.

If we, on the other hand, look at buildings that we celebrate as high-quality Baukultur, they are built to last for hundreds of years. It is essential that digital systems, tools, and flows should have the in-built robustness and adaptability throughout the buildings' lifecycles and beyond. The question of how to guarantee the longevity of data, the associated data accessibility, the synchronization of data and the realized artifacts, which are based on this data, remains open.

Another important aspect related to data is that we need to understand the data and its potential impact on more qualitative values. Also, we need to connect material knowledge better with design and construction. How to store, manage, and in some cases restore data in future as systems and software change? In this context, tacit knowledge, if unused, is just as at risk of being lost as digital data is.

If we look at the craftsmen of the past, they passed the data on physical material through tacit knowledge. The "new" digital form of material data is very rich but still detached from the tacit craftsmanship process and knowledge. The symbiosis of material, design and construction knowledge, and (digital) data is very powerful.

4. *Material and a "new beauty"? What is the level and amount of data to guarantee beautiful structures/spaces?*

Baukultur as we know it epitomizes building quality, beauty, embraces aesthetics and human/use values where materials are crafted to a level that ensures the quality that Baukultur stands for. Many of the architectural masterpieces of the past were created before the emergence of digital opportunities. Digital workflows enable us to handle complexities of building projects at present. Matching data levels/requirements for achieving the quality of a new Baukultur is essential.

A final comment that arises from the **BuildDigiCraft** project relating to material is that digital materials/data will not replace the physical realm. For a high-quality Baukultur, the physical and digital realms are becoming increasingly inseparable and have the potential to inspire each other. Therefore, the crafting qualities, tacit knowledge, the qualitative-unmeasurable qualities have to be interlaced in new meaningful ways with the digital, quantifiable and data-driven ones. This will result in future high-quality Baukultur as it is envisaged in many of the **BuildDigiCraft** project's examples. For achieving high-quality Baukultur, it is essential to establish the connections between data, material, design, and construction knowledge – making the tacit explicit.

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3.0 Manifesto
Intellectual Output 5

Manifesto for High-quality Baukultur in the Digital Age

Authors
BuildDigiCraft project team

Contents

1.0 The story behind the Manifesto [introduction]

Ideally, in every piece of work that designers, engineers, and planners create, there should always be an inner striving to achieve higher quality in the surrounding built environment.

In a technologically advanced and highly digitally-driven professional environment **the values and leading principles of traditional craftsmanship**, such as dedication or pride in one own's work and the mindful and sustainable dealing with the building material, need to be reintroduced into the processes of the built environment and validated again.

At the same time one should ask: ***What is the high quality of the built environment? And how do we measure and enhance the perception of this quality in the digital age?***

With two major political milestones – the **Davos Declaration 2018 "Towards a European vision of high-quality Baukultur"** and the **New European Bauhaus Initiative 2020**, a very clear message was sent throughout Europe. This was an open invitation to reflect together on the need for a crucial change in the mindset of the professionals responsible for the built environment as well as of society as a whole. It also invites us to look at how we want to address and shape the built environment of the future in the context of global societal and climatic challenges.

The building and construction sectors are known for being very conservative when it comes to risks and changes, and at the same time not flexible enough to manage and adapt quickly to changing circumstances. Therefore, it is not surprising that it's this sector precisely that meets most challenges in finding a way to adapt its rules and regulations as well as its business policies and logic to the ongoing digitally-driven transformation. There is a **need for a fundamental change in the way "we are doing things" and the way "we communicate and collaborate with each other"** and digital technologies play a major role in this transformation process.

This Manifesto results from exploring the following questions:

- ***How is the ongoing digital revolution affecting the work of designers, architects, engineers, urban planners, and other professionals responsible for the shaping of the built environment?***
- ***What new opportunities arise from the available digital and data-processing technologies for creating innovative solutions for the design, construction, maintenance, and management of buildings and cities (beyond standard workflows and material use).***

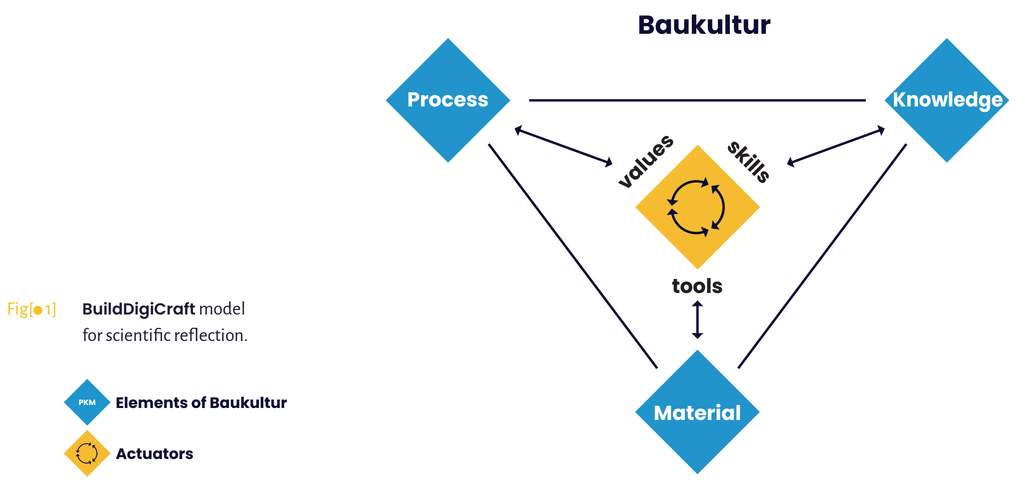
BuildDigiCraft builds on the holistic concept of Baukultur and seeks to explore opportunities to further develop it in the context of a highly digitalized world.

2.0 Acknowledge the elements of Baukultur [method]

Dealing with the built environment is a complex task that has direct impact on the physical space and on social and societal processes taking place in that space. Specialists of the built environment use different tools, methods and intellectual models to manage this complexity.

BuildDigiCraft introduces a new model for intellectual reflection on any type of physical intervention in the built environment. With its help specialists can better assess the quality of their work process as well as the quality of their intervention.

Therefore, **we deconstruct Baukultur down to its core elements, i.e., *Processes, Knowledge, and Material*** (Fig[●1]). Shaping and maintaining the built environment results in complex and diverse processes and includes design, planning, construction, maintenance as well as end of use phase. In broader terms, these Processes behind the intervention of the built environment are influenced by the available Knowledge and understanding of Material. The project development is actuated by values, skills, and tools being used by designers, planners, developers or builders as well as the building society.



Fig[●1] **BuildDigiCraft** model for scientific reflection.

Process–Knowledge–Material reflection

Analyze and reflect on your individual design and intervention project by answering the following questions:

Q1 *What is the Process, what is the Material, and what is the Knowledge that you are addressing and using in your design project, and what is the Process, Knowledge, and Material that you would like to derive from it?*

Q2 *How do you see the relation between the Process, Knowledge, and Material in the context of your work?*

Q3 *What are the values you are following and addressing in your project?*

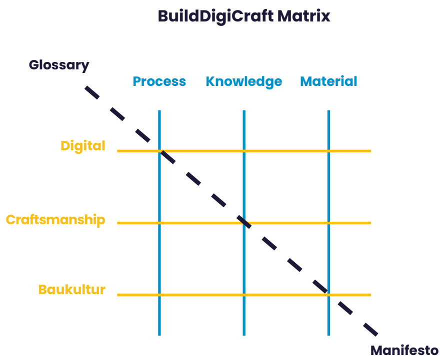
Q4 *Which skills are you applying, and which are the new skills that you are developing within your project?*

Q5 *What tools do you use and plan to use?*

Q6 *Try to define the term Baukultur in your own words and in respect to your individual project.*

3.0 Structure your project with the BuildDigiCraft matrix [method]

The **BuildDigiCraft matrix** is a tool to structure your project concepts and to gain a contextual analysis. The matrix is based on the **core elements of Baukultur** (see Fig[● 2]): ***Process, Knowledge***, and ***Material***, which intersect with the three major thematic concepts of Baukultur, Craftsmanship and Digitalization addressed in the **BuildDigiCraft** project.



Fig[● 2] **BuildDigiCraft** matrix.

On the **vertical axis** we find: (1) **Digital(ization)**, which influences the current and future process of shaping the built environment, (2) **Craftsmanship**, which addresses the gap between the actual situation of digitalization and its potential, and finally, (3) **Baukultur**, which lays the values and principles we follow in the process of shaping the built environment and which at the same time joins the above concepts. We believe that there is a strong connection between these three components as they all refer directly to the quality of space created by the design team as well as to the acceptance of the proposed design by civic society, including all the actors involved both directly and indirectly in the process.

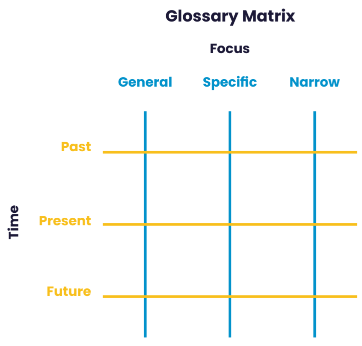
The horizontal axis consists of the following components: (1) **Process**, which includes the whole cycle of design, planning, construction, maintenance, end of use, and start of reuse, (2) **Knowledge** defined as tacit and implicit knowledge that influences these processes and (3) **Material**, which relates to the physical representation of design in the built environment and also responds to the need of understanding materiality in the digital context.

One of the questions related to trying to position concepts and ideas within the matrix-based intersection of the pillar concepts of the **BuildDigiCraft** project:

Q ***Can you deconstruct the concepts and ideas you use in your work/intervention in such a way so that they can fit in the matrix grid?***

4.0 Apply the Glossary Matrix tool to your project [method]

The **Glossary Matrix tool** (see Fig[● 3]) allows for a temporal as well as scale-oriented exploration of the terms, concepts and ideas used in the project. The Glossary Matrix serves as a framework tool for establishing the dimensions within which the posed concepts and notions can be explored. The Glossary Matrix helps to identify and structure the content of your own project-related Glossary.



Fig[● 3] Glossary Matrix.

Apply the matrix-based Glossary tool to the concepts, ideas and terminology you use in your project. The Glossary builds on the concept of the **BuildDigiCraft** project matrix and specifically on one of its two main axes, containing the three components of ***Process, Knowledge***, and ***Material***.

The two axes of the Glossary Matrix are: **focus** and **time**.

The **"x" axis** of the matrix – **Focus** – enables the identification and use of notions and ideas according to the scale of their focus, which is connected with the availability and use of different terms derived from a broad spectrum: **general**, which is available to a wide range of non-specialists, through to a more **specific** one, which is used by specialists in the context of their profession, up to a **narrow** one – used strictly in relation to the problems of specific research projects such as PhD or Master's theses of the ISPs' participants.

Time factor, pictured on the **"y" axis**, is used to describe the meaning and appearance of notions and ideas throughout time. This section is divided into the **Past**, meaning both the distant and more recent past, the **Present**, which includes both the present time and the very near future, and finally, the **Future**, both near and distant, including the future that is very difficult to predict.

Q ***Can you place your concepts and ideas in a temporal and scale context (in the time and focus matrix) for others to understand them?***

5.0 Understand the changing paradigm of Baukultur in the digital age [context]

Digitalization is revolutionizing our society and all actions related to our everyday life, our professional world, our social interrelations as well as the way we are dealing with physical space.

We have identified seven major aspects which characterize the changing paradigm of Baukultur in the digital age:

A Dialectic between the visionary world of design and the physical world of project realization

In the context of the built environment we need to deal with the dialectic between the generally creative and interactive character of the design process on the one hand and the targeted character of the realization process on the other; a continuous interaction with the physical world is necessary and characterizes the intersection between the visionary world of design and the physical world of project realization.

Transferring this understanding/these circumstances into the world of digital possibilities implies new approaches: for example, digitalization allows the transfer of an idea or vision into materiality already during the design process. This implicates a change of the process: now we can control the design process for example though physical representations, for example by a printed model of the digital vision. This means on a printed, materialized version, a design idea can be conveyed though physical representations, for example by a printed model of the digital vision. This means a design idea can be quickly evaluated on a printed, materialized version. .

B Digital twin representation

Another aspect of the dialectic between the physical and digital world is the digital twin, or more precisely, the digital representation of a design as well as a real object. There is a need to assess the benefits and roles of a digital twin for the physical built environment and its future use in the virtual world. A discussion is necessary about the costs and the efficiency of the digital twin, too. However, it is first the design process behind the digital twin that needs to be better understood in order to be able to later answer further questions related to its performance.

C Connection between the creator and the creation

Any process is characterized by the creator and the connection between the creator and the creation. What seems to be most obvious needs to undergo a new evaluation process under the conditions of the digital time boundary conditions. The most pressing question then is whether the connection between the creator and the creation will be set in a contemporary process and how rapid digital prototyping influences it. This will help prove the design idea in multiple evaluation loops, without losing time in manufacturing. It thus links the creation closer to the creator. The qualities of craftsmanship therefore need to be reintroduced consciously in the digital process in order to fill up the connection gap between the creator and the creation.

D Roles and responsibilities in a complex collaborative context

Collaboration and interdisciplinary exchange are essential for the processes dealing with the built environment. The digital context collaboration between design stakeholders has become much more flexible, accessible and transparent. New digital technologies allow more participants to be part of the design process. At the same time, participation and collaboration do not immediately mean shared responsibility. The designer as a professional, for example, remains responsible for the shape of design. Yet there is in particular a need for ownership of the project, which incorporates responsibility among all stakeholders.

Roles and responsibility allocation is seen as a crucial aspect of any design and intervention process. Design ideas need a critical review and discourse which is part of the characteristic iteration inherent to the design process. The designer needs to feel responsible for the design and the decisions necessary during the design process. Such an attitude needs to be developed individually by the designer/creator, and it's also based on a social understanding, which in turn reflects individual and social values.

In the context of digitalization new responsibilities now arise. An array of digital tools influences and shapes the design process. This also reveals an ambivalence toward the new tools and processes. On the one hand, digitalization offers new methods and approaches toward essential questions but on the other, digitalization comes with the fear of standardization, simplification, and automatization – to an extent, the designer's fear of being replaced by a digital process is stirred. But the role and responsibility of the designer is non-negotiable, which at the same time needs to be understood by the designer while he/she is drawing own consequences from this fact.

E Speeding up, time as a crucial factor and the non-linearity of the process

The role of time is crucial to any design process but this aspect becomes even more essential and influential on the process itself when set in the digital context. First, digitalization allows for much faster processes. Secondly, it allows for the introduction of new contents and knowledge at any step of the process chain. Traditionally approved sequence of process steps can be questioned now or can even be re-organized. The process is not only linear anymore. For example, digital production processes like 3D printing allow the making of a physical representation of a design version at any stage of the design process. These representations enable a more holistic evaluation of the design concept.

A digital model enables and at the same time requires the integration of vast sets of data, often unstructured, and information much more than in the analog design process. In a traditional design process this information merges step by step, while developing the idea from a vision to a realized and materialized intervention in the built environment. In contrast, the digital model requires the integration of information in a much earlier design phase, in a phase where "normally" this information is not available yet. This means that the initial design phase of any digital building process will require more attention, more time and more design loops.

F More data – more knowledge?

Any design and building activity is based on the availability of information, e.g., data. Through digitization the amount of available data increases enormously as well as the capacities and tools for handling data and big data. However, more data does not lead self-evidently to more knowledge.

Knowledge is based on data, but we cannot easily extract knowledge from data. Knowledge is also based on the experience of making/doing/creating as well as exploring. Data and experience joined together fill up the reservoir of explicit and implicit knowledge.

Knowledge in its essence can be explicit or implicit, the second also including the unspoken aspects that tacit knowledge includes. Where explicit knowledge can be easily accessed and transmitted to others by articulation, codification and verbalization, the tacit and implicit knowledge is gained by personal experience and is more difficult to express and transfer.

Today, physical and digital worlds are merging closer than ever before and digitization plays a big role in producing, transferring, and communicating all types of knowledge in formal, semi-formal and non-formal activities (workshops, conference discussions, training). Explicit knowledge is actively shared in e-journal publications, e-databases, e-books, websites and videos. Still, there is a changing paradigm on how knowledge about the real world is gathered due to significant and growing attention paid to AI, VR models, and collecting information from simulations of data variables in these models.

G Dealing with data

How to store, manage and in some cases restore data in future (as systems and software change)? The history of digitization spans a very short period in comparison to the history of our civilization, but the development in digital workflows, processes, and tools is extremely fast. Systems that a few years ago presented the height of human achievement in the field are now not only obsolete, but also impossible to use anymore. The data we use is short-lived if its supporting digital systems are outdated. Buildings that we celebrate as high-quality Baukultur need to be built to last for hundreds of years.

It is essential that digital systems, tools, and flows should have the in-built robustness and adaptability throughout the buildings' lifecycle and beyond.

6.0 The idea of Craftsmanship in the digital building culture [context]

Craftsmanship addresses in its essence **quality, beauty, and resource efficiency**; it promotes a relation to sustainable material and techniques and offers tangible experiences through synergies of mind and hand while intimating satisfaction in achieving a level of mastery and highest quality.

Craft entails **implicit and tacit knowledge** and is passed on between craftspeople. Its values are deeply sustainable as their core value is quality and reducing wasteful approaches.

The Craftsmanship ethos in design and building projects is essential for strengthening the **sense of belonging and commitment to the surrounding space** because **it gives meaning to the process** and because through Craftsmanship the process can be **identified with the material** and the physical outcome of the project.

The craftsmen of the past passed the data on physical material through tacit knowledge. The "new" digital form of material data is very rich but still detached from the tacit Craftsmanship process and knowledge. The symbiosis of material, design, and construction knowledge and (digital) data is very powerful.

Craftsmanship is associated with being as humanistic and having artistic values that stand behind the work and the "material." Material is understood as both traditional building materials like "wood," but also data, emotions, and information from a community. Craftsmanship is thus transformed into the digital realm as representing, for instance, uninterrupted experiments, a special time quality as well as artistic quality.

Baukultur as we know it epitomizes building quality, beauty, embraces aesthetics and human values where materials are crafted to a level that ensures the quality that Baukultur stands for. Many of the architectural masterpieces of the past were created before digital opportunities had surfaced. Digital workflows enable us to handle complexities of building projects at present. Matching data levels and data requirements for achieving the quality of a new Baukultur is essential.

7.0 Recommendations and statements [outcome]

For achieving high-quality Baukultur, it is essential to establish the connections between data, material, design, and construction knowledge – making the tacit explicit. The craftsmen of the past passed the data on physical material through tacit knowledge. The "new" digital form of material data is very rich but still detached from the tacit craftsmanship process and knowledge. The symbiosis of material, design, and construction knowledge and (digital) data is very powerful – **making the tacit explicit**.

Process

Toward guidelines for a design process leading to a high-quality Baukultur in the digital age

The design process is often overlooked as something invisible, not tangible. However, it is this series of decisions made in a design process that will eventually lead to poor- or high-quality Baukultur. We now have a situation where designers involved in design processes of Baukultur have access to new digitalized, visualized information that was not accessible just a few years ago. We have thus the potential for creating design processes that will lead to higher levels of sustainability and cultural appreciation. Digitalization also poses considerable risk, because design processes used to be regulated by industry standards and tradition. Those processes are now much more free, and the guidelines are there to help designers reflect on the quality and values behind the design processes they perform.

Two main points to think about:

1. ***Commercial mainstream processes and artistic process – what is the balance?***

Digitization may push forward any standardized, automatized process which in turn may lead to commercial mainstreaming. These seem to be the opposite of any free creative process. Keeping the balance is key.

2. ***Criteria-driven or value-driven process – what is the balance?***

The role of digital tools in contemporary design processes is to support humans most effectively, allowing for the reduction of errors and the most accurate analysis and results. However, what can be seen from the illustration of these processes is that digital tools and new technologies do not dominate the processes, nor are they an end in themselves. The ultimate goal of the undertaken research issues is to strive to build better and better quality and search for new solutions and opportunities in the physical world, the true framework of human life.

One can also see the reflection and the questions posed as to whether such advanced use of digital tools is always economically justified, whether digital tools are not starting to lead a "parallel life" that has no impact on contributing to the improvement of the quality of reality in which people live.

Creating a design process to answer a specific contextual challenge is a skill that any designer/builder needs to excel in. Digital tools at hand can be used creatively and contextually – even though the tools themselves might not have been developed for a specific design stage, they can still be used in new ways.

Some **aspects and guiding questions** to be considered when creating/using a digital design process:

Informed design process (support decision-making and potentially provide access to better choices)

Q *How is the design process created?*

Q *Which design process could I propose to fit a specific context, place and design task? What are the questions I would like my process to answer?*

Access to the new levels of information behind the digital design processes

Q *Who has access to the information? Who can afford a prolonged pre-design phase and can pay for the software, tools and IT expertise? What about those who cannot?*

Q *Is there an open-source version of the digital tool you want to include in your design process?*

Use and misuse of information involved in the digital design processes

Q *Will my use of data compromise the privacy and dignity of anybody?*

Non-linear design processes

Q *Have I included more lifecycles and considerations about end of life and reuse?*

Q *Have I taken enough time for reflection on the design loops into account in order to continuously improve my design?*

Collaborative platforms and stakeholder inclusion through visualization

Q *How can I ensure accessibility to design collaborative platforms for all stakeholders?*

Q *Are the visualizations adequately designed to communicate to stakeholders and create transparency and inclusion?*

Respect of humanistic values and social sustainability (beyond quantitative data)

Q *Have I included considerations of environmental impact?*

Q *Have I included in the design process information concerning:*

- *sense of place (genius loci)*
- *biodiversity*
- *beauty?*

Transparency in weighing qualitative and quantitative information

Q *Do I have a multi-criteria framework where I have an overview and can weigh qualitative and quantitative information and criteria?*

Q *Have I established transparency in how to weigh different criteria and indicators? Have I included both qualitative and quantitative information in my design process?*

Art and work of the human hand (creative process)

Q *Have I left space for "the mark by the work of the hand"?*

Q *Have I reflected on whether the digital tools in this project have improved or indeed at times restricted the artistic freedom and the work with values?*

Control of the design process

Q *Have I checked whether the automated iterations are running wild? Who or what controls the "design" of the design process?*

Q *Have I assigned respectively clear roles and responsibilities within the design process?*

Time for the design process

Q *Have I planned enough time for the initial design phase to "build" first digitally, then in reality?*

Strategic recommendations:

- Criteria needs to be flexible at the beginning of the design process.
- The process should be based on values (art, culture, sense of place, nature, humanity ...) not data-/criteria-driven.
- Use more time and resources on design process – make sure it is artistic, driven by humanistic values (digitalization can harm the quality of the design processes behind the built environment because it is tempting to "copy and paste" financial reasons, instead of creating a sense-of-place-driven original design process for it).

Knowledge

Toward guidelines for the development of a higher education curriculum: bridging craft and digital for a high-quality Baukultur

The human factor in decision-making

Digitalization addresses the way we are handling knowledge today in terms of the increased amount and intensity of the available data and the indefinite number of complex relations that can be recognized within the specific data vs. information vs. knowledge context. However, decision-making on how data should be acquired, selected, arranged, evaluated, and communicated remains a process principally dependent on the human factor. Humans tend to rely on implicit knowledge, which also involves some sense of intuition, when dealing with specific problems that require customized decisions (sense of place).

Knowledge as a public good

Knowledge should be viewed as a public good rather than intellectual property. Knowledge application, relevance, contextualization, outreach, transfer, and management should be developed in society and cannot be traded like other goods or services can. Here the higher education institutions play a big role as "knowledge hubs," animating indigenous development and innovation that spans between industry, government, and society. This stresses the growth of mutual learning between scientists and societal actors.

Qualities of good craftsmanship

The qualities of good craftsmanship need to be sustained in the digital era. It is suggested that focus should be in gathering professional knowledge, understanding and training skills in relation to "materiality" (being real, not virtual), "location" (being grounded), "sustainability" (being adapted to nature), "diligence" (being passive and professional), "openness" (being vague), "good life" (being human).

Ethical knowledge and the role of design education

Knowledge should be about training the ability to take well-grounded design decisions in complex situations. The contemporary role of academia needs to serve as a facilitator of emerging modes of learning, preparing future generation of designers to take responsibility for shaping high-quality built environment. Education and research should be directed toward how we can prepare individuals to grow in all three of Aristotle's categories of knowledge – "episteme" (scientific knowledge), "techne" (knowledge of craft) and "phronesis" (ethical knowledge). The new modes of learning require creating opportunities for students and young professionals to make informed design decisions and exploring phenomena-based knowledge. This includes learning about cultural values like the history of architecture and built environment (old and contemporary), humanistic understanding of design questions, state of the art, and that every problem is unique involving phronesis.

Material

The meaning of Material, Materiality, and the Digital for Baukultur

For achieving high-quality Baukultur, it is essential to establish the connections between data, material, design, and construction knowledge – making the tacit explicit. The craftsmen of the past passed on the data about physical material through tacit knowledge. The "new" digital form of material data is very rich but still detached from the tacit craftsmanship process and knowledge. The symbiosis of material, design, and construction knowledge and (digital) data is very powerful – **making the tacit explicit**.

How to understand material and materiality in a digital building culture? The building culture of today is one relying on and supported by digital workflows, processes and tools. Materials with their inherent characteristics are not only understood, but also described through highly sophisticated and detailed data. The availability of digital tools and the ease of handling complex data enables us to manipulate material giving rise to new types of designed material behavior. Through the new digital material, understanding material's behavior and performative qualities can be tuned, customized, and optimized, leading to the development of new materials with specific designed performance.

This leads to three perspectives on material:

Perspective 1.

Added value through digital ***materials***

Digitally defined/created/optimized/fine-tuned **materials** will have a designed performance. It will embrace both measurable and qualitative Baukultur values.

Perspective 2.

Added value through digitally modified ***materiality***

Building longevity, good indoor climate and resources optimization can be achieved through digitally modified **materiality** – achieving values closely associated with Baukultur.

Perspective 3.

Added value by short-cutting digital workflows linking and speeding between the design idea and final creation/product/object

Digital workflows enable real-time simulations and optimizations. Constructing while testing and before designing enables new workflows and opportunities that will secure quality.

Final remarks

A final comment that arises from the **BuildDigiCraft** project relating to material is that digital materials/data will not replace the physical realm. For a high-quality Baukultur, the physical and digital realms are becoming increasingly inseparable and have the potential to inspire each other. Therefore, the crafting qualities, tacit knowledge, the qualitative-unmeasurable qualities have to be interlaced in new meaningful ways with the digital, quantifiable, and data-driven qualities. This will result in future high-quality Baukultur and the high quality of spaces.

4.0 Catalog of Video Lectures

Catalog of Video Lectures

Lectures ordered chronologically by ISP and in order of appearance

All lectures are available online on the project webpage in the section "media"[1] or on the project's YouTube channel.[2]

[1] https://www.builddigicraft.eu/media/

[2] https://www.youtube.com/channel/UC8bldsOCxTQCwF2Xu1H3_rA/videos

ISP1 Concepts and Fundamentals

19.10.2020

- **Chris Luebkeman, Dr.**, ETH Zürich
  What is the world we want to live in?

Chris Luebkeman's career has spanned various professions and geographies. His multidisciplinary education (geology, civil engineering, structural engineering, entrepreneurship, and a PHD in Architecture) was encouraged by his Midwestern family of educators. His journey included Vanderbilt, Cornell, and the ETH in Zurich. He became an academic gypsy, teaching courses on design and on technology at the University of Oregon, the Chinese University of Hong Kong and at MIT. He joined Arup in London to lead the Research and Development group in 1999 and became a corporate intrapreneur by founding the Foresight, Innovation and Incubation teams.
He established the Drivers of Change program and is proud to have been said to have a mindset "in league with the future," as *The Guardian* describes it. He is deeply passionate about curating constructive dialog, insatiably curious, relishes the opportunity to discover the opportunities which will be created by change and to evolve positive solutions to the profound challenges we face today. For 20 years he traveled the globe, sharing his observations and insights by leading projects focused on the future for Arup, Arup's clients and for many of the world's leading institutions.
He has spoken at TED, hosted conversations at and for WEF and keynoted dozens of conferences around the world.

Video link: https://youtu.be/E_zMTb_oLlM

20.10.2020

- **Inga Glander, Dipl.- Ing.**,
  German Federal Foundation Baukultur
  What is Baukultur in general and what is Baukultur in the digital age?

Inga Glander: Dipl.-Ing. Architecture. Studied at Technical University Braunschweig and Universitat Politècnica de València. Project management for several architecture firms in Berlin, including braun.busse.architekten and Pott Architects. Correspondence course in journalism at Freie Journalistenschule. Assistant of the board of the Federal Foundation of Baukultur since July 2018.

Video link: https://youtu.be/F4nS4aexBww

21.10.2020

- **Claes Caldenby, Prof. em**,
  Chalmers University of Technology, Gothenburg
  Craft in a Digital Era. A Search for Earthly Paradise

Claes Caldenby is professor emeritus in Theory and History of Architecture at Chalmers. He is also an architectural critic and an editor of the Swedish review of architecture. As a historian his interest has mainly been 20th century architecture and the history of ideas as an important aspect of architecture.

Video link: https://youtu.be/pLL1ZR5Uvko

22.10.2020

- **Kristoffer Negendahl, Assoc. Prof.**,
  Denmark University of Technology
  Engineering Architectural Arguments

Assistant professor Kristoffer Negendahl represents the Technical University of Denmark and his research in application of scaled analysis of sustainability and circularity in early design stages. He has applied his background in building physics (energy, thermal comfort and computer fluid dynamics) with the aspects on design optimization in practice as well as with his work in research and teaching. Kristoffer has been part of forming the internal R&D unit within Bjarke Ingels Group called

BIGIDEAS, and has worked with BIG since 2015. Kristoffer is a co-founder of Procedural.build, which organizes and scales environmental, lifecycle and sustainability analyses for architects and designers.

Video link: https://youtu.be/bd2Zzq2WuQM

ISP2 Digital Futures

15.02.2021

- **Mette Ramsgaard Thomsen, Prof.**, Royal Danish Academy, CITA, Copenhagen
Digital craft in a bio-based material paradigm

Mette Ramsgaard Thomsen examines the intersections between architecture and new computational design processes. In the last 15 years her focus has been on the profound changes that digital technologies instigate in the way architecture is thought, designed and built. In 2005 she founded the Centre for IT and Architecture research group (CITA) at the Royal Academy of Fine Arts, School of Architecture, Design and Conservation where she has piloted a special research focus on the new digital-material relations that digital technologies bring forth. Investigating advanced computer modeling, digital fabrication, and material specification, CITA has been central in the forming of an international research field examining the changes to material practice in architecture. This has been led by a series of research investigations developing concepts and technologies as well as strategic projects such as the international Marie Curie ITN network Innochain that fosters interdisciplinary sharing and dissemination of expertise and supports new collaborations in the fields of architecture, engineering and fabrication and the Sapere Aude Advanced Grant Complex Modeling, which examines new modeling paradigms in computational design.

Video link: https://youtu.be/ZUWAXtiBdXU

16.02.2021

- **Mark Burry, Prof.**, AO, Founding Director of Swinburne University of Technology's Smart Cities Research Institute, former Prof. of Urban Futures, University of Melbourne
Urban futures and designing the digitalized city: from parametric design to parametric urbanism

Professor Mark Burry offers an overview of his experiences pioneering parametric design for architectural scale projects to precinct and city scale projects. He argues that parametric design is more than BIM, and that parametric urbanism is more than PIM and CIM (Precinct and City Information Modeling). His approach refers to his 37-year-long contribution to the design team completing Gaudí's Sagrada Família Basilica in Barcelona and how it relates to the recent establishment of "iHUb" across four major cities in Australia – a national urban research platform to bring people to the digitalization on the built environment, and vice versa. He considers the question of how much closer we are to designing cities with people rather than simply for them, and what new agency digitalization and the Internet of Things offers to citizens today.

Video link: https://youtu.be/zZ-e-xoZ_8A

17.02.2021

- **Vicki Thake, PhD**, Assis. Prof., Institute of Architecture and Design, Royal Danish Academy, Copenhagen
Fiber Reinforced Polymer Composites in an Architectural Context

Vicki Thake studied at the Royal Danish Academy and has an industrial PhD, which introduces an architecture form-led by an advanced composite, with a focus on the relationship between space, material, and light. Through an experimental study conducted in different scales, the thesis examines the integration of FRPs (Fiber Reinforced Polymers) within an architectural context as a special material-geometry with a focus on the internal composition between the composite's two elements: fibre thread (Reinforcement) and matrix (Mass). The aim is to seek new ways of composing the tectonic principles of fiber geometry with textile, fluid, and form-led properties, in the creation of a translucent material logic for architectural space, element, and assembly.

Video link: https://youtu.be/Gzczg93owDk

- **Anton Kuzyk, Assoc. Prof.**, Aalto University, Department of Neuroscience and Biomedical Engineering
DNA-based nanoscale architectures

Anton Kuzyk (born 1981, Lviv, Ukraine) received his Doctor of Philosophy degree in 2009 from University of Jyväskylä. After graduation, he worked as a postdoctoral researcher at Technical University of Munich (2010–2012), Aalto University (2012–2013) and Max Planck Institute for Intelligent Systems (2013–2016). Anton's research focuses on DNA-based self-assembled systems with functionalities tailored for bio-sensing, nanophotonics and bio-mimetics. He is well-known for his contribution to the field of self-assembled plasmonics and his research has been published in, for example, *Nature*, *Nature Materials*, *Nature Communications* and *Science Advances*.

Video link: https://youtu.be/Qz-YeBqKwGQ

18.02.2021

- **Helle Rootzen**, CEO of andhero, former Prof. in Learning Technology and Digitalization, LearnT DTU – Center for Digital Learning Technology, DTU Copenhagen
Big or small data for big and small problems?

How do we compute sustainability? And how do we put a number on good architecture? We are often overwhelmed by an enormous number of parameters that we can take into account when modeling our data. But what is the philosophy behind treating big data and what about testing hypotheses – is that old-fashioned?

Helle Rootzen worked as a professor at DTU on data science, digitalization, learning technology, and leadership – and in 2020 she founded her own company andhero.

Video link: https://youtu.be/J_zusriWqAI

19.02.2021

- **Lars Botin, Assoc. Prof.**, Department of Planning; Technical Faculty of IT and Design; Techno-Anthropology and Participation, Aalborg University, Denmark
Do Digits Have Morality?

Lars Botin is Associate Professor at Aalborg University and has during the past 20 years performed research within the interdisciplinary programs of Architecture and Design, Art & Technology and Techno-Anthropology. His focus is philosophy of science and technology with an outset in Continental Philosophy, i.e., phenomenology and post-phenomenology. He has published and edited a multitude of books and scientific papers with a technological focus on architecture, health informatics, and social media.

The lecture interrogates the intrinsic relationship between the worlds of humans and technologies and questions whether humans are exclusive carriers of moral and political values.

Video link: https://youtu.be/-K4ZicLotzo

- **Vincent Kuo**, PhD, VXT Research
"Baukultur" Actionable Insights with Natural Language Processing

VXT Research is a boutique machine-learning company, based in Finland. Our story began in 2016 when we secured our first large AI procurement contract with Business Finland (previously Tekes), the official agency for innovation and research funding in Finland. We were then just a group of naive researchers, though with a burning passion for textual artificial intelligence and semantic technologies. Despite our underdog attitude, we were very proud to have triumphed in the procurement contest amid seasoned industry adversaries. As a way to honor the spirit of theory-practice union and the endless potential of machine learning for the masses, VXT was born. Through VXT, we exercise our passion of combining our research and industrial expertise to transform how our customers and partners approach traditional niche problems. Our mission is to inspire all to think about semantic technologies and machine learning, without any fear. In doing so, we strive to help people realize that big old niche problems can be solved through the fusion of creativity, integrity, and technical excellence.

Video link: https://youtu.be/5zegL6_mavk

ISP3 Craft and Craftsmanship

14.06.2021

- **Jüri Soolep, Prof.**, Estonian Academy of Arts
  Digital disturbing Delight

Jüri Soolep is the Head of Doctoral School in the Faculty of Architecture, Estonian Academy of Arts. He has worked as Professor in NC State European Center in Prague, Czech Republic, and as Guest Professor in Umeå School of Architecture, Sweden. He has been the Rector of the Nordic Academy of Architecture as well as Dean and Professor of the Faculty of Architecture in the Estonian Academy of Arts. He has lectured in the universities of Tartu, Oulu, Porto, Cork, Portsmouth, Liverpool, and Hosei in Tokyo. Jüri Soolep is on the editorial board of the journals *Ehituskunst* and *ArchiDoct* and has been a member of steering boards for the Strong Research Environments ResArc and Making within Swedish Research Council Formas grant.

Since 2001 he has been partner and lead architect in the architectural studio *AB Medium*. Most of his designs are built in Pärnu and Tallinn. He published a book titled *Architecture, Imagospheric Horizon and Digital Universe* with Archimedium in 2018 (https://soolep.ee). His current field of research includes studies in the representational systems of architectural phenomena in the digital age.

Video link: https://youtu.be/M-JI6MRLNeo

15.06.2021

- **Jörg Noennig, Prof.**, HafenCity University Hamburg
  Digital City Twins: Urban Analysis and Anticipation

Prof. Dr.-Ing. Jörg Rainer NOENNIG (*1973) is Professor for Digital City Science at the HCU HafenCity Universität in Hamburg and also directs the WISSENSARCHITEKTUR Laboratory of Knowledge Architecture at TU Dresden. From 1992 to 1998, he studied architecture at Bauhaus Universität Weimar, Polytech Krakow and Waseda University Tokyo. Between 1998 and 2001 he practiced as an architect in Tokyo. From 2001 he was Research Associate at TU Dresden, where he was appointed Junior Professor for Knowledge Architecture (2009–2015). His research focuses on digital cities and interactive, co-creative spaces from architectural to urban level.

16.06.2021

- **Lauri Tuulberg**, CEO of Welement
  Prefabricated Craftsmanship

The construction industry is facing huge problems. Productivity is low, there is a lack of skilled labor and it is a major contributor to the impending climate disaster. To meet the growing demand and lower the cost, we need to build more in less time. But can digital tools and automation solve the problem or do we need to rethink how we approach the whole value chain? Does it make sense to bring robots to the construction site and will automation drive out skilled craftsmen?

Studied Industrial Engineering and Logistics Management at Hong Kong University and Civil Engineering at TalTech. Has worked as a site engineer and project manager on projects ranging from large-scale apartment buildings to tunnels and private villas. Been part of real estate development projects from preliminary architectural design to client hand-over and ownership stages. For the past five years mostly involved in managing Welement AS.

Video link: https://youtu.be/G4ou0wkZyH8

17.06.2021

- **Henric Benesh, PhD**, University of Gothenburg
  On situated knowing, digitalization, and two burning buildings

  Henric Benesch is an architect, educator, and researcher with a PhD in Design, who is based in Gothenburg, Sweden. Ongoing areas of interest include Curating the City (together with Ingrid Martins Holmberg, Clare Melhuish, and Dean Sully), addressing environmental and cultural heritage dilemmas posed through and over time in built environment through site-based methodologies and the right to design (together with Onkar Kular). He's also invested in rethinking design education and design learning within and beyond their institutional and professional settings in relation to "rights" – as a form of readership and as a means to foster and claim more sustainable ways of life. Currently, he is a senior lecturer at HDK-Valand – Academy of Art and Design at the University of Gothenburg as well as a co-coordinator within the Centre for Critical Heritage Studies (CCHS), and since September 2019 Deputy Dean at the Faculty of Fine, Applied and Performing Arts at the University of Gothenburg.

  Video link: https://youtu.be/ANUhp1Y9bV8

- **John Ochsendorf, Prof.**, MIT Architecture
  Building from History for a Low-Carbon Future

  John Ochsendorf is the Class of 1942 Professor of Architecture and Civil and Environmental Engineering at MIT, where he directs research on pre-industrial construction traditions. He is the designer of numerous award-winning structures internationally and is the author of Guastavino Vaulting: *The Art of Structural Tile* (Princeton Architectural Press, 2010). Ochsendorf is a partner in the firm ODB Engineering and he served as Director of the American Academy in Rome from 2017 to 2020.

  Video link: https://youtu.be/tNaHo27kvfE

18.06.2021

- **Didzis Jaunzems**, CEO Didzis Jaunzems Architektūra
  Symbiosis of the past and the future

  Didzis Jaunzems' creative portfolio includes projects in the fields of architecture, urban planning, landscape intervention, as well as concert, dance, and opera. He has studied and gained practical experience of architecture and urban planning in Latvia, Norway, and Italy. Likewise he has participated in architectural workshops in The Netherlands and Finland, workshops in India, China, and Switzerland, as well as various architectural competitions across Europe. Didzis Jaunzems has worked in one of the leading architecture offices in the world OMA (Office for Metropolitan Architecture) on library, exhibition park, university projects in France, Moscow agglomeration project in Russia and other country-scale projects in the Middle East. In 2012 he established his own professional practice DJA and since then has received the Annual Latvian Architecture Award in 2012 and 2015, and the title of the Young Architect of the Year 2019 was to follow in recognition of his ambitious approach to design.

  Video link: https://youtu.be/YvWF2ZINmC4

ISP4 Rethinking Baukultur in the Digital Age

29.11.2021

- **Jadwiga Urbanik, Prof.**,
  Wroclaw University of Science and Technology
  History of architectural revolution of the first half of the 20th century – waste of time or useful knowledge?

  Werkbund, Bauhaus and the State Academy of Arts and Crafts (Saatliche Akademie für Kunst und Kunstgewerbe) – "Bauhaus before Bauhaus" – with Hans Poelzig as its director since 1903.

  Gesamtskunstwerk and Max Berg Cenntennial Hall – concrete building phenomenon.

Werkbund model housing estates – new urban layout, new architectural form, new interior arrangement, new color scheme, new way of living in modern dwellings – social aspect.

Jadwiga Urbanik lectures on urban planning from ancient times till the 20th century and on the area of research. She is taking part in historical urban research on Wrocław and studies Wrocław housing estates from the period 1872 to 1939. Her publications include many papers and reports concerning history of architecture and town planning of the 20th century. She has participated in many international conferences and in design projects concerning conservations of Modern Movement building. Her main fields of interest are history of architecture and town planning, especially in the 20th century, and revaluation of architectural heritage of modern movement.

Video link: https://youtu.be/oSGEUH6BE8o

30.11.2021

- **Robert Sochacki, Assis. Prof.**, Wroclaw Art Academy
The Integration of Art and Technology

The lecture focuses on how artists incorporate the latest technology into their artistic strategies and at the same time engage in the discourse of the contemporary world. It is about how their art tries to be a significant voice in the discussion on the future and the creation of new models of relations, not only the internal human ones, but also the non-human ones. The tools used by contemporary artists are so diverse that their spectrum covers analog, digital, but also everyday, ordinary activities – or those that define our common relations as collective consciousness.

Performative lecture, with elements of AI system collaboration, collage of external materials and live discussion.

Video link: https://youtu.be/Q3sSdGLbLRs

01.12.2021

- **Leif Høgfeldt Hansen, Assoc. Prof.**, Aarhus School of Architecture
Bauhaus: New Society and the New Man in Its Environment

Short description not available

Video link: https://youtu.be/GZ9At1qzIA0

02.12.2021

- **Olga Ludyga**, Gdańsk University of Technology
Teacher – the Architect of Learning Process

Olga Ludyga is an academic teacher, pedagogue, Cambridge ESOL examiner and learning designer, who is also working as an intercultural teaching methodology specialist. Currently her research focuses on innovative teachers in narrative interviews.

How do we learn? Who do we learn from? When do we know that we have learned something? Is it necessary to know things when nowadays we carry all the knowledge in our pockets, thanks to smart phones and the Internet? These questions are in the mind of many people living in digital era. A look at education in the past and now, taking under consideration what we actually need to learn.

Video link: https://youtu.be/89n_GYyzrPw

- **Fernando Manuel Alonso Pedrero, PhD,** University of Navarra
New Degree in Design ETSAUN – Winner of the New European Bauhaus Prize 2021

"New Degree in Design" Universidad de Navarra, is an experience that fits perfectly within the framework pursued by the "New European Bauhaus wave." At interdisciplinary education models, it is a teaching methodology that integrates the theoretical, digital, practical, technical, and creative contents, which acquire their whole meaning applied to a project. The students, through the practical and creative exercise of the project, can connect and understand the whole constellation of subjects, ideas, and teachings offered to them.

Fernando Alonso Pedrero (Zamora 1992) is a PhD Architect (2020) based in Pamplona (Navarra). He graduated from the University of Navarra, Spain, where he is currently researching and teaching in the field of "Critical analysis of digital culture in architecture." In his career as an architect, his work is physical and virtual: architectural projects, installations, sculptural models, sheets and articles, and focused on the dissemination and critical reflection of formal digital concepts. He completed his international doctoral thesis in Philosophy of Applied Creativity in Architecture: "#Design #Mathematical #Form, contemporary geometric construction. From point to fractals."

Video link: https://youtu.be/DImG9vS1vdo

Workshops ISP2

16–17.02.2021

- **Kacper Radziszewski**, Fundacja Architektury Współczesnej
  "Introduction to Grasshopper"

  Grasshopper is a visual programming language and environment that runs within the Rhinoceros 3D computer-aided design application. Grasshopper is primarily used to build generative algorithms, such as for generative art. Many of Grasshopper's components create 3D geometry. Programs may also contain other types of algorithms including numeric, textual, audio-visual and haptic applications. Advanced uses of Grasshopper include parametric modelling for structural engineering, parametric modelling for architecture and fabrication, lighting performance analysis for eco-friendly architecture and building energy consumption.

  The workshop offers a general introduction to Grasshopper in Rhino 6 specially designed for architects and structural engineers.

18.02.2021

- **Clemens Preisinger**, Bollinger und Grohmann ZT GmbH
  "Introduction to Karamba 3D"

  Karamba3D is a parametric structural engineering tool which provides accurate analysis of spatial trusses, frames and shells.

  Karamba3D is fully embedded in the parametric design environment of Grasshopper, a plug-in for the 3D modeling tool Rhinoceros. This makes it easy to combine parameterized geometric models, finite element calculations and optimization algorithms like Galapagos.

  Karamba 3D is being developed by Clemens Preisinger in cooperation with Bollinger und Grohmann ZT GmbH Vienna.

Workshops ISP3

15.06.2021

- **Milos Mikasinovic**, NUCE Consulting GmbH
  "Workshop: Kickstart the Digital Twin"

  The practical experience in strategic and operational BIM management as well as the services of the digital transformation of NUCE Consulting result in an operationally applicable digital twin. The web-based digital representation in connection with a "single-source-of-truth" makes it possible to map the entire lifecycle of a building in a customer-specific way. The main task of M. Mikasinovic is the project management and the implementation of the digital transformation in the construction and real estate industry. The implementation is done by means of goal-oriented consulting, solution-oriented workshops, innovative think tanks, expert concepts in software development and especially in building the operational digital twin in customer projects. His focus is on BIM management, Digital Twin prototypes and the BIM2 field.

  Video link: https://youtu.be/GQNzq6ylVos

16.06.2021

Prof. Jörg Noennig, M. Niggeman, A. Sliusarenko, HafenCity University Hamburg Digital City Science Unit

"Digital Public Participation Platform for City Development (DIPAS)"

The platform for digital participation is a joint project of the City of Hamburg and the Unit for Digital City Science at the HafenCity University Hamburg, which has been in practical use for already couple of years. Prof. Jörg Noennig will first introduce you to the processes and tools for public participation within the city development processes, then you will get a closer look on the Hamburg Public Participation Tool – DIPAS by getting an interactive demonstration tour. There will be enough time for questions and answers.

17.06.2021

Elias Valters, Freelance 3D Artist, Riga Technical University, SIA Free Architecture
"Workshop: Blender 3D"

Blender is a free and open-source 3D computer graphics software toolset used for creating animated films, visual effects, art, 3D printing, motion graphics, interactive 3D applications, virtual reality, and game development. Eliass Valters introduces the software toolset and its use cases and provides insights into testing either organic/procedural modeling for concept design or 3D visualization techniques for architectural/engineering projects.

Video link: https://youtu.be/Ltlg-qlt0Bw

5.0 Full List of Participants

Full List of Participants

Authors and project team members:
(in alphabetic order by university)

Project Lead

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Professor of Analysis and Design of Structures
Vice president of Research and Internationalisation

Emiliya Popova
M. Sc. Urban Design
Project Management and Content Development

Student assistants:

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B. A. Design
Student assistant – Graphic Design

Benjamin Gellie
M. Sc. Urban Design
Student assistant – Web Support, Kumu, and Metaverse

David Ehrenreich
B. Sc. Urban Planning
Student assistant – Web Support and Miro Boards

Project Partners

Aalto Unversity

Günther H. Filz
Professor of Structures and Architecture

Chalmers University of Technology

Anna Kaczorowska
Associate Professor in Urban and Spatial Planning

Karl-Gunner Olsson
Professor in Architecture and Engineering

Gdańsk University of Technology

Bartosz Macikowski
Assistant Professor in History of Architecture and Architectural Design

Dorota Kamrowska-Załuska
Assistant Professor in Urban Design and Regional Planning

Justyna Borucka
Assistant Professor in Urban Design and Drawing (Architectural Representation)
Vice-Dean for Development and Internationalization of the Faculty of Architecture

Małgorzata Kostrzewska
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Riga Technical University

Sandra Treija
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Deputy Dean in Research

Uģis Bratuškins
Professor in Architecture
Dean of Faculty of Architecture

Royal Danish Academy

Olga Popovic Larsen
Professor in Material and Structures in Architecture
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Roode Liias
Professor of Practice in Facilities Management

Raido Puust
Tenured Assistant Professor in Civil Engineering and Architecture

Technical University of Denmark

Lotte Bjerregaard Jensen
Associate Professor in Sustainable Design
Since September 2022 Professor at Aarhus School of Architecture and affiliated with DTU

Full list of participants at the four Intensive Study Programs (ISP) within the **BuildDigiCraft** Training Program 2021.

(in alphabetic order by first name)

ISP1 Concepts and Fundamentals

Anna Patrycja Rubczak,
Gdańsk University of Technology

Annarita Zarrillo,
Royal Danish Academy

Asad Tayyebi Fallah,
HafenCity University Hamburg

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Egīls Markus,
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ISP2 Digital Futures

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Serenay Elmas,
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Suzi Pain,
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Szymon Kowalski,
Gdańsk University of Technology

Theophilus O.O. Olowa,
Tallinn University of Technology

Wiktor Skrzypczak,
HafenCity University Hamburg

ISP3 Craft and Craftsmanship

Anna Patrycja Rubczak,
Gdańsk University of Technology

Asad Tayyebi Fallah,
HafenCity University Hamburg

Christopher Görsch,
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Egīls Markus,
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Sepehr Hosseini,
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Serenay Elmas,
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Szymon Kowalski,
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ISP4 Rethinking Baukultur in the Digital Age

Asad Tayyebi Fallah,
HafenCity University Hamburg

Egīls Markus,
Riga Technical University

Ewa Michałowska,
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Faezeh Sadeghi,
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Serenay Elmas,
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