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On Middle-Ground Solutions for Domain-Specific Problems: The Case of a Data Transfer System for Sign Language Teachers

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Abstract. Oftentimes domain-specific problems are imperceptible. The end users are so accustomed to the conditions that they do not request any other solution. In the context of a school for both hearing-impaired and hearing children, the particular way of teaching sign language led to the emergence of technology-mediated yet ill-supported work practices. This paper contributes to the CSCW community by introducing an approach for addressing domain-specific problems by applying a *middle-ground* yet optimal solution. As a direct outcome of this approach, we present the case of a data transfer system that supports sign language teachers' work practices. This system, which is indefinitely deployed in the school, is a tangible representation of current infrastructural and contextual issues the teachers are facing, and serves both as a reflection on the work practices and an articulation means of the limitations that constraint them. We reflect on our approach, we discuss on the resulted case in terms of an indefinitely deployed research product, and we speculate on the system's alternative application domains.

Keywords: domain specific problems, middle-ground solution, integrated school, work practices, sign language teachers, data transfer system.

1 Introduction

The starting point of this paper is the field research we conducted at an integration school in Salzburg[1], to gather a deeper understanding of the contextual particulars as well as the technological needs of the students and teachers. At this school, teachers and students with varying degrees of hearing abilities (i.e., hearing, hearing impaired, and deaf) are teaching and being taught. The uniqueness of this constellation is reflected in the school's exceptional way of teaching, educational philosophy, and subject matter. Beyond verbal communication, sign language is a key communication means among students and school staff. Consequently, at this school, sign language[2] is a compulsory subject, taught by two sign language teachers. Sign languages are fully-fledged natural languages with their own grammar and lexicon that make use of visual perception to convey meaning (Wilcox and Occhino, 2016). These particularities require teachers to develop new, innovative teaching material in terms of format, media, and content.

There is a substantial amount of work in both HCI and CSCW research with hearing-impaired and deaf communities and, in particular, with children (e.g., Slegers et al, 2010; Vermeulen et al, 2012). What unites these research efforts is their strong dedication to user-centred and participatory approaches to user involvement and design (e.g., Morningstar et al, 2015; Slegers et al, 2010; Vermeulen et al, 2012). In line with research suggesting strong user involvement, our presented research is also characterised by strong user participation and involvement; conducting participatory observations in classes or conducting semi-structured interviews with teachers. Throughout the conducted fieldwork, we identified that videos are considered as essential media and educational material to teach sign language, i.e., video footage of teachers to assign homework, or video footage of students to perform and document exercises, tests, or homework.

Currently, video file transfers are accomplished via an exchange of USB drives. In our research, we observed that the teachers' current practice of exchanging video files between them and the students results in a lot of effort since the copying process is both a tedious and time-consuming task. Other, more elaborated and state-of-the-art technology is already available on the market which supports this kind of data transfer (e.g., cloud or server-based solutions, or even a tailored local file transmission platform) allowing for an *ideal*[3] (Table I), yet not optimal, solution

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1 The Josef Rehrl school comprises of an elementary and a secondary education school. https://www.josef-rehrl-schule.salzburg.at

2 Having sign language as a compulsory subject is exceptional and unique since Austrian sign language (ÖGS) was legally recognised as an official language by the Austrian Parliament on September 2005, and certified ÖGS translators are no more than 105. https://www.josef-rehrl-schule.salzburg.at/2014-05-12-09-52-56/methodik-und-leistungsziele.html

3 In this paper we make use of the adapted definition of the adjective *ideal* from the Oxford Learner's Dictionary of Academic English: "the best that can be imagined, but not likely to become real". https://www.oxfordlearnersdictionaries.com/definition/academic/ideal1, accessed February 1, 2019.

for the given problem space. The problematic case here is the school's current technological infrastructure, the lack of technical maintenance, and a shortage in teaching staff i.e., a lack of certified sign language teachers in schools, plus a lack of a community of practice to communicate and cooperate with. All these constraints provide the ÖGS teachers with a certain boundary box, forcing them to invent their own teaching practices and materials.

In our empirical research (i.e., participatory observations and semi-structured interviews) we identified this tension of an evolving new subject; while the technological infrastructure in the school, as well as the community-based exchange among ÖGS teachers is Austria, lags behind. In this paper we present a technological solution that from a research perspective may be perceived as the *middle-ground*[4] solution (Table I). Our *middle-ground* solution embodies both, the teachers' need of technical support in their data transfer practices, while being at the same time an *optimal* solution in the given context that colludes with the existing technological infrastructure in the school, rather than radically disrupts the infrastructure or the teachers existing work practices. It is important to mention that what is perceived as ideal or middle ground is very context and user specific. Therefore, throughout this paper, we indicate for whom the solution is perceived as ideal or middle ground. This technological solution is currently deployed at the school and used by the teachers.

Table I. In the design of work practice infrastructures striving for the ideal might not result in feasible solutions.

The ideal	**The *middle-ground***
An ideal solution is considered to be the theoretically perfect yet often unattainable opportunity.	A *middle-ground* solution is an attainable compromise between the ideal solution and the current boundary conditions.

The main goal of this paper is to articulate why addressing certain domain specific problems requires to also advance systems, that at first glance might seem outdated or superseded by the state of the art.

The contributions of this paper are threefold: 1) we present an approach for addressing domain-specific problems with *middle-ground* yet *optimal* solutions, 2) we present the case of the *design* of a fully functional system as a direct outcome of that process, and 3) we *reflect* on our pursued process and the developed system from diverse angles.

We first present related work to position our research in the realm of HCI and CSCW, we describe the process we pursued throughout our research, we continue

4 In this paper we make use of the adapted definition of the noun *middle ground* from the Collins English Dictionary: "a position of compromise between two opposing views, parties, etc". https://www.collinsdictionary.com/dictionary/english/middle-ground, accessed February 1, 2019.

by motivating our work that is based on empirical findings, and describe the design process of the data transfer system we developed that aims to support existing material exchange practices of ÖGS teachers. On the basis of the given case of the developed data transfer system, we finally discuss how our pursued approach of a *middle-ground* solution (from a researchers' and the technology providers' perspective) may be of value for reflection on existing work practices and a means to articulate issues that are posed by the given context. We elaborate on the potential of indefinite deployment and conclude the discussion by outlining potential further applications of the developed data transfer systems not only within but also outside the educational context.

2 Related Work

As our research touches upon diverse fields of research, this section details related work mainly in two areas: Infrastructuring (e.g., Karasti, 2001; Pipek and Wulf, 2009, Bødker et al., 2017; and Andersson et al., 2018;), and HCI for hearing-impaired children education (e.g., Slegers et al., 2010; Vermeulen et al., 2012, Cano et al., 2016, Korte et al., 2012).

Infrastructuring is a subject that has been given a lot of attention in the CSCW community. The term was first defined by Karasti & Syrjänen (2004) in the context of participatory design and as Bossen et al. (2014) state, infrastructuring focuses on the relation between an infrastructure and its user with issues and dependencies. Although the infrastructure discourse spans multiple domains, our work is situated within the domain work infrastructures (Hanseth & Lundberg, 2001; Pipek & Wulf, 2009; and Stevens et al., 2010). Bødker et al. (2017) argue that most design projects are infrastructuring projects since they build on pre-existing technologies, competencies, and practices; similarly, the work we present in this paper is based on current technologies at the school, the technological competencies of the ÖGS teachers, and their current work practices since.

Following Karasti (2001), it is crucial to initially comprehend work practices and incorporate them in design in order for collaborative technologies to be effective. Infrastructures can be thought as relations that embed choices and politics, meaning that they shall not be perceived as isolated and discrete entities but rather that the use of a single technology emerges in complex relationships and becomes integrated into organisational processes (Andersson et al., 2018). We contribute to the infrastructuring discourse with our work which aligns with existing research, and we are aware of the complex relationships that the development of technology is embedded in and shaped by. However, our contribution diverges in terms of making explicit that this "dedication" to context-sensitivity also leads to a compromise in terms of achieving the *optimal* solution from both a technological and a research perspective; a topic which is rarely reported in scientific work.

As part of our research, the developed system does not only serve the specific purpose of addressing a particular problem; it may be considered a *middle-ground* solution from a research as well as technology providers' perspective, 'embodying' a compromise between the teachers' identified needs for data transfer and the contextual constraints in the school. Consequently, the developed system informs about the complex relationships at the school and serves as a means to *reflect* on given practices that are shaped by given constraints.

Reflection is used as a tool to "think about" since it aids in comprehending and reframing situations leading towards a problem-solving procedure (Schön, 1983). Designing for reflection is not a novel topic; in fact, it has been and is used by researchers in HCI (Baumer, 2015; Baumer et al., 2014; Odom, Banks, Durrant, Kirk, & Pierce, 2012). Drawing on (Fleck & Fitzpatrick, 2010) reflection can serve a multitude of aims (i.e., uncertainty resolution; critical review; reflection on learning); in our case, we use reflection as a tool to create new understanding and appreciation of the said complex relationships formed through the infrastructure of the teachers' work practices but also to communicate those relationships to third parties.

From the perspective of conducting research with and for hearing impaired, Slegers et al. (2010) and Vermeulen et al. (2012) indicate the challenges of pursuing research that involves hearing-impaired children in school contexts, due to their deficiencies in written and spoken language. They suggest following a user-centred design approach to understand the needs of such a vulnerable user group. Kinnula et al. (2018) follow a similar collaborative process in a school setting and introduce a non-context specific, analytical lens for conceptualising, understanding and supporting collaborative design where the value is co-created by the different stakeholders. Morningstar et al. (2015) indicate two dimensions to support inclusion; support for participation and support for learning. In a similar fashion, we contribute to this body of work through our developed system with which we support participation by providing all students access to academic curricula content (sign language vocabulary).

3 The case of addressing a domain-specific problem

This research project's starting point was to collect insights regarding the students' and teachers' communication and learning practices in that particular context, and how technology may facilitate and support them in the future. In our research process (Figure 1) we initially conducted fieldwork in the form of participatory observations and semi-structured interviews and through them, we identified the ÖGS teachers' teaching material exchange practices based on their limited technical solution. The ideal solution, from the researchers' perspective, would involve deploying a state-of-the-art technology readily available on the market or a technologically advanced tailored platform that supports the teacher's practices (i.e. a digital platform in the form of a smartphone app or a website that hosts a digital sign-language vocabulary with supplementary exercises and a server to save homework). However, given the constraints and complexities of the research context, these options were not feasible since it would require a drastic modification of the teachers and students existing practices. Such modification would subsequently require alteration of the school's technical infrastructure, provision of technical training to support the teachers, and other unpredictable modifications.

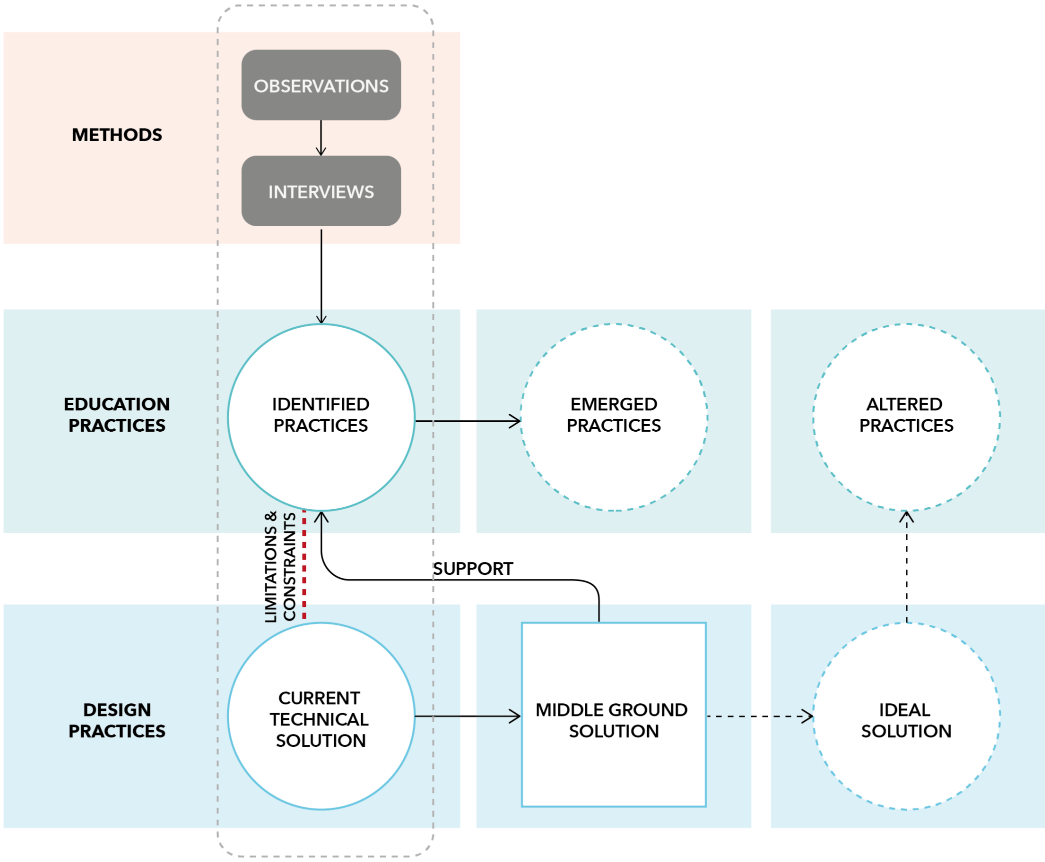

Figure 1. Illustration of the research process we followed based on the utilised methods, the identified teachers' practices and existing technological solutions. The non-dotted shapes indicate steps in the process we already conducted, identified, and developed dotted shapes indicate potential future directions that we could envision to further investigate into.

A less technologically and scientifically advanced solution was selected in favour of supporting existing practices that would simultaneously ameliorate the practices' weaknesses (less time-consuming). We opted for a less drastic modification of the practice which was the most *optimal* option; even though that meant that from a research perspective we had to compromise for a *middle-ground* solution. In the future, we plan to conduct further fieldwork to discover how the practices have changed based on the introduced solution.

In the following we present the empirical foundations of the work described in this paper, along with an account of the design process of and design rationale for our data transfer system, and the reasons that render the system as a compromise on the researchers' part, in terms of technological possibilities of data transfer procedures.

3.1 Empirical Foundations

In this sub-section we introduce the empirical foundations of our research; the research context and the identified problems. We outline how these insights have informed the design process of the data transfer system we developed. Our system was designed and developed in interwoven phases in constant collaboration with the ÖGS teachers. This section concludes by outlining initial reactions of the teachers to the deployed system.

3.1.1 Research Context

The motivation for this work emerges from the *Diversity-Centred Design* project[5] where we have been, are, and will be collaborating with a number of professionals from various disciplines. The project's aim is to study, analyse, develop, and deliver a better school experience for both the students and the teachers of that specific school.

3.1.2 Data gathering Methods and Data Analysis

In order to learn about the students' and teachers' communication and learning practices, we conducted participatory observations (Flick, 2009). We chose to set-up observational sessions after consulting the school's headmaster who got us in contact with the associated teachers. We (three researchers from the Center for Human-Computer Interaction) observed a Biology lesson, an English language lesson and an Austrian Sign Language (ÖGS) lesson. We made use of observation sheets and schemes (Flick, 2009) to take handwritten notes of technology use, communication and learning practices, and of anything that introduced friction during lesson delivery. The notes were subsequently used as part of the data analysis.

After these observations, we performed three semi-structured interviews (Flick, 2009) consisting of open-ended and more theory-driven questions with the respective teachers of these subjects. Both data sources were textual notes from the observation sheets and notes from the semi-structured interviews that were analysed using an inductive approach to content analysis (Mayring, 2004). We (the

5 https://hci.sbg.ac.at/special-needs/

three researchers that took part of the observations and interviews) familiarised ourselves with the data and individually identified relevant themes. In a joint session, we discussed unclear cases and agreed on the categories. For the purpose of this paper, we only present selected findings that were decisive for the development of our system.

3.1.3 Selected findings

Through our observation sessions, we discovered several issues during class delivery. We clustered those issues in three categories: *spatial, social,* and *technological*. *Spatial* sitting configuration and visibility in classrooms with hearing-impaired children were of high importance, especially in the case of multiple speakers. Similarly, we identified issues regarding *social* encounters in which communication problems seemed to surface quite frequently within the 45-minute lessons; a single class illustrated diverse dynamics in terms of comprehension. The most severe issues seemed to be mainly *technological* ones where teachers would sacrifice time during lessons to attempt to overcome those issues, thus, pausing lesson delivery. Specifically, during the sign language class, we observed that the ÖGS teacher struggled to deliver her lesson, which required that the students performed the new signs they learned that week via recording themselves on Apple iPads placed on their desks; a task that seemed complicated and challenging due to the iPads' low memory capacity.

Based on this observation we wanted to find out more about the teachers and students' practices (and related issues) of video capturing and transfer in sign language classes. During the interview the ÖGS teacher claimed that sign language cannot be taught without the use of technology and indicated that *technological* problems were the biggest issue she was facing during lesson delivery. The teacher gave an account of the way her colleague and herself structured the curriculum of the sign language course on their own, with improvised visual sign language vocabulary booklets (e.g., the teachers taking pictures of one another while signing out and making hand-written notes below to translate the sign) and self-recorded videos (e.g., created at home with an iPad on a tripod) as there are non-existent guidelines to follow nor ready-made material they could use. This is due to a very small Austrian sign language community and an even smaller number of teaching professionals. The ÖGS teacher explained how *data transfers* and specifically, *distributing* video recordings through USB flash drives to the students is crucial, not only to teach them new signs but also to assign homework. In return, the second data exchange takes place when the children have to record themselves at home performing the words the teacher assigned, and save the recording onto a removable data storage device such as USB flash drives. One of the issues the teacher mentioned was that a number of children do not have access to a personal computer with a web camera at home or even an internet connection. During class, the teacher copies all the homework from each child's USB so that she can watch all the videos and grade them in her free time.

3.2 The case of an off-web data transfer system for teaching material exchange practices

Based on the issues we identified throughout our empirical fieldwork, we saw the opportunity to develop a technical solution that would support the ÖGS teachers in their everyday practice of exchanging teaching materials with the students, since we observed that they were relying the most on technology during lesson delivery. The solution is part of a bigger project that revolves around a series of design interventions we will deploy at the school, that aim to address identified teachers' needs. Additionally, any teacher working with assorted media at the school can potentially benefit from our developed solution, e.g. for exchanging files with other teachers, or other media files with students. In this section we will describe the design process we have followed; the initial concept, the early prototyping that led to low-fidelity prototypes, and we will conclude by describing the developed system that aims to support the teachers' practices in terms of functionality and components.

3.2.1 Initial concept and scenario development

A first concept diagram was drafted to communicate to other members of the research team what the teacher and the interviewer had discussed as an initial solution as part of the semi-structured interviews. Specifically, the teacher requested a system that she could plug-in all USB drives and it would perform the copying process to and from all the students' USB drives as simple as possible. The diagram, as illustrated in Figure 2, comprises of the *two scenarios* of data transfer use via a stand-alone device; (1) data transferred from the teacher's USB drive to the children, and (2) vice versa. A button switch is assigned to each scenario of use.

- Scenario 1: The students copy their homework files onto their USB drives in the 'homework' folder. At the beginning of the lesson, the students connect their USB drives to their designated USB port on the system. A green button press transfers the homework files from the children's USB drives to the teacher's.

- Scenario 2: This scenario involves the teacher updating the vocabulary files onto her USB drive. Then, with the press of a blue button switch, the files are transferred to all children's USB drives, in a 'vocabulary' folder.

The initial idea was extending the functionality of an existing USB hub by connecting it on a micro-controller. An additional USB port connected directly to the micro-controller would act as the teacher's USB port. All the components would be enclosed in a fabricated acrylic casing.

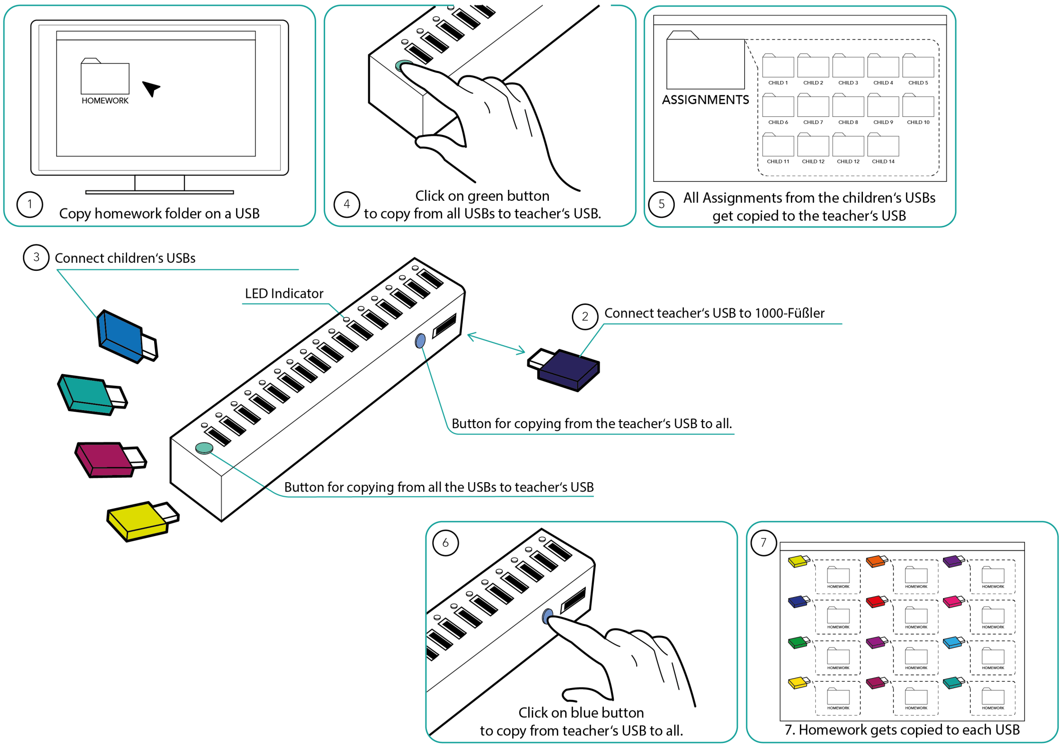

Figure 2. Concept drawing of the data transfer system.

3.2.2 Early Prototyping

Following specifics from the teacher, such as the wish to have a device smaller than a standard A4 page size and slimmer than a book so that it can fit in her backpack, we commenced exploring initial physical forms for the system using cardboard modelling (Figure 3). In designing the cardboard mock-ups, the team took a set of design decisions; ensuring the device's size would be able to fit in a backpack and that no sharp edges should be exposed. The next step was creating a proof of concept by coding the behaviour of the single-board computer and testing our ideas in practice.

3.2.3 Low-fidelity prototype and initial feedback cycles

A low-fidelity prototype was developed via connecting a self-powered USB hub and two button switches to a single-board computer (Raspberry Pi 3 model B). We managed to transfer data from one primary USB drive to four other that were connected on the USB hub and vice-versa through triggering the push switches. In order to communicate the status of the device to the user, we assigned four LED colours; i.e., green indicated that the system is ready for the data transfer, blinking blue indicated data transfer in progress, constant blue indicated successful data transfer, yellow indicated a data transfer error, and red indicated a system error. A casing fabricated out of white acrylic (selected due to durability) enclosed the hardware components.

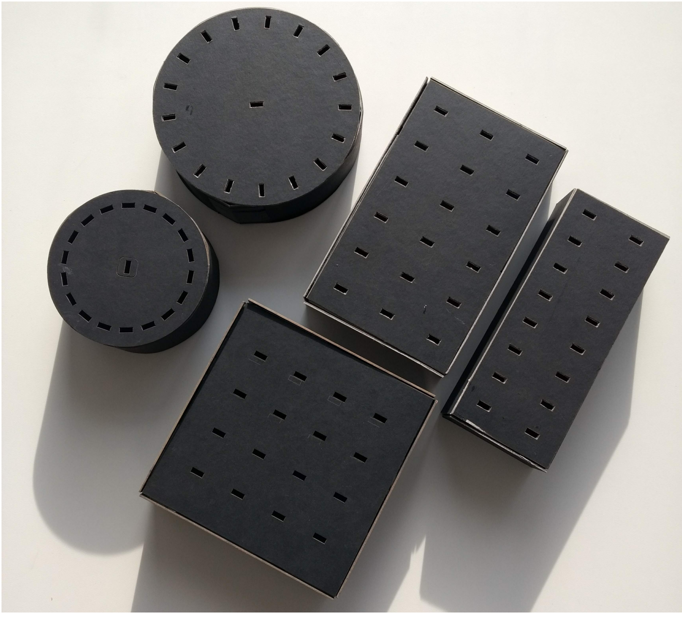

Figure 3. Photograph showing the five initial form explorations in black cardboard.

We invited the ÖGS teacher for a meeting, where we presented the tangible representation of the concept we had discussed during the initial interview. During our demonstration of the early prototype (Figure 3), the teacher embraced our ideas and suggested minor changes (e.g., the USB slots configuration, the form factor, and the folders' organisation format). We discussed the system's specifics regarding functionality related to her practice (i.e., the folder organisation system she's using) to align the two as much as possible.

3.2.4 Final design of the data transfer system

The end result of our design process was a stand-alone data transfer system (Figure 4) that consisted of a square casing with 19 USB hubs (one for the teacher and 18 for the students) with corresponding LEDs and two buttons to copy one or several data files from either a teacher's USB drive (source) to multiple USB drives (target) and vice versa[6]. In order to reduce the number of interactions to the bare minimum, whilst making sure that the system is comprehensible, we automatised repetitive tasks and implemented a light pattern for signalling the device's status. Our system now allows for a once a week homework assignment instead of a biweekly one,

[6] Video-demonstrator of the final data transfer system and its functionality. https://myfiles.sbg.ac.at/index.php/s/XOEKIPnhKizmEgo/download

since the teacher does not have to take the students' USB drives home to perform the data exchange.

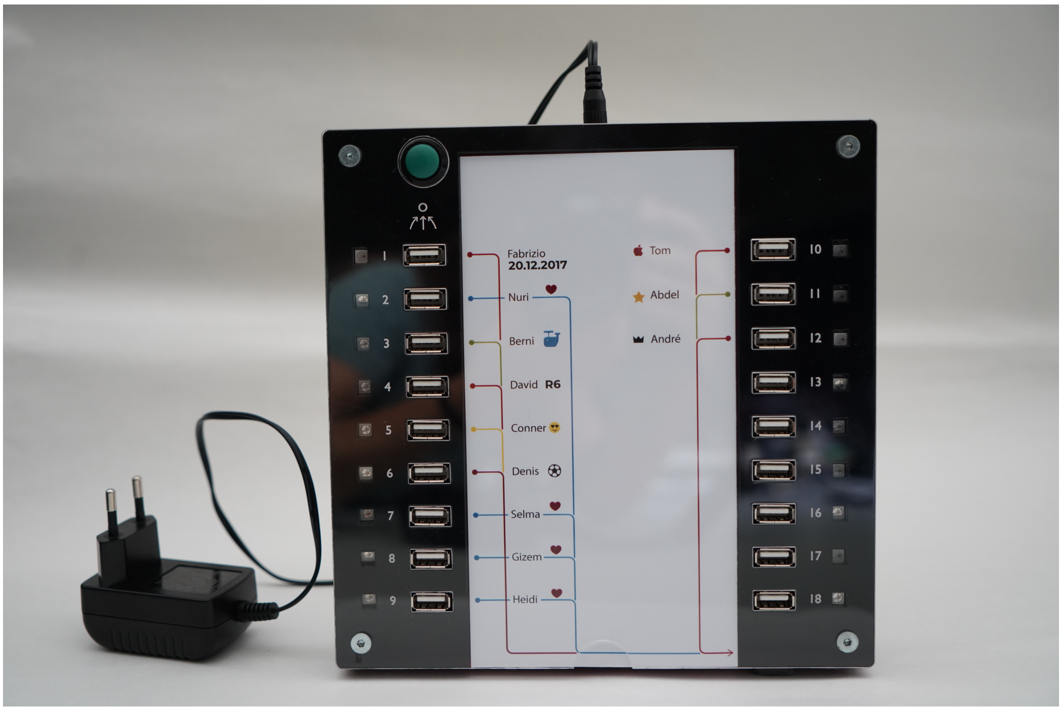

Figure 4. The deployed data transfer system features a slot that holds interchangeable keys (tailored to each class' name list) that assign each USB port to a student.

Hardware Components

During lesson delivery, all homework files are copied to her USB drive, the updated vocabulary files and next week's homework are copied to all students' USB drives.

Consequently, two 10-port USB 2.0 Hubs were employed in combination with a Raspberry Pi Zero W (to minimise the physical size) for building the main functionalities of our system. Moreover, we added a LED strip to indicate the aforementioned different states of each port. All components of the system are powered through a central 5V / 2A power supply. The software was written in Python and made use of different libraries to be able to interact with the connected USB hubs and LED-Strip.

The thickness of all components was calculated in order to build a casing as small and slim as possible. We laser-cut acrylic layers with cut-outs to the exact size of the internal components, stacked them and mounted them with screws and bolts to create a solid casing.

Functionality of the data transfer system

When an USB drive is inserted into a port and recognised by the system, the corresponding LED turns green. The minimum copying requirements are that the teacher's USB drive and one of the students' USB drives are plugged-in and that the student drives contain the designated folder for homework (named "ABGABE"). If these prerequisites are fulfilled, copying is possible with the press of either, a) the blue button, for copying from teacher-to-students, or b) the green button, for copying from students-to-teacher. Following a button press, the corresponding LEDs of the plugged in USB drives commence to blink successively and then light in constant green. This pattern indicates that the system is mounting all drives.

Once all LEDs light up in constant green, the system initiates the copying procedure. As soon as copying is finished, the LEDs turn blue. As soon as the LEDs turn constant blue, the corresponding USB drive can be safely removed Respectively, in case of a copying error, the LEDs turn yellow, while in case of a system error, one or more LEDs turn red.

4 Discussion and Outlook

In the following, we discuss the outcome of our approach in terms of applying the *middle-ground* solution and its potential. We further elaborate on the case of the data transfer system as a means for reflection and articulation of issues, we refer to the implications of its indefinite deployment, and we elaborate on its further applications.

4.1 The *middle-ground* solution

One of the most striking discussion points that emerged through our research and design approach was the twofold way of reading the solution. Third parties (e.g., other project partners involved in our research project) immediately identified other state-of-the-art technology that would support the teachers' material exchange practices (i.e., USB data transfers) and, therefore, considered them as a workaround to deal with the constraints of given contexts (e.g., limited technological infrastructure in the school and the students' homes). In contrast, the ÖGS teachers considered their practices as the only way to operate, and *they* perceived the developed system as the *ideal* solution. We argue that even though there are widespread technological and scientific solutions that could pose as the better option (i.e. a technologically advanced platform that could serve as an online dictionary or a smartphone vocabulary application, while additionally, a local server could host the students' assignments), the case of the data transfer system serves, from a research perspective, as the *middle-ground* solution that supports the teachers' practices and alleviates issues they were facing during lesson delivery. If a technology-wise *ideal* solution in the form of a non-web-based data transfer platform or a cloud-based data transfer system was employed, it would unavoidably require alteration of the teacher's practices and the school's current technological infrastructure as well as teacher's training of how to use the new system.

Aiming for the *middle-ground* solution is an unusual but not a novel approach; it has been utilised as a management strategy for software development as the most optimal approach based on total cost minimisation (Goldstein et al., 2010). Indeed, as we experienced in the case of the data transfer system, employing the *middle-ground* solution in certain contexts might be more optimal than chasing the *ideal* solution. This resonates with work by Pipek and Wulf (2009), as e-infrastructures also follow the same logic; their employment could improve the design of IT infrastructures in organisations.

We strongly believe that the reported approach has the potential of becoming a technique. Through the case of the developed data transfer system, we explored how a *middle ground* solution could be the optimal one for the teachers based on the limitations posed by the given context. However, conforming to Wulf et al. (2011), design case studies in other fields of practice are necessary in order to identify cross-cutting issues to compare and combine insights from those cases. The pursued approach in this research represents a highly contextual and user-centred one. For future work we aim to further elaborate on how such middle ground solutions may serve as highly contextualised indicators of (technological, infrastructural, or else) change; meaning that indefinitely deploying such solutions and accompanying this deployment over time may help to identify new opportunities for technological innovation.

4.2 Reflection and articulation of issues

Apart from the practical contribution of a fully functioning data transfer system, this system may be furthermore considered as a means to *reflect* on and exhibit the problems such a school might face. We envision to use this system as a reflection, to initiate discussion and demonstrate the issues that the ÖGS teachers were facing, the solution we developed and what would have been the *ideal* solution to third parties (i.e., future stakeholders). Specifically, through the mere existence of the developed system we reflect on the unreliable technical infrastructure that does not allow for smooth lesson delivery. Through this reflection process we are attempting to reframe the situation to relevant parties which could possibly lead towards a problem-solving procedure on a higher level (Schön, 1983).

In addition to a reflection, the system serves as a supplementary articulation means that illuminates prevailing yet overlooked issues to present them to teachers, parents, and other potential future stakeholders (e.g., representatives from the deaf community). It may be read as a kind of tangible representation of the practices and workarounds the teachers have to perform on a daily basis 'to get their work done'; it embodies deficiencies in the educational system (e.g., lacking professional teaching curriculum for Austrian sign language), deficiencies in sharing and exchanging knowledge as part of a community of practice, or deficiencies in the current infrastructure of the school (e.g., lack of internet access) or the students home (e.g., partially not having full internet access or computer access).

4.3 Indefinite deployment of a *research product*

This subsection refers to the indefinite deployment of the developed research product, independent from conceptualising this research product as an ideal or middle-ground solution. As argued by Lim et al. (2008), the fields of HCI, software engineering, and design commonly use the term 'prototype' to indicate that a certain artifact is used as part of a design process. In these fields, the importance of prototypes is obvious and unquestionable. However, as argued by Odom and colleagues (2016), diverse complexities and challenges emerge when researching human-technology relations in *real-life* contexts over a *longer period of time*. 'Prototypes' may not be sufficient enough to research questions related to these complexities (Odom et al., 2016). *"While the fidelity of prototypes can range, they remain references to future products, systems, or services*" (Odom et al. 2016, p. 2549). In this perspective, prototypes may be considered as placeholders for something else; an instantiation of a *future outcome* (Lim et al., 2008). In this line of thought, Odom and colleagues (2016) suggest that the concept of a 'prototype' might not be adequate to support inquiries regarding everyday life and introduce the notion of *research products* whose explicit aim is actuality (i.e., users experience the artifacts as they are and not what they might become*)*. With our developed system, we have created a research product that can be indefinitely deployed in real-life context, without any dedicated maintenance from our side; meaning it can be used *as is*, rather than what it *might become*.

Our work does not only contribute a fully functioning system to support teachers' work practices but also, a research product that is deployed in the school in an indefinite manner and, is therefore, also open for future explorations and research. This is of particular importance, as prototypes developed in HCI and CSCW research, are often no longer in working order or even existence. Work that reports on designs or relevant deployment studies which make use of research prototypes is often archived, but the said prototypes are not (e.g., Truong et al., 2015).

Truong et al. (2015) point out several factors that define the length of a system deployment in the wild such as the context, frequency of use, and shelf-life. In contradiction, our deployed system stands out by providing the teachers with a solution that they will use in their everyday practices indefinitely (as long as the users wish to) without the researchers collecting use data, iterating on the system, or retiring it back to the research facilities. Through the established trust and collaboration between researchers and ÖGS teachers, a direct communication channel is in place in order to revisit the school to see how our system facilitates and/or alters the teachers' initial work practice. The importance of long-term deployments has been argued for a long time, due to several benefits. According to Karapanos et al. (2009), prolonged use of a deployed system allows for meaningful mediation. Moreover, a confluence between the said system and the pre-existing work practices of that context is crucial in order for the introduced system to be utilised in a meaningful way (Pipek and Wulf, 2009). Additionally, during long deployments, interesting relationships might unfold among people and computational things (Odom et al., 2016).

Deriving from our gathered insights, there is a set of design attributes to take into consideration when designing technology for indefinite deployment such as: the life-span of the electronic components based on the frequency and purpose of use, the high quality of finish, the material durability of both the external casing and the hardware components and a plan for unexpected maintenance, such as, easy access to electronic components. However, caution should be given when deploying a solution indefinitely due to the disadvantages it might hinder, such as slowing down solution development or solution stagnation. In our view, researchers should monitor indefine deployment; in case of emergent opportunities for further technological development (e.g., changes to the technological infrastructure) that would allow for further iterations on the initial solution or the development of an altogether new solution.

4.4 Further Applications for the data transfer system

As far as further applications go, other teachers working with assorted media can benefit from the developed system (e.g., digitally distributing or collecting homework with and from students). Additionally, we are confident that open-sourcing our system on a platform that hosts do-it-yourself projects such as Github[7] or Instructables[8] will increase its availability. Thus, other individuals facing similar technological limitations and simultaneous data transfer needs can fabricate their own system without purchasing any sophisticated equipment. Purchasing the bare minimum material requirements of two ordinary USB hubs, a raspberry pi single-board computer, a common LED strip, and some basic coding skills would suffice, rendering the system into widely available equipment. Following the use of the system on a daily basis since deployment (five months), the ÖGS teacher to whom the system was delivered, benevolently suggested to make the system available to other sign language teachers in other country regions; feedback that reassured us of the system's appropriateness and its widespread applications.

We envision that a data transfer system could prove useful in contexts where people meet, such as events where quick data transfers are called for (i.e.,

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[7] Github is web-based hosting platform for software development projects. https://github.com

[8] Instructables is web-based platform that hosts user-created and uploaded do-it-yourself projects http://instructables.com/

international conferences or consortium meetings where exchanging general info simultaneously is necessary). Furthermore, in offices where sharing files wirelessly or using web-based services is not an option or in settings where confidentiality is an issue and keeping files off-line is of great importance, the system could be used as the main data transfer method. Moreover, we see this system utilised for recreational and entertainment purposes (i.e., sharing music or video content, art installations, design exhibitions).

5 Conclusion

Domain-specific problems encountered at work practices may seem insurmountable to the end user. In this paper, we have reported on our research project at an integration school with hearing and hearing-impaired staff and students where we observed the work practices of the sign-language teachers. Through our empirical insights, we have identified domain-specific problems within the said practices; explicitly, disruption of lesson delivery due to mundane, time-consuming teaching material exchange procedures. This paper contributes to the CSCW community through presenting an approach for addressing domain-specific problems with a *middle-ground* solution. In addition, we have reported on and contributed the resulting outcome of this approach, the case of a data transfer system that supports the sign-language teachers' practices and alleviates their issues. The developed system can be read as a tangible representation of the contextual issues the sign-language teachers are facing and as a means of a reflection on current practices and an articulation of the limitations that constraint them. We have reflected on our approach and discussed the resulted case by outlining potential new roles for research products, elaborating on long-term deployment, and speculating on alternative application domains. As demonstrated, *middle-ground* solutions can be the most optimal ones in supporting work practices instead of chasing after the ideal. As the *ideal* solution, from a research and technology advancements' perspective, might not always be feasible or accessible, we argue, that there is a need to also advance middle-ground systems. Researching what might not be cutting-edge (from a technological perspective) or ideal (from a users' perspective) requires specific research and design approaches we aim to further advance in future research.

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