
Exploring the Design Space of Embodied Architectonic Interaction

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Figure 1: Three design instances at the entrance of an integration school.

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Abstract

This PhD abstract outlines a thesis that investigates potentials of interactive technology integrated in the built environment. Through constructive design research and design fiction, a series of these instances are and will be conceptualised, designed, developed, and deployed in under-construction educational contexts. Based on the deployment of the designed instances and the respectively applied design processes, a variety of contributions can be drawn: (1) *design knowledge* at the intersection of Interaction Design and Architecture, (2) *methodological insights* on designing and developing fully-working, long-term deployed, large-scale instances, and (3) *empirical insights* on their use and user experience.

Author Keywords

Architectonic Interaction; Embodiment; Constructive design research; Design Fiction.

CSS Concepts

- Human-centered computing~ Human computer interaction (HCI)

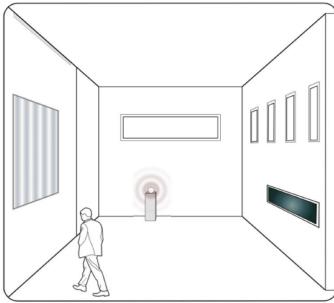


Figure 2: Early concept drawing of the three instances. Left: Kinetic, physical display. Center: 3D Sound Landscape. Right: Video wall.



Figure 3: Kinetic display in use by two children during an open-day school event.

Introduction and Background

Interaction Design (IxD) and Architecture have traditionally dealt with different domains, split amid the digital and the physical, among others. Nonetheless, as of late, the boundaries between the two are blurring as hybrids begin to emerge. Inevitably, having an educational background in both fields, I am intrinsically drawn towards their intersection.

Bridges across the two are emerging under a plethora of terms such as, Human-Building Interaction (HBI) [1,4], adaptive architecture [17], media architectures [21], and architectonic interaction [15,19,20]. The latter is defined as "*Interaction Design at the scale of architecture*" as well as the "*design of architectonic elements with interactive capabilities*" [17:74], a definition which fits with the aim of this research. Albeit the many notions, few examples explore instances deployed in real-life settings. This fusion allows for HCI examples that shift away from physical objects towards interactive environments, raising the question of how the interaction with large-scale instances may be designed. In this sense, embodiment becomes cornerstone, revealing indefinite possibilities of how humans can interact with their built environment.

This work is situated within HCI, in the context of embodied interaction, constructive design research, and design fiction. In line with other research (e.g., [5]), embodiment in the area of architectonic interaction guides and creates the connection between an individual and their environment. As part of a research project at an integration school, I have been intensively involved in conceptualising, designing, developing, and implementing a series of fully-functioning design instances integrated in the building fabric of the

school's entrance hall (Fig. 1, Fig. 2). What all of these instances share is that they allow or even force users to interact with them in an embodied and bodily manner (Fig. 3). In a follow-up project, future design instances will be conceptualised through a Design Fiction approach to allow future users to tell their story of their envisioned built environment that will inform design.

Challenges of Architectonic Interaction

One of the salient challenges within the convergence of HCI and Architecture is the aspect of *scale* [6,19]; which poses questions on design, embodiment, and experience. Architectural design is inextricably linked to human scale in relation to the built environment [2], while HCI research is predominantly focused on small-scale objects, devices, and interactions. As of late, HCI research is pushing towards advancing from interactive artifacts to technology augmented spaces and environments, with relevant workshops hosted at DIS [2,12] and CHI [4,8,9] conferences and emergent examples that consider the scaling of interactions (e.g., [16]). However, these examples do not report on the implications of large-scale, embodied interactions on the user experience.

Constructing and embedding large-scale installations in HCI research "*can be a massive undertaking*" [11:380], accompanied by a plethora of design challenges relevant but not restricted to materiality, cost, or health and safety regulations. Most of these challenges are considered to be temporal constraints [15] due to the different life-expectancies between architectural and HCI research projects. Due to their large scale, the complexity of design and implementation is increased, thus, most of these examples are "*non-human centred*" [11] to reduce complexity.

Research Questions

RQ1: How to design for embodied interaction at the intersection of Architecture and IxD?

- A) How to implement design instances for architectonic interaction?
- B) What challenges arise when deploying large-scale instances of architectonic interaction?

RQ2: How do people use and experience architectonic interaction?

RQ3: How to employ design fiction for envisioning the future of architectonic interaction?

Expected Research Contributions

- **Design knowledge** at the intersection of IxD and Architecture on how to design large-scale instances integrated in the built environment, situated in the educational context.
- **Novel design instances** in the context of architectonic interactions developed through constructive design research.
- **Methodological insights** of moving beyond conventional HCI research prototypes towards fully-working, instances at architectural scale which are deployed indefinitely.
- **Empirical insights** on the use and experience of such design instances through user evaluations.

As argued by Alavi et al. [3], most of the existing work in this area remains on a rather conceptual level. The HCI research community requires additional cases to support theoretical considerations in the context of HBI. Few examples explore the intersection of Architecture and HCI from an applied perspective, such as the early example of Pinwheels visualising data flow in an architectural space [13] or the integration of dynamic media on a building façade by Houben et al. [12].

As an answer to these challenges, I will contribute architectonic interaction cases with an emphasis on long-term, real-life deployment and the way users feel about these embodied experiences. Design-related and empirical learnings drawn from these cases will be used to build conceptual arguments that are abstracted from the particular cases, aiming to transfer knowledge in how to synthesise processes common to IxD with construction processes of buildings. The anticipated contributions are summarised in the sidebar.

Methodology

The research questions (see sidebar) will be addressed through the following methods:

1. Design instances as an outcome of constructive design research [14] (RQ1), where the instances are means of constructing knowledge.
2. A combination of qualitative and quantitative investigations based on the developed design instances (RQ2), such as (i) observations, (ii) in-situ interviews, and (iii) online questionnaires.
3. Design Fictions [7] created jointly with future users and other stakeholders envisioning future technology augmented environments which will inform the design of future design instances (RQ3).

Research Context

As part of my thesis, the developed instances are deployed within two kinds of under-construction educational contexts: (a) one integration school (with hearing, hearing-impaired, and deaf children and staff) located in Salzburg, and (b) three kindergartens located in the Salzburg region.

The integration school consists of a primary and secondary education establishment and it strives for a 50:50 ratio of hearing and hearing-impaired students and staff. Sign language is an essential communication means among students and teachers.

Progress to Date and Next Steps

My work to date has resulted in designing, developing, and long-term deploying of three interconnected instances located at the entrance of the integration school (Fig. 1) which performs as a sensitising space for all visitors to facilitate awareness about the school's particularities (i.e., diverse perceptual conditions of pupils and teachers). So far, I have conducted empirical investigations to familiarise with the context leading to a series of design interventions (e.g., [10]) that facilitate the teachers' practices. The findings of the investigations inspired the design of the three instances. Initial low-tech prototypes were created as proof of concept, whereas the final instances are fully functional systems that will remain in the context for an indefinite time period under low maintenance.

Together with architecture practitioners and other construction professionals involved in this project, we have worked the past two years on integrating these instances in the building fabric of an under-construction school. We discussed our concepts with them, made



Figure 4: Left: a Kinetic physical display with human for scale. Right: mechanism-notch that rotates each individual pixel.



Figure 5: Tangible User Interface that emulates a hearing aid's functionality.



Figure 6: Sign language video clip projecting on a video wall of three wide LED screens with a privacy filter which restricts passer-by view to a 45° frame.

design decisions together (e.g., in terms of design and functionality, materiality, and positioning) and we collaboratively implemented the three instances.

Each instance reveals a fragment of information, which in combination forms a riddle that changes every day. The riddle conceals contextually relevant information (e.g., deaf people sign when they dream) and can only be unravelled by interacting with each instance separately. The riddle is solved by piecing the different information together. The three installations make use of different technologies; kinetic mechanic movement, induction loops, and micro-louver technology found in privacy filters for screens.

The **first instance** (Fig. 4), a 2,7m square kinetic “display” matrix mounted to the wall, consists of a grid of 25x25 black and white metal ‘pixels’ that through mechanical movement construct an image each night, representing one piece of the riddle (Fig. 2). The **second instance** (Fig. 5) consists of three overlapping induction loops, placed under the mosaic floor, which transmit audio signals through. One of these audio signals reveals another part of the riddle. A hexagonal pyramid-shaped Tangible User Interface (TUI) receives the audio signals and amplifies them through a speaker emulating the functionality of a hearing aid. The visitors experience the soundscape by walking around the room while holding the TUI close to their ear. The **third instance** (Fig. 6) consists of three wide LED screens covered with a privacy filter film, causing the screens to black out completely apart from a 60° viewing angle. Content-wise, the screens display sign-language video sequences which reveal the final part of the riddle. The sequences are moving from the right side of the screens to the left, compelling the viewer to move

along in order to continue viewing and deciphering the content. The next step will be to empirically evaluate these instances through longitudinal studies.

As case follow-up, I will continue this line of work in an upcoming two-year project regarding three kindergartens. Additionally, I am currently working on a design fiction approach (currently under submission) to envision and develop further fictional scenarios with stakeholders and the general public. I would like to employ this approach and capture stakeholders' and future users' visions as a means to inform the design of future instances deployed at the kindergartens.

Expectations and Contribution

The DIS Doctoral Consortium offers an ideal opportunity to receive feedback on future research, and meet and exchange ideas with the scholars of the committee, as well as draw on their expertise in design research. Additionally, conversing with peers having similar challenges in their research will be valuable in answering questions that I am facing (e.g., Feedback on the evaluation methods described in this abstract. How to better incorporate design fiction as a method for envisioning future instances?). In return, I could contribute my learnings on designing, developing, and deploying large-scale interactive instances, as well as insights (benefits and challenges) on designing for long-term deployment.

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