

Investigating Creativity Support Opportunities through Digital Tools in Dance

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Silke Buchberger, BSc

Matrikelnummer 01402621

an der Fakultät für Informatik

der Technischen Universität Wien

Betreuung: Ass.-Prof. Dr.x Katta Spiel

Mitwirkung: DI Janis Lena Meißner, MRes PhD

Wien, 2. April 2024

Silke Buchberger

Katta Spiel



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Investigating Creativity Support Opportunities through Digital Tools in Dance

DIPLOMA THESIS

submitted in partial fulfillment of the requirements for the degree of

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in

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by

Silke Buchberger, BSc

Registration Number 01402621

to the Faculty of Informatics

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Advisor: Ass.-Prof. Dr.x Katta Spiel

Assistance: DI Janis Lena Meißner, MRes PhD

Vienna, 2nd April, 2024

Silke Buchberger

Katta Spiel

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Silke Buchberger, BSc

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Kurzfassung

Creativity Support Tools (CSTs) dienen der Unterstützung kreativer Arbeit und galten ursprünglich als “große Herausforderung” für HCI. Die Forschung rund um CSTs und deren Designprozesse liefern jedoch wertvolle Einblicke in das komplexe Thema menschlicher Kreativität und die Potentiale für zukünftiges Interaktionsdesign. Die CST-Landschaft im Tanz ist vielfältig und Systeme werden oft nach ihrem Einsatz in bestimmten Phasen des kreativen Prozesses klassifiziert, wie etwa dem Erstellen, Darbieten oder Festhalten einer Choreografie oder eines Tanzstücks. Viele CSTs sind in Kooperation mit erfahrenen Choreographinnen und Choreographen oder im akademischen Umfeld westlicher Konzerttanzformen entstanden. Anhand einiger Beispiele aus der Literatur wurde außerdem eine vorwiegend bildschirmbasierte Interaktion mit visueller Representation der Tanzbewegungen festgestellt.

Diese Arbeit erweitert die bestehenden Ansätze um die Einbindung von tanzformübergreifenden und nicht-professionellen Tänzerinnen und Tänzern in die Forschung. Gemeinsam gingen wir der primären Frage nach, wie kreative Prozesse im Tanz durch digitale Tools unterstützt werden können. Die Arbeit folgte einem “Research through Design” Ansatz und verlief in drei Phasen: *Forschung*, *Design* und *Evaluierung*. Diese wurden durch auto-ethnographische Reflexionen ergänzt, um die Gefühlsdimension der Kreativität im Tanz zu erschließen und somatische sowie kinästhetische Erfahrungen näher zu untersuchen.

Das Herzstück der Arbeit bezieht sich auf den iterativen Designprozess eines nicht bildschirmbasierten, physischen CST-Prototyps, der auch als Wearable am Körper getragen werden kann. Dieser basiert auf empirischen Forschungsergebnissen zu Definitionen von Kreativität im Tanz, Bewegungsgewohnheiten und Einflussfaktoren tänzerischer Kreativität. Als Resultat eines dreistufigen Nutzerforschungsprozess und eines Vergleichs mit der Literatur werden vier Ebenen kreativer Unterstützung im Tanz identifiziert: *persönlich*, *umgebungsbezogen*, *sozial* und *aufgabenspezifisch*. Darüber hinaus werden acht wiederkehrende Themen in Bezug auf die Wechselwirkung zwischen der Nutzung digitaler Systeme durch Tänzerinnen und Tänzer und deren Tanzpraxis diskutiert. Diese berücksichtigen kinästhetische, soziale und kulturelle Aspekte. Insgesamt liegt der Schwerpunkt auf dem Verständnis von Kreativität als einem über choreographischen Output hinausgehenden Prozess sowie auf der Komplexität, die durch Individualität und ein abstraktes, körperinternes “kreatives Artefakt” im Tanz entsteht.



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Abstract

Creativity Support Tools (CSTs) are designed to enhance the work of creative practitioners. Initially introduced as a “grand challenge”, the development, evaluation, and analysis of their use in creative domains provide valuable insights into the complex area of human creativity and potentials for interaction design. In dance, there is a heterogeneous landscape of CSTs. Tools and systems are often classified by their use in a certain stage of the creative process concerned with the creation, performance or documentation of choreography or a dance piece. Across the examples examined within this work, it was found that the prevailing type of interaction is screen-based with a form of visual dancer or movement representation. Additionally, researchers have mainly collaborated with expert choreographers or scholars in western concert dance forms.

Therefore, this thesis aimed to expand on these approaches by including non-professional dancers, as well as dancers from various dance forms, in the research. Together, we explored the guiding research question how creative processes in dance can be supported through digital tools. This included a focus on creativity rather than dance technique and on examining in what ways dancers’ use of tools affects their practice. The work followed a research through design principle, progressing along three intertwined but distinct phases: *research*, *design* and *evaluation*. Complementing these phases, autoethnographic reflections were used to access the felt dimension of creativity in dance and examine somatic and kinaesthetic experiences more closely.

At the core of the work, the iterative design process of a non-screen based tangible and wearable CST prototype is described. This is informed by empirical research findings about definitions of creativity in dance, the exploration and disruption of habits as well as factors influencing dancers’ creativity. Based on a three-staged user research process and comparison to literature, four levels of creative support in dance are identified: *personal*, *ambient*, *social* and *task-specific*. Drawing on evaluation results of the *Movement Explorer* prototype and research findings, eight recurring themes concerning the interrelationship between dancers’ use of digital tools and their dance practice are discussed. Across these themes, kinaesthetic, social and cultural aspects are considered. Overall emphasis is placed on the notion of creativity as a process beyond output, and the complexities of designing for individuality through an abstract notion of bodily artifact in dance.



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CHAPTER 1

Introduction

The integration of digital tools into creative processes, predominantly in fields such as visual arts or music, has become indispensable for modern artists. Based on a literature review by Frich et al. [30], computational support in creative domains has been studied for approximately thirty years in Human Computer Interaction (HCI), building upon a rich history of psychological studies on human creativity. Originating in the 1950s, the focus in psychology shifted from the individual's creative capabilities to collaborative and social aspects of creative work. With creativity research becoming accessible to further disciplines by the end of the century, it found its way into HCI. According to the authors, the initial focus was on collaborative creative work.

Ben Shneiderman, who significantly contributed to the research and development of *Creativity Support Tools (CSTs)* in its early years raised the following question:

“How can designers of programming interfaces, interactive tools, and rich social environments enable more people to be more creative more often?” [63, p.20]

He considered this “a grand challenge for HCI researchers” [64, p.1] and designers of CSTs. In an overview of tools to support creativity from 2002, he listed domains such as mathematics, engineering, software development, architecture, music, visual arts and journalism among application areas of existing software products, with the purpose to foster innovation and discovery [63].

In the creative practice of dance, the first individual advances in the use of computers for choreographic work were made as early as the 1990s [14]. As shown in a study by Zhou et al. [82], it is only in the last decade that greater interest in computational support for dance has grown in HCI. The authors highlight the characteristic relationship of this line of research to the third wave of HCI, studying culture, human experience

and embodiment. Due to the complexity of the moving body as a material of creative expression, they point out different angles for studying dance in HCI, including an emphasis on embodied interaction and kinaesthetic creativity, movement analysis and the development of computational support for the creative work as a process towards dance creation.

The research area of creativity in dance is diverse, as is the approach to studying it. This diversity is reflected in the contributions of artifacts. CSTs for dance described in HCI literature serve different purposes within a broad range of dance-related tasks. Among others, these include the choreographic process, stage performances, dance education, research and analysis, and dance learning tools [23]. Across these areas, the different kinds of tools range from interactive installations to mobile applications and form a diverse spectrum of computational support.

What is dominant is that many of these tools communicate with the dancer or the audience via screen-based information transmission. Additionally, with videos being the main digital means of documenting and sharing movement as well as drawing inspiration from others in dance, visual perception and augmentation prevails in digital dance support. Raheb et al. report that among their reviewed dance learning tools, “the predominant method is the Mimetic” [23, p.15], which aims at aligning the learner’s movements as much as possible with the comparison movement in the game. These two aspects, visual modalities and correctional practice support, are also pointed out by Silveira et al., with the addition that “video recordings or screen-based interactions might not inform on the inner movement qualities nor the kinaesthetic sensations in dance” [3, p.1582].

Among the dance forms studied in HCI, western concert dances such as contemporary dance, modern dance and ballet are the predominant [58]. Common collaborators in research projects include professional dancers, choreographers or scholars [40]. Therefore, the resulting tools often reflect the specific needs of these kinds of creative professionals. While this focus is a reasonable endeavor for this field of research, a solely academic engagement neglects professions and dance forms not to be encountered in this environment. With dance as a cultural heritage, very few forms have been institutionalised. In Austria, professional university education in dance is limited to contemporary dance forms, movement and dance pedagogy, and rhythmic.¹ In 2018, academic training in Urban Dance Styles was introduced, but students do not graduate with an academic degree, but receive a certificate of completion.² However, individuals who identify as teachers, performers, or choreographers still exist outside of this realm. They may have diverse backgrounds in various dance forms and may have acquired their skills through auto-didactic training or attending dance schools, studios and workshops. This is an important aspect to consider when involving dancers in computing research, which was part of the motivation for this thesis.

¹<https://www.tanzstudios.at/ausbildung/>, last accessed on 07/01/2024.

²<https://urbandancestyles.at>, last accessed on 07/01/2024.

1.1 Motivation and Aim of the Work

Given this context, I was interested in studying dance close to the practical field, which involved dancers of diverse backgrounds and professional levels. In terms of their interaction with digital tools, there was a particular curiosity about technological possibilities beyond video and screen interactions. The dancer's relationship to the own body, the music, the physical space and to fellow dancers in collaborative situations were among the topics of interest. Having a passion for dance myself, the present research project was also motivated by personal reasons. Observations from teaching and practicing dance in the past years both reflected and extended themes present in HCI and dance research, which was why this thesis offers a more in-depth examination of the topic.

The aim of this work was thus to investigate creativity support opportunities in dance with an emphasis on the dancer's felt experience. This aligns with research directions in HCI on the intersection of dance and creativity suggested in recent literature [82]. More precisely, establishing an understanding for the meaning of creativity in this domain and the design of a CST to support that specific purpose were among the goals of this research project.

To clarify the boundaries of this work, it was not intended to provide dancers with support for learning a particular dance technique, which would have required a restriction to its corresponding dance form. Due to the nature of my personal network of dancers, however, the accessible dance landscape for this research spanned primarily across dance forms practiced without a partner in Austrian dance studios, such as street and club dances, commercial dance, contemporary dance, jazz dance and ballet.

1.2 Research Questions

The above introduced research interest was guided by the following three questions:

1. *How can creative processes in dance be supported through digital tools?*

Answering this question firstly required a review of literature on technology for dance in HCI. However, many tools developed in academia have not progressed beyond the prototype stage and are therefore not used in the context of studio dance practice. Hence, the goal of this research question was to identify overlaps between the findings from literature and the actual value of tools for dancers' continuous practice. The investigation of tools used in everyday dance activities aimed to identify gaps and opportunities for supporting dancers' creative workflows.

2. *How does a non-screen based digital artifact fit into a creative process in dance as a means of creative support?*

Following initial findings from the first research question, the next step was to identify potential functionality, appearance and interaction types for the design of an artifact intended to support creativity in dance. After a data-informed selection of a particular creative process, the goal was to design and implement a tangible or wearable artifact using a Research through Design approach. The artifact was created, refined and evaluated based on dance workshop sessions. Qualitative and quantitative results of the prototype assessment are interpreted to answer this research question.

3. *In what ways do the used digital tools affect dancers' creative processes and outcomes?*

Lastly, insights into dancers' previous interactions with various tools from the first research question and findings from probing the prototype were blended into an analysis of the interplay between dance and digital technology. This question guides the discussion section of the thesis, exploring dancers' relationships with technology, added values and potential problems from both the dancer and the HCI perspective.

With this outline of interest, the results of this thesis are empirical and artifact contributions to the body of HCI research, as defined by Wobbrock and Kientz [81].

1.3 Methodological Approach

Without anticipating in-depth details about the specific methods applied, which are explained in chapter 3, the present section provides an outline of the approach and a brief discussion of its value for the defined research topic.

The methodology utilised within this work was of predominantly qualitative and exploratory nature. The initial research involved establishing a theoretical foundation through literature. Attention was given to the first research question and to an assessment of the state of the art in dance-related HCI research. The subsequent and main part of the work was guided by user research, design, and evaluation phases, which included an iterative development process of a prototype in the context of a Research through Design framework. Additionally, an autoethnographic component accompanied the whole project, offering a first-person perspective into kinaesthetic experiences.

The primarily qualitative, multi-method approach to the investigation of creativity support in dance allowed an inquiry into the felt dimension of dance as well as the analysis of complex relationships between creativity, technology and the moving body. Moreover, the second research question illustrates very well that the research space for this thesis was not clearly defined before undertaking the practical work of this study. The actual user needs for future CSTs in dance were not known, but rather shaped and defined along an exploratory process. Adams et al. point out that this is often the case in HCI:

“[W]e frequently find that we do not know what the real HCI issues are before we start our research. This makes it hard, if not actually impossible, to define the variables necessary to do quantitative research.” [1, p.138]

They furthermore stress the emphasis on people’s feelings, attitudes and application scenarios, which can be captured using qualitative methods [1]. Although quantitative assessments also played a role in this thesis, they were not in the foreground of the work. What was more important was to shed light on a topic in different contexts, which was facilitated by a combination of multiple methods. Beyond that, the design of the artifact within this work was not only a design process, but an opportunity to gain more knowledge through the development process and the usage of the prototype itself.

1.4 Structure of the Thesis

The thesis is organised into eight chapters. Following this introduction, related work from the fields of HCI research and dance, creativity theory as well as CSTs is presented, highlighting the main topics of interest for this thesis. Chapter 3 provides a more detailed explanation of the methodological structure outlined above and the utilized framework for the analysis of research data. The core work done within this study is divided into chapters 4, 5 and 6, presenting findings from user research, the design process and the evaluation of the final prototype, respectively. Subsequently, a discussion of the triangulation between dance, creativity and digital tools synthesises the collected data. For this, chapter 7 first answers the above stated research questions, which leads over to a more in-depth analysis of added values and problems of computational support for dance. At the end of said chapter, limitations of this research and suggestions for future work are discussed. Finally, chapter 8 concludes the thesis, providing a summary of how the presented research contributes to the body of literature about creativity support on the intersection of dance and HCI.



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Related Work

Because of the various dance forms that exist and the intricacies of human movement, dance has been explored from different angles within HCI. A comparison of different works is not an easy endeavour, since each technological solution was created within a specific research and dance context and therefore may not be a suitable tool for another, although similar, use case. Zhou et al. use the dance performance context to point out that it is “difficult to design tools that serve multiple types of performances, or to generalise understandings gained from one performance to another” [82, p.2]. Nevertheless, the following section intends to provide an overview of the possibilities to merge the dance and computation domains by means of dance task the respective study was designed for. This addresses the first two research questions in terms of identifying existing creativity support in dance and selecting a potential creative task to design for within this thesis. Further movement-related research directions in HCI are introduced subsequently, which aid the positioning of this thesis within the sub-fields of embodiment, kinaesthetics and somatic research. In order to return to the focus on dancers’ creative support, the last two sections of this chapter are dedicated to theoretical models of creativity and creativity support tools, in particular.

2.1 Dance in HCI

As touched upon in the introduction of this thesis, technological advancements have played a role in dance before the research area of HCI existed. Loïe Fuller utilized the first electrical spotlights in the creation of her famous Serpentine dance at the end of the 19th century [32]. Around sixty years later, John Cage produced electronic music for the dance pieces of the choreographer Merce Cunningham [50]. Cunningham’s first experiments with interactive performances date back to 1965, where he used various antennas, photoelectric cells and contact microphones in his piece “Variations V”. Dancers’

spatial movement on stage, their shadows and physical contact with the sensors served as signals for modifying the music.

Within HCI, dance was gaining in interest especially in the third-wave shift, “incorporating the cultural, experiential, and embodied characteristics” [82, p.1] of this phase. Zhou et al. reviewed twenty years of research on dance in HCI and highlight four themes of applying technology in the dance context: “physiological sensing, multisensory perception, movement quality, and agent collaboration” [82, p.8]. While physiological sensing and movement quality (analysis) are closely related to a quantification of data *produced by* a dancing body, the remaining two themes concentrate on technology *affecting* the dancing body. Several authors have emphasized the latter in recent works, examining the kinaesthetic and somatic layers of technology-supported dance (e.g. [3, 37, 40, 82]). These concepts will be explained in more detail in section 2.2. The above mentioned themes demonstrate the diversity of computational investigations into dance. Some examples are presented below, following a categorization similar to [23] and [82].

2.1.1 Performances

Having introduced Cunningham’s early interactive dance piece, the performance aspect of dance is still one of the most prominent topics in HCI research [82]. As part of this performing art form, dance pieces and their creation processes are of great interest for exploring means of technological integration.

The idea of translating the dancer’s movement into sonic output has been picked up in a more recent work by Palacio and Bisig [53], titled *Piano & Dancer*. It is an interactive performance between a dancer and an electromechanical acoustic piano, which is controlled by the dancer’s movement. With accelerometer sensors on the dancer’s joints, movement qualities are analyzed and algorithmically mapped to control the piano’s sounds.

Similarly, Latulipe and Huskey [46] utilized accelerometer sensors in a later version of their *Dance.Draw* project performances in order to map movement to live background visualizations on stage. Having initially experimented with hand-held gyroscopic mice, their final sensing system allowed the combination of both the hand-held mice as well as the attachment of sensors to the body and stage props. This enabled more flexibility in the use of the system and gave dancers more freedom in their range of movement.

Alaoui [26] took these approaches further and produced the multi-media performance *SKIN*, including both sonic and visual enhancement of the performance. Among multiple modalities, a combination of muscle activity, proximity sensing and touch allowed the dancers to control the audio-visual material during the performance. Moreover, Alaoui experimented with appropriating existing technology, such as using smartphone cameras for proximity sensing.

A specific piece of software designed for the purpose of mapping real-time data to audio-visual performance effects, is Marc Coniglio’s *Isadora* [20]. It has been developed for over

20 years and is applied primarily in theater and performance context, but is also used for educational purposes.

In order to identify needs and expectations of dancers with respect to interactive dance performances, Masu et al. [48] conducted a focus group study with ten professional contemporary dancers and choreographers, who also had technology expertise. They deduced design guidelines for the integration of technology in dance performances, highlighting the three factors “communication with the audience”, “the role of the technology in the creation of the piece” and “input and output strategies” [48, p.6]. To name a few specific details, technology is supposed to facilitate a multi-layered communication with the audience, provide room for appropriation in the creation process and add ambiguity to the performance.

2.1.2 Choreography

Before putting a dance piece on stage, choreographic work needs to be accomplished. A computer-aided choreography generation tool, *DanceForms*, formerly known as *LifeForms* was developed by Calvert et al. [14] and intensively used by Merce Cunningham in its early stages. It is a desktop software designed for large screens, that allows the manipulation of virtual avatars into body positions of the choreographer’s choice. It is compared to animation software, such as Maya or MotionBuilder, with the difference that it was especially designed for dance and is said to be easy to learn [17]. Human figures can be arranged on a virtual stage and simulations of created movement sequences are visualized. It includes a palette of pre-saved movements known from ballet and modern dance, from which examples can be selected without having to adjust the avatar from scratch.

In order to be able to integrate the software more easily into the choreographic process in the studio, a mobile version, *iDanceForms*, was developed [17]. It utilizes the integrated accelerometer and camera of the mobile device for “pose estimation and marker-less motion capture” [17, p.71] in order to reduce the amount of manual user input needed.

While these examples require the user to piece the choreography together manually, several algorithmic approaches to generating movement sequences have been described in literature as well. [16] describes a sub-module for the above described *iDanceForms* application, which generates body pose keyframes based on the Laban Movement Analysis framework. Other works, such as [11] and [54], describe machine learning systems trained with motion captured dance data. Another example, which is not described in scientific literature, but adds to the artificial intelligence approach, is the Google experiment *Living Archive* [49]. In cooperation with choreographer Wayne McGregor, movement from an extensive collection of video material of his dance pieces was classified and digitally archived. Through a web interface, users can select single key frames of extracted body positions from a data cloud and add them up to a sequence, which is animated and can provide creative input for the creation of choreography.

Beyond specific examples of technology supporting choreography composition, Ciolfi Felice et al. [19] assessed six contemporary choreographers' approaches to creating choreography. They propose a framework of important factors within the creative choreographic process and state five implications for the design of computational choreographic support. These include visual manipulation of ideas, knowledge management about the piece, the possibility to shift between focal points, collaboration, and attention to the situational context of applying the tool.

2.1.3 Notation

A crucial part in the choreographic process is dedicated to capturing ideas. This can be done using different strategies, such as drawing, writing text, taking videos or using formal notation [19]. Examples of formal notation, such as Labanotation or Benesh notation, provide symbolic language for capturing movement. It is also represented in software, such as LabanWriter [76], LabanDancer [79] and MacBenesh [61].

More interactive notation tools are *The Choreographer's Notebook* [67] and *Knotation* [19]. The Choreographer's Notebook is a web-based application for video annotation, which facilitates analysis of rehearsal videos and feedback among the choreographer and dancers. Singh et al. [67] report that in their study the tool supported dancers in using their rehearsal time efficiently for dancing, as much discussion was outsourced to the platform. As a mobile, pen-based system, Knotation allows the combination of sketches, images and video for documenting ideas. It is not dedicated to a specific choreographic approach or formal notation language, and therefore supports dancers to appropriate the tool to their needs.

2.1.4 Improvisation

Although interactive systems were introduced in a performance context above, they have also been explored with respect to dance improvisation in HCI research. Akerly [2] designed a responsive audio system (RAS), which was originally used in a dance performance. However, in the research study, it served the investigation of a dancers' felt experience in an improvisation setting in the RAS. She highlights that, unlike in previous studies involving interactive systems, her aim was to gain knowledge about the dancer's felt experience rather than to emphasize "the system's ability to serve the work or serve the audience" [2, p.9]. This situates her work more in an improvisational context, as neither the audience nor a choreographic piece was prioritised.

A similar interactive approach, using visualizations instead of sound, is described by Hsueh et al. [37]. Their so-called *Choreoprobe* serves as cooperative instance for inspiring the dancer's movement ideation process. Through tracking of the body contours and movement dynamics using Kinect, visualizations projected onto a surface are shaped and modified accordingly. Attention in the study is given to how the visualizations mediate the relationships between dancers in the shared studio space as well as the concept of kinaesthetic creativity, which will be discussed later in this chapter. A related example is

Choreomorphy, a motion-capture based visual exploration system with multiple avatar representations of the dancing body [57]. In this case, the authors not only position their work within the improvisation area, but highlight its potential also in terms of a reflective instead of mimetic learning approach.

Beyond audio-visual systems, other artifacts have been incorporated into the dance improvisation context, such as drones [80] and robots [39]. However, these studies aimed at a more general examination of potential creative movement-based human-technology collaborations, without intending to create supporting systems for the improvising dancers per se. In contrast, the latter was subject of interest in the development of the *Wearable Choreographer*, a soft robotic wearable for dance improvisation worn on the leg [3]. By connecting joints of the lower body with strands of artificial muscles and alternately contracting and releasing them, movement of the leg is restricted in order to challenge the user in generating novel movement. The evaluation of the prototype was done with attention to the “lived felt embodied sensorial experiences” [3, p.1582].

2.1.5 Dance education

A recent study related to dance education was conducted by Vialle et al. [77] and concerned the use of augmented reality for acquiring dance skills. Motion captured data of Isadora Duncan’s dance technique was displayed on a HoloLens headset for learners to explore the movement quality and put it into practice themselves. While the results of their study show that technology of this kind cannot replace a human dance teacher, it has its advantages in terms of sequence repeatability depending on individual needs of the learner. This aspect reflects an assessment of dance interactive learning systems (DILS) by El Raheb et al. [23], who acknowledge the added value of educational technology for self-paced dance practice, among other aspects. They also stress the indispensability of physical dance class and human teachers in dance education.

Another example designed to assist the dance learning process is the *Delay Mirror* by Molina-Tanco et al. [51]. The system consists of a video camera, projector, projection surface and open source software and was probed in adult Ballet classes. The Delay Mirror records the dancer on video and projects the image onto a large screen with a delay of a few seconds. This offers the dancer the possibility to analyse their movement and correct their dance technique without having to interrupt for replaying video recordings in a usual manner.

As mentioned before in the case of the *Choreomorphy* project, other tools besides dedicated tools for dance education, can be considered educational as well. They may serve improvisation or reflection purposes, which can elevate a dancer’s skills.

2.1.6 Analysis

So far, this section has introduced various representations of the themes mentioned in the beginning of this section, namely “physiological sensing”, “multi-sensory perception” and “agent collaboration” [82]. The last theme, “movement quality”, is related to the

classification and analysis of movement, which can serve movement-based computation as well as correctional dance feedback.

Several works in literature have used the framework of Laban Movement Analysis (LMA) for this task, in combination with data-collection via Kinect motion capture technology [69] or accelerometer sensors [66, 44]. These systems classify movement data into pre-defined categories of movement qualities according to the LMA framework. Sun et al. [69] additionally evaluate a dancer's rhythm and offer instructional feedback to the learning dancer. This was also the subject of research for [68] and [62], who examined the dancer's tempo consistency, or ability to stay on beat, based on acceleration sensor data. In both cases, working either in the Solo Jazz [68] or Brazilian Forró context [62], the algorithms could accurately detect the dancer's timing consistency. However, Santos et al. [62] point out the gap between their quantitative evaluation and the qualitative, more holistic, assessment by expert dancers. According to the authors, the experts' evaluations took into account aspects such as the dancer's gaze, upper body and general posture and thus were able to provide more detailed feedback to the dancer in terms of improvements to enhance rhythmic abilities.

These examples illustrate the interest in dance movement analysis for the purpose of improving dance skills, which is related to the above described education category. In a broader context, dance movement analysis can certainly enhance the comprehension of human movement for the creation of movement-based interactions and highlight real-life intricacies that are not yet translatable into computational methods.

2.1.7 Documentation

Finally, the task of archiving dance has gained some advancements through novel technological systems. Standard written notations and drawings cannot ensure a reproducibility of the documented dance. In addition, video collections easily become disorganised and lack spatial information.

Two approaches to solving the organisational problem of large amounts of video data include the AI based *Living Archive* and *BalOnSe*, a web based video annotation and archiving system based on Ballet ontology [22]. Moreover, improvements in Motion Capture technology allow to record and archive dance movement digitally. An advantage of motion captured data is the possibility to explore the movement in three dimensions. The digital dance database by Aristidou et al. [8] contains motion capture data of Greek folklore dances, serving as an example of a dance movement archive.

2.1.8 Summary of Overarching Similarities

As diverse as the above presented examples are, there are three noticeable characteristics among the reviewed literature. First, the majority of these research examples are situated within the context of western concert dance forms, such as contemporary, modern dance or ballet. A study from 2022 conducted by Rajko [58] examined a total of 135 publications in the field of dance and computing. According to the author, 60% of the reviewed

publications either explicitly identify the context of western concert dance forms in their work or imply *dance* to be understood in these terms. Considering the historical perspective of dancers and choreographers experimenting with novel technology in a performative setting on theatre stages [52], this emphasis can be understood as a natural evolution. However, Rajko argues as follows:

“Here, I suggest that it is not so much that contemporary dance methods and practices are inherently bad or should not be engaged in computing contexts. Rather, I argue that perpetuating a belief that any western concert dance practice could ever speak on behalf of ‘human movement’ tacitly leans into the neocolonial and white supremacist undertones of computing’s desire to create universally adoptable and adaptable systems.” [58, p.12]

Second, a logical consequence of the focus on western concert dances is the common understanding of choreography or a dance piece as the creative end-product in dance. “The creative process” in dance is often described in singular and is divided into different stages working toward the creation of a (stage) performance or some form of post-processing or analysis thereof.

Third, the predominant means of conveying information to the dancer interacting with a given system takes place on a visual level of dance representation, such as through avatars, stick figures or abstract data visualizations, shown on a screen or similar projection surface. Hsueh et al. [37] found that the screen-based interaction with their visuals influenced the spatial relationship of a dancer can thus result in neglecting the third dimension of movement. Silveira et al. [3] also question the effectiveness of these interaction types for accessing a felt dimension of dance and movement.

2.2 Movement-based Research

Following these dance-specific examples, the present section aims at providing a more comprehensive overview of movement-based research in HCI. Herein, especially the previously mentioned focal points of embodiment and somatic research are highlighted and discussed in the subsequent sections. These concepts provide a useful frame of reference especially for accessing the felt dimension of creativity in dance within this thesis.

Movement-based research focuses on gaining understanding about human movement and leveraging its potential for designing interactions with technology. It ranges from interest in single body parts to full-body movement. Common procedures to capture and analyse movement data include the aforementioned motion capture technology, video signal processing and mobile sensors. Application areas, in which knowledge about human movement is useful include, among others, person identification, virtual reality systems, game design, avatar animation, assistive technology and gesture or full-body control interfaces for robots and drones [10]. This line of research requires a quantification of

human movement for informing the design of systems. The systems, in turn, give back to their users by enabling natural interactions, supporting the exploration of movement, promoting physical exercise or fostering social interactions.

This diversity of movement-based technology is illustrated by Hsueh et al. [37], who propose a taxonomy of six interaction types inferred from their study results with dancers interacting with visualizations. The taxonomy served as a lens for an analysis of more general, not necessarily dance-specific, movement-based interactions and comprise the following categories:

- *Control-based* interaction refers to using full-body movement or gestures as the basis for controlling a system. This can apply to games or gesture-controlled musical instruments.
- *Expressive* interaction enables the user to explore and gain awareness about certain movement. In contrast to control-based interaction, the tool's characteristic is to reflect the movement instead of trigger external events.
- *Following* interaction is given in mimetic behaviour. The user is guided by the system in the task of fulfilling a goal. This can apply to movement learning systems, where instructions given by the system are followed by the user.
- *Negotiating* behaviour was identified in interactions between humans and AI systems. It is based on the tool's characteristic to generate its own movement from a given set of rules.
- *Directed* interaction describes an interaction between two humans that is mediated through technology. The interaction of one user with the system is translated to the second user and triggers reactive movement. It can be both uni- and bidirectional.
- *Co-creative* interaction fosters collaborative exploration of movement. It is another form of technologically-mediated interaction between humans, but in a more open context.

While the term *movement-based* research provides a broad umbrella, several other labels in this area were mentioned in a 2006 introduction to a special issue on movement-based interaction by Larssen et al.:

“Many terms have been used to describe this area, to mention just a few - physical interaction, embodied interaction, graspable interfaces, tangible interfaces, embodied interfaces, physical computing and interactive spaces. Each area has a somewhat different orientation, but is covering closely related areas.” [45, p.607]

The underlying bodily concept that all these areas can make use of is *kinesthesia*. It refers to “the awareness of the position and movement of the body in space” [27, p.91] in a physiological sense. According to Proske and Gandevia [56], the first to define the term was Henry Charlton Bastian in 1888. They point out the individual’s unawareness of it for the greater part of everyday life. Kinaesthesia helps us catch a ball, reach for a glass or touch our nose when our eyes are closed. It “underlies everything we do as embodied beings” [15, p.6] and helps us respond to our surroundings in the form of movement [27].

Frequently, it is equated to *proprioception*, which Fogtman et al. choose to include in their definition of kinaesthesia in its use for interaction design. On closer inspection, however, proprioception is the ability to sense “the position of the limbs, and the state of internal organs” [27, p.91]. According to the authors, the presence or absence of kinetic motion is the distinguishing factor between the two concepts.

2.2.1 Embodied Interaction

One of these many fields listed above, which is especially interesting in a context, in which implications of movement-based interactions are studied more holistically, is embodied interaction. According to Svanaes, the term was coined by Paul Dourish in 2001 “to describe a new paradigm for interaction design that focuses on the physical, bodily, and social aspects of our interaction with digital technology” [70, p.8:1]. Loke and Robertson [47] point to related concepts by Merleau-Ponty, Robertson, Svanaes, and Kirsh, who see an individual’s interaction with and sense-making of the world not only in terms of cognition but of the whole living body. They describe part of this entity as kinaesthesia, which helps us perceive the world and react to it with our bodies. What separates embodied interaction from other disciplines within movement-based interaction is that movement is considered a design resource and researchers engage in acquiring or practicing movement skills themselves [47]. Höök, for instance, engaged in horseback riding and deduced qualities for design processes [35]. Erkut and Dahl conducted dance workshops with students of an *Embodied Interaction* course to inform their practical implementation of movement-based technology projects through exploring movement themselves. According to the authors, it is “widely accepted that the designers should develop their bodily skills and learn how to use the movement as design material” [25, p.1].

In this context, Loke and Robertson introduced *Moving and Making Strange*, a design and evaluation methodology for movement-based interaction using an embodied approach, which they explain as follows:

“Design approaches that incorporate an understanding and valuing of the moving body and felt, kinaesthetic experience can contribute to creating conditions for technology-mediated human experience anchored in the sensing, feeling, and moving body—an *embodied approach* that takes full account of the central role of the body and movement in lived cognition.” [47, p.7:2]

Their methodology combines a first-person perspective of the moving person, a second-person perspective from an observer, and the technology-perspective as third instance. It incorporates the five principles “making strange, direct bodily experience, multiple perspectives, openness to phenomena, and creativity” [47, p.7:9]. *Making strange* refers to a defamiliarization process, which can facilitate an awareness for habits and trigger novel ways of perceiving and moving.

Due to the nature of dance, embodiment has been closely connected to research on the intersection with dance (e.g. [2, 26, 3, 40]). However, it is also applied in other domains, such as a music context described by Tomás et al. [72]. After listening to sequences of electroacoustic music, workshop participants were asked to enact gestures of how they would imagine playing an instrument that produces this sound. The embodied ideas were translated into clay models representing these novel instruments.

2.2.2 Soma Design and Somaesthetics

Soma and *somatics* are concepts originating from the movement theorist and philosopher Thomas Hanna. According to Höök et al. [38], he defined somatics as the study of the soma, which refers to the inner perception of the body from a first-person perspective. It is the combination of mental, physical, emotional and social aspects of an individual, which are all parts of how we sense and perceive our environment [71]. Richard Shusterman’s *Somaesthetics* extends the concept of the soma with *aesthetics*, which “is a way to examine connections between sensation, feeling, emotion and subjective understanding and values” [38, p.5]. It refers to the way we interact with our environment and to a heightened awareness of what is perceivable in the world [71].

Common somatic movement practices include the Feldenkrais Method and Alexander Technique as well as Yoga and Tai-Chi. Höök et al. [38] vividly describe how such practices can guide our attention back to bodily habits that we have suppressed awareness of. Such habits often take place on a sensory-motor level and can influence our posture, movement patterns, and overall well-being. Engaging in somatic practices can thus help in regaining this awareness and appreciating “the richness and aesthetics of our own somatics” [38, p.6].

Consequently, soma-based design or somaesthetic design of technology prioritises the designer’s first-person perspective in a holistic process that addresses the whole soma instead of the body only. It aims at producing artifacts that are informed by an awareness of the designer and help the user to heighten their attention to the own soma [71].

Artifacts developed through somaesthetic design processes include Höök et al.’s *Soma Carpet* and *Breathing Light* [36]. The Soma Carpet communicates with the person lying on it through heat. It directs attention to different body regions in alignment with an audio recording of Feldenkrais instructions. In the Breathing Light prototype, a sensor measures a person’s chest movement and controls ambient lights accordingly, becoming in tune with the person’s breath. This happens under an enclosed, but transparent

dome-shaped object in order for the user to have an immersed and private space while at the same time not feeling confined.

While these examples deal with the body in its natural form, Rajko et al. [59] transformed the approach to a digitally extended body. They argue that large parts of our lives take place in the digital space. Therefore, not only our personal devices but also the data we produce are merged into our self. With their interactive installation performance *Vibrant Lives* they translated the immaterial data output of participants' devices into vibro-tactile feedback. The project aimed at gaining first-person insights about the participants' felt experiences while interacting with the system.

Other designs resulting from a somaesthetic approach include two VR simulations exploring sensory misalignment [71]. In the *Balance Beam* and *Flying Harness*, simulations of balancing and flying activities were influenced by several acoustic, textural, vibro-tactile and heat interventions. The experiences without and with these modifications were compared. The authors found a phenomenon that they call *somatic trajectory*. It refers to an initial technology-induced misalignment of a user's senses, which is realigned at a later point in order to "create for a somatic sense of catharsis" [71, p.9].

2.3 Creativity

After having discussed the research areas related to dance and movement within HCI, the last relevant field of interest explores the concept of creativity in order to understand how technology can support dancers in their creative tasks. There are several definitions of creativity, as will be discussed in the following section, many of which build upon western perceptions [33]. They share the common idea of creating something novel, original, appropriate and useful [4, 33, 41]. As mentioned by Helfand et al. [33], these characteristics need to be judged based on their context, as the creative process involves social, cultural and psychological aspects, which have to be taken into account. The authors point out that, while western definitions of creativity are more focused on the creative product, eastern approaches value the process and personal fulfilment [33].

Due to the scope of this thesis, only a few well-known theories will be presented, which fall under the western umbrella. Each of the models discussed below views creativity through a different lens. This includes the individual's professional level [41], the stages of the creative process [78], an interrelated three-component system [21] or the motivation for engaging in a creative activity [74].

2.3.1 Creativity Models

Four C Model: The Four C Model of creativity by Kaufman and Beghetto [41] builds on a differentiation between the so-called "Big-C" and "little-c" creativity. Big-C is understood as "eminent creativity" and achieved by prominent professional artists and scientists. It is related to great achievements in human history. In contrast, little-c creativity describes everyday creative tasks realisable by any individual. To be able to

identify more nuanced characteristics when researching creativity, they argue that these two categories are not enough. Therefore, the additional “Pro-c” and “mini-c” creativity are introduced. The latter is understood as subjective creativity, which is meaningful to the individual. It is about the “dynamic, interpretive process of constructing personal knowledge and understanding within a particular sociocultural context” [41, p.3]. Pro-c fills the gap for creatives working on a professional level, who are neither to be classified as lays nor prominent creatives. This does not mean, however, that their creative work needs to be their main profession. Vice versa, it is not given that any individual with an occupation in the arts attains Pro-c creativity. Pro-c creativity is considered to take a duration of approximately ten years of engagement with the respective creative discipline beyond the foundational skills. The Four C Model accomplishes to portray a developmental view on creativity, although the authors state that not many individuals achieve a full trajectory from mini-c to Big-C level.

Four phases: In his book *The Art of Thought*, Wallas describes “four stages in the formation of a new thought” [78, p.80]. It begins with *Preparation*, which means the systematic investigation and analysis of the problem. This is followed by *Incubation*, a stage in which the problem rests and is not addressed consciously. Not only should the problem itself rest, but the individual should come to a state of “actual mental relaxation” [78, p.87]. The third stage, *Illumination*, describes the moment, in which an idea spontaneously comes to mind. Wallas even introduces the term “Intimation” for the moment when the individual knows that the illuminating idea is underway, even if they do not know yet what the idea will be. This idea, finally, has to be tested for validity, which is done in the last stage, *Verification*.

Systems model: The systems model by Mihalyi Csikszentmihalyi [21] builds upon the interaction of three elements: domain, field and person. The *domain* can be found within the broader concept of culture and stands for what we were taught. Various domains exist within the culture, which operate under their own particular terms and guidelines. Information from the respective domain can be acquired by a *person*, who represents the second element of the system. But not every person produces novel contributions to the domain. Many are satisfied with working with what they know and not intending to change the given domain through their creations. Which and how novel contributions are accepted and adopted in the domain are, in turn, decided by the so-called *field*. This can comprise critics, judges or other experts who can be understood as gatekeepers.

Componential Theory of Creativity: Amabile’s theory defines four components, which have an impact on creativity [4]. Three of which are intra-individual: *Domain-relevant skills* refer to the individual’s knowledge, talent and expertise in the specific domain. *Creativity-relevant processes* comprise personality traits and cognitive processes of the individual, which can foster creativity. These may include risk-taking and self-discipline. The third intra-personal component is *task motivation*, which refers to the intrinsic motivation of the individual. This component is connected to Amabile’s Intrinsic Motivation Principle. According to a paper from 2016, intrinsic motivation can enhance the creative process in every stage, inducing more creative solutions in terms of novelty

and usefulness [6]. The fourth and last component is the individual's *environment*, which can positively or negatively influence creativity from the outside [4].

Although Amabile's work was primarily conducted in the context of organizational creativity, her research originated in 1983 and is one of the most esteemed theories also accepted in creativity research concerning individuals. Since then, it has been refined and expanded to include further studies, such as the mentioned Intrinsic Motivation Principle and investigations about the individual's affective state impacting creativity [4]. According to the latter, events of positive affect can positively influence creativity on the same and following day [5].

Creativity type matrix: Unsworth developed her creativity type matrix as a response to a critique about common emphasis on end-products of creative processes, which disregards the starting point, reason or type of an idea [74]. She proposes a matrix, which results in a "continuum" of creativity types, with each corner of the matrix representing one of four types, as depicted in Figure 2.1. For this matrix, two dimensions that relate to the initial engagement in the creative activity are relevant: the *driver-type* and the *problem-type*. As drivers, Unsworth states a range between internal and external sources as initiators and thus answers the "why" of the creative endeavour. The problem-type is determined by asking the "what" and ranges from so-called closed to open problems. Closed problems specify the method by which they must be solved, whereas open problems require being discovered.

According to Unsworth, professional creatives are often focused on responsive creativity. This type is characterised by being required to do creative work and having limited choice in the type of task to do. Expected creativity represents the combination of external driver and open problem. This is the case if a task is defined for someone to accomplish, but the methods are up for the individual to choose. In contrast, internal motivation is given in contributory and proactive creativity with the difference of having a closed and specified, or open and discoverable, problem, respectively. The particular type of a given situation can only be determined through examining more detailed circumstances. The matrix creates an awareness for viewing creativity as a continuum, in which initial factors of undertaking the creative activity are relevant.

Creativity research has become an intensively studied field, finding its way from psychology into other domains, such as HCI. The discussed theories provide an insight into different lenses through which to possibly view creativity. This list is certainly not complete, as several other theories exist. These, however, are left for the reader to look into for their own interest.

2.3.2 Kinaesthetic creativity

In the previous section, influential factors for the creativity of an individual in a psychological and socio-cultural context were discussed. When working with dancers, especially, another factor to consider is the moving body. The term *kinaesthetic creativity*, coined by Svanaes, now bridges the two aspects of creativity and movement. It is explained as "the

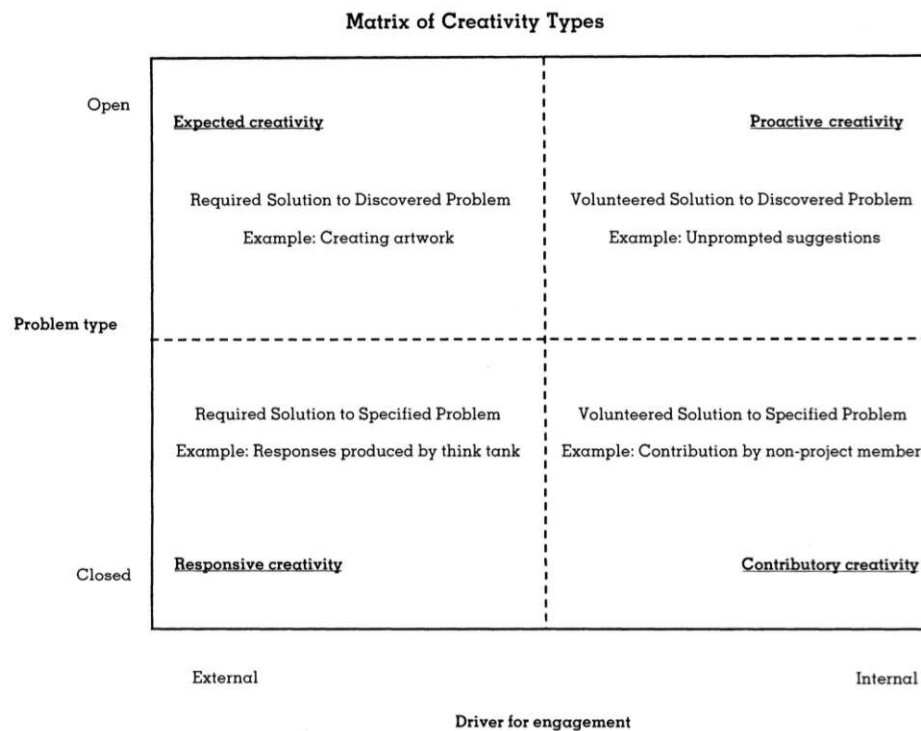


Figure 2.1: Unsworth’s matrix of creativity types, resulting from the domains ‘driver-type’ and ‘problem-type’ (screenshot taken from [74, p.291])

active use of the body through abstract movements to explore possible futures” [70, p.21]. This means that novel ideas in the sense of creativity discussed before, not only arise as the result of thought processes, but can occur out of bodily movement. Dancers are a critical source for researching kinaesthetic creativity. It not only is a form of creativity relevant to dancers, but dance exercises have been used before in the ideation stages of designing embodied interaction or to engage in somaesthetic design.

In the course of this thesis, this concept will be relevant in the context of two roles: the designer and the user. For the designer perspective, understanding the user’s bodily actions is a valuable resource in the process of designing technological interactions. Svanaes illustrates this in an example, in which design choices had not come up in a conventional ideation session, but through a bodily enactment of the situation. He also differentiates observation from a first-person perspective. He argues that “the feeling of using an interactive product is totally different from the feeling of observing someone else using it” [70, p.24]. This touches upon the second role, which is the user. More specifically related to the topic of this thesis, Hsueh et al. [37] aimed at understanding dancers’ kinaesthetic creativity. They expand the concept from something that is “used” for understanding the embodied human-artifact interaction to something that can be “designed for” [37, p.2]. The authors see the enactment of possible futures as estrangement,

meaning a disruption of usual behaviour. They thus investigate how they can break movement habits in order to support the user’s ideation process. What they found in their interactive visualization experiment is that “dancers’ kinaesthetic creativity is driven by their ability to shift between different interaction patterns” [37, p.11].

Zhou et al. assess the cultivation of dancers’ kinaesthetic creativity in interactions with technological or human partners as “difficult due to the delicate relationship formed in the abstract meaning-making process” [82, p.12] with the interaction partner. A question that arises for the present thesis is therefore how technology can not only act as a dance partner but represent a medium for dancers to engage in a meaning-making process with their own self.

2.4 Creativity Support Tools

The use of technology to optimize and enhance work tasks and productivity has been a traditional focus in computing and HCI. With an increased interdisciplinarity with social sciences and psychology, the topic of creativity grew in interest and became a part of HCI research in the 1990s [30]. Ben Shneiderman framed the problem space as increasing people’s creative engagement through the design of novel tools and interfaces. He described it as a historic shift of “moving from the comparatively safe territory of productivity support tools to the more risky frontier of creativity support tools” [63, p.22]. His differentiation of productivity from creativity support was the ability to measure the efficiency and error rate of processes by quantifiable metrics. In contrast, creativity support is associated with exploration and discovery, which he describes as important tasks in many disciplines, such as mathematics, engineering, software development, architecture, music, visual arts or journalism [63]. However, these unclear requirements were considered to make the evaluation of systems in these terms more difficult. Nevertheless, Shneiderman considered this research area a promising field, despite the vague and thus “risky” circumstances [64].

Until today, CSTs have been developed in multiple contexts and domains. A lack of conceptualization to it still remains, which led to more recent definitions other than the original idea of making “more people more creative more often” [63, p.20]. Cherry and Latulipe explain CSTs as software applications used to either create a digital artifact or as “part of the process of working toward the completion of an artifact” [18, p.21:2]. With this definition, one could argue that any software that allows the creation of *something* falls under this umbrella. The authors therefore point out that the task that is performed within a tool can be decisive whether the tool is considered a creativity or a productivity support tool. Writing a novel in a word processing software would be considered more in the realms of creativity support, while using the same software for preparing a mail merge supports primarily the productivity aspect. This does, however, not indicate a problematic overlap. Considering that an execution phase of a creative idea is part of the process, a tool can support various stages of the process at once [18]. Another definition of CSTs that incorporates this aspect is given by Frich et al.:

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“A Creativity Support Tool runs on one or more digital systems, encompasses one or more creativity-focused features, and is employed to positively influence users of varying expertise in one or more distinct phases of the creative process.” [29, p.10]

Although it points out relevant factors of a CST, the authors consider their definition too broad and suggest to find adequate definitions for different CST-subsets.

Concerning the design of CSTs, Shneiderman et al. formulated a set of design principles after a workshop conducted in 2005. These resulted from a focus on tools, which help people to “generate, modify, interact and play with, and/or share artifacts such as programs, diagrams, designs, texts, images, and music” [65, p.70]. The following is a direct quote of the listed principles:

1. Support exploration.
2. Low threshold, high ceiling, and wide walls.
3. Support many paths and many styles.
4. Support collaboration.
5. Support open interchange.
6. Make it as simple as possible - and maybe even simpler.
7. Choose black boxes carefully.
8. Invent things that you would want to use yourself.
9. Balance user suggestions with observation and participatory processes.
10. Iterate, iterate - then iterate again.
11. Design for designers.
12. Evaluate your tools.

The second principle refers to ensuring a good usability for novices and experts alike, as well as enable exploration. Regarding the last item in the list, the evaluation of CSTs is an aspect, which is complicated by the above mentioned lack of clarity in designing the tools. Cherry and Latulipe, however, developed the Creativity Support Index (CSI), which is a standardized questionnaire that has been used to evaluate how CSTs support their users in performing creative tasks [18]. It builds upon the NASA Task load index and has theoretical foundation in creativity research theories. Not only does it provide a general score regarding the level of creativity support, it also gives insights into users' perceived importance of six dimensions related to a creative task. Further details about the CSI will be discussed in chapter 3, since this framework was used in the evaluation of the prototype developed during this research project.

Methodology

3.1 Research Structure

This thesis aimed at understanding digital creativity support in the context of dance. It is characterised by a multi-method study design that involved literature and user research as well as the implementation and evaluation of a CST prototype for dancers. The description as *multi-method* is preferred over the sometimes interchangeably used *mixed-methods* and expresses the combination of multiple methods in this thesis. Although quantitative data was collected in this study, it predominantly served as a means to provide context or as an addition to qualitative data. I understand mixed-methods as a more balanced study design between qualitative and quantitative methods and therefore choose to describe the combination of the methods conducted in this thesis as multi-method (cf. [7]). In line with an exploratory approach to the investigation of the topic and the guidance by the research questions stated in section 1, intermediary findings steered subsequent steps in the process. As explained above, overall emphasis is placed predominantly on qualitative components.

“Typically, qualitative projects are much more open ended, having titles like ‘To investigate the phenomenon of ...’. They are also exploratory; that is, they are examining phenomena and fields where we may not be at all clear what we expect to find.” [31, p.10f]

This quote by Graham R. Gibbs demonstrates how this approach involves fewer initial constraints or specific expectations. Although this may entail some risks, an exploratory approach immensely supported the shift between several divergence and convergence phases in order to achieve a meaningful design based on the collected data. The methodology was thus influenced by concepts, such as Research through Design and Design Thinking, which are discussed in more detail in section 3.4.

3.1.1 Project Overview: Research, Design, Evaluation

Figure 3.1 provides an overview of the conducted methods, clustered into separate phases for a better understanding of the overall process. It involved the three areas, *research*, including both literature and user research, *design* and *evaluation*, which were accompanied by a continuous side strand of autoethnographic, first-person inquiry. This implies that the project provides insights into three different perspectives from autoethnographic, participatory as well as observational accounts, respectively. Although an abstracted representation with separate areas was chosen for reasons of comprehensibility, several overlaps between the phases were present in the research process. For example, the design and evaluation phases were intertwined, as it was an iterative development process with intermediary evaluation steps. The same applies to user research and design, as several initial code samples were tested as a response to certain research findings before deciding on the functionalities that eventually constituted the prototype's first version. More detailed justifications for the choice of methods along the way will be more plausible to the reader when corresponding findings of each previous phase are presented in chapter 4.

The thesis was expected to yield empirical as well as artifact contributions [81]. This goal was pursued under guidance of three research questions to be answered within this thesis:

1. *How can creative processes in dance be supported through digital tools?*
2. *How does a non-screen based digital artifact fit into a creative process in dance as a means of creative support?*
3. *How do the used digital tools affect dancers' creative processes and outcomes?*

As illustrated in Figure 3.1, the first question mainly focused on the phases of literature and user research. Findings thereof were used to narrow down the design space to a specific creative process within dance. The second research question subsequently concentrated on the design and evaluation phases of the CST prototype. Finally, answering the last question blends previous findings into an analysis of the interplay between dance and digital technology. This question guides the discussion of this thesis in chapter 7, exploring dancers' relationships with digital tools, added values and potential problems from both the dancer and the HCI perspective.

3.1.2 Positionality Statement

As will be explained in more detail in section 3.5 below, I would like to note at this point that as the author of this thesis I do not only represent a researcher-perspective, but also a dancer- and user-perspective. This is because I am myself a dancer and dance teacher, who could personally benefit from a creativity support tool in this area. The objective of the study was therefore not to subtract any personal experiences from the description of study results, but to actively reflect on first-person experiences. With respect to the embodied interaction and soma-based design concepts introduced in the previous chapter,

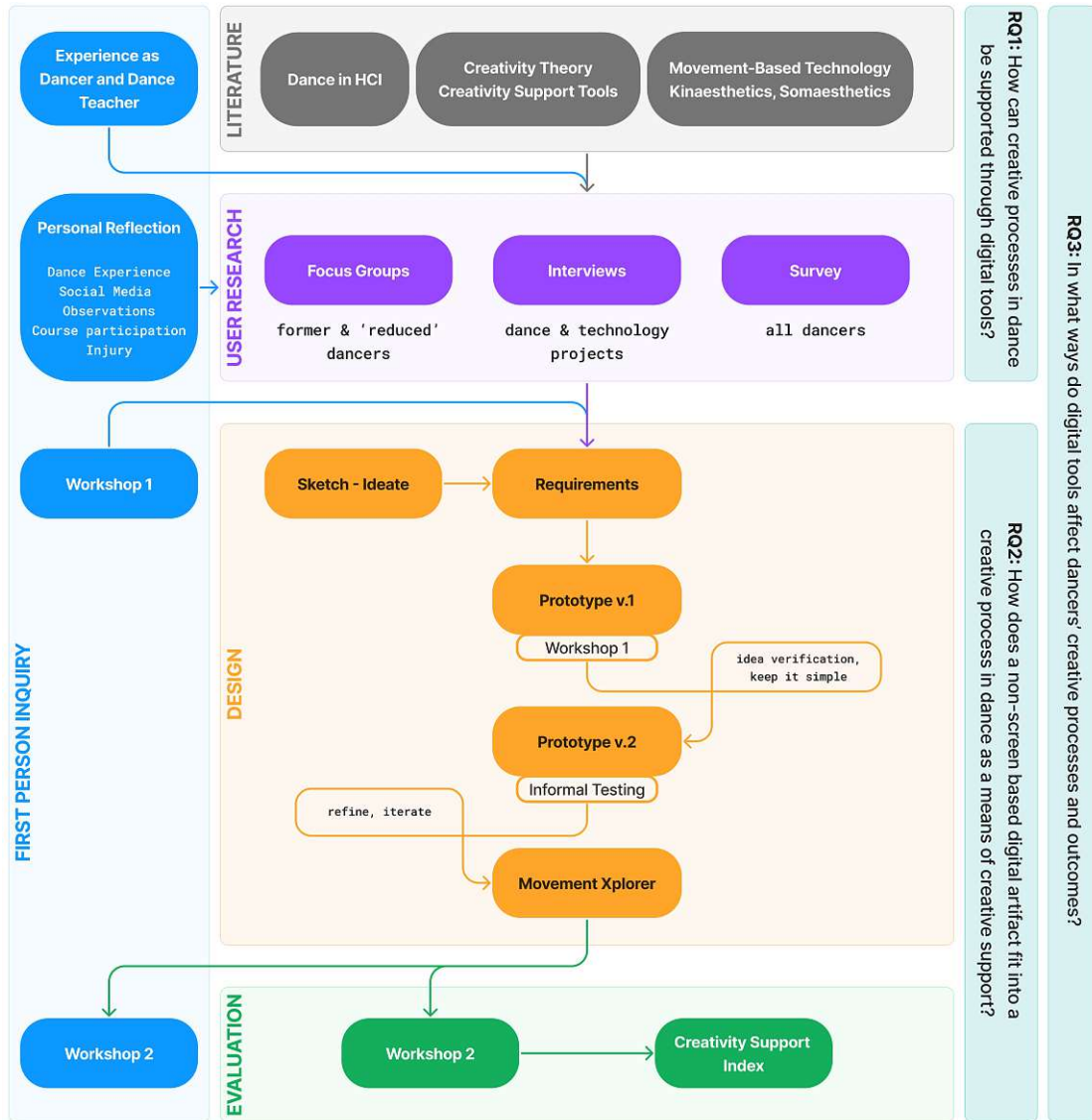


Figure 3.1: Methodological Overview: literature and user research, design and evaluation, accompanied by first person inquiry

this can be a valuable resource for offering insights into the felt dimension of creativity support in dance. Moreover, it relates to Shneiderman et al.'s eighth design principle about designing something one would like to use oneself [65].

This implies that a combination of observed and personally experienced descriptions is presented throughout this thesis. It will be pointed out for the reader, which perspective is being presented in each case. Given that my personal background in dance goes back further than the start of the present study, the first-person perspective also involved reflections on earlier experiences. At the same time, such glimpses into the past offer the opportunity to establish the context in which the project evolved.

3.2 Literature Research

The initial study of literature on the three main topics of dance in HCI, movement-based technology and creativity laid the groundwork for the choice of methods in the user research phase of the thesis.

Through the various examples of computational support in dance introduced in section 2.1, there was a curiosity to find out, whether the tools used by dance practitioners in Austrian dance studios were as diverse as those suggested by literature and how their effects on dancers can be compared. Moreover, due to the gaps stated at the end of said section, concerning the predominance of engagement with certain dance forms and roles of dancers in existing research, the user research phase of this thesis was intended to collect insights from a diverse dancer audience, who may not be represented as much in the body of literature.

The research on movement-based technology especially directed attention to an embodied and kinaesthetic engagement with the topic, encouraging reflections about my first-person perspective as a dancer. This aimed at understanding dance beyond a quantifiable moving body, providing qualitative insights into a more holistic understanding of circumstances and factors affecting dancers. Somatic aspects particularly influenced the design of the workshops and personal reflections.

Finally, knowledge about creativity theories and CSTs, especially the common focus on the output of creative processes, led me to question the understanding of a creative product in dance. In combination with user research findings, this shaped the design phase of this thesis.

3.3 User Research

The methods applied in the user research phase included a focus group, interviews and an online survey. They aimed at exploring the broad field of creativity in dance and examine from different angles in what context digital technologies are or could be used by dancers. The following subsections describe each method in more detail. With the exception of some survey questions, the data from all three methods was of qualitative nature and

analysed following a similar approach. To avoid repetition, the analysis process is thus explained separately in section 3.3.5 after detailing each of the methods applied.

3.3.1 Method 1: Focus Group

The start of the research project was motivated by identifying a problem to be solved within the dance scene with respect to supporting creativity. Considering Shneiderman’s idea of CSTs to enable more people to engage more in creative activities, I was curious about finding out why people quit or reduced their dancing activities. The initial phase of user research thus made use of the Focus Group method. This was chosen to get insights into former or “reduced” dancers’ opinions and experiences with dance, investigating their reasons to leave it behind. At the same time, it provided the opportunity for participants to reconnect with people who may share similar experiences.

The focus group was planned to take place via the online conferencing platform Zoom¹ and last between 30 and 60 minutes. Participants were recruited through my personal network as well as through advertising the session on my private Instagram profile as well as in dance-related Facebook groups. Interested people were asked for their availability via the scheduling platform Termino² and two final dates were set accordingly.

All scheduled participants electronically received an information sheet explaining the purpose of the session and data handling information. It was mentioned that the session would be recorded, given that all participants agree to this. The final five attending persons gave their informed consent verbally at the beginning of each Zoom session. They repeated their verbal consent for documentation reasons after starting the recording. Although this way of handling informed consent differs from common written signatures, this allowed a minimization of people’s organisational overhead. Otherwise, they would have had to digitally sign and send written consent forms after already having participated in the scheduling correspondence.

Both sessions were conducted in German. Participants were not reimbursed materially or financially. An email was sent afterwards, expressing gratitude for their help.

3.3.2 Method 2: Interviews

The second part of the exploratory user research concerned interviews with dancers who have put digital technology at the center of a piece of their work. These interviews were intended to shed light on motivations for combining dance with technology, the dancers’ felt experiences and how it impacted their dance, among others. Due to the expectation that the nature of potential projects could vary, the interviews were planned to follow a semi-structured approach with similar topics of interest, but specific questions adapted to fit each context. The final projects discussed with the four interviewees in this phase of the research will be presented in section 4.

¹<https://zoom.us/de>, last accessed on 20/11/2023.

²<https://www.termino.gv.at/meet/>, last accessed on 14/12/2023.

The interviewees were either known personally or contact was established via word of mouth. An initial inquiry was made via direct message to their Instagram profile with a short description of my interest in their work. They were asked for an email contact address for discussing further organisational things in case they were interested. The email correspondence covered setting a date, time and an online or in-person location for the interview as well as forwarding an information sheet and data handling details.

Each interview was planned to be recorded and interviewees were asked to give their informed consent either in the beginning of the interview session or by sending a signed consent sheet in advance. Because all interviewees were German native speakers, this was the chosen language for all interviews.

3.3.3 Method 3: Online Survey

As the previous two methods were addressed at a very specific target group of either dancers distancing themselves from the field or dancers involved in specific projects, the exploration phase was concluded with an online survey open for everyone involved in dance. It was implemented via the platform Soscisurvey³ and offered in German and English. The questionnaire was available for six weeks and distributed via Instagram, Facebook and direct messages to dance friends.

The resulting dataset was cleaned, removing all empty cases as well as test-cases created in the developing process. An exception were three cases created in the process of providing feedback to a first version of the questionnaire. These persons were not asked to fill out the revised version again, since only minor changes were made afterwards, based on their feedback. Any effects on statistical results will be pointed out in the respective findings section of the survey. Since quantitative data was predominantly used for participant demographics, keeping these three cases despite some inconsistencies to other cases was not considered problematic.

The survey contained 22 questions in total, which were categorized into four topic categories: *demographics*, *creativity*, *dance* and *digital technologies*. These categories aimed at collecting information regarding participants' dance background, factors that support or disturb their creativity, their perception of the dance scene they find themselves in and dancers' habits of integrating digital tools in their dance activities. The category labels were not revealed to participants, but questions of the same category were displayed consecutively. Most questions provided an open answer format, except multiple choice questions for demographics and 5-point Likert scale ratings about creativity in dance. The complete questionnaire can be found in Appendix A.

3.3.4 Data Collection and Processing

To summarize the data collected in the user research phase, Table 3.1 provides an overview of final participant numbers, data types and processing steps in preparation for analysis

³<https://www.soscisurvey.de>, last accessed on 26/11/2023.

Method	Total participants	Raw data type	Preparation for analysis
Focus Groups	5	audio recordings	manual transcripts, anonymisation, audio upload to dedoose
Interviews	4	audio recordings	manual transcripts, audio upload to dedoose
Survey	33	qualitative and quantitative responses	data cleaning, separation of qual. and quant. data files, qual. data upload to dedoose, quant. data preparation in SPSS

Table 3.1: Overview of data collection and processing during the user research phase of the thesis

for each of the conducted methods.

The audio files were uploaded into the CAQDAS (computer aided qualitative data analysis software) tool *dedoose*⁴. Because all verbal discussions included some form of Austrian dialect, partial transcripts were produced manually. They consisted of timestamps and topic labels of each section’s core content as well as selected full sentences containing information, which was considered relevant for this thesis. Focus group participants were anonymised, using labels P1-P5. This was not necessary for the interviewees, as the discussions evolved around their public projects and they gave consent to mentioning their names in the thesis. The transcription process was done in a first familiarization process with the data, which is explained in more detail in the subsequent section.

The survey data was cleaned of any empty and test-cases, which resulted in a final set of 33 valid response sets. The data was separated into a qualitative and quantitative dataset to be analysed in dedoose and IBM SPSS v.29.0.0.0, respectively.

3.3.5 Analysis of User Research Data

The analysis of the qualitative data collected through the mentioned methods followed an inductive approach, which can be compared to the family of Thematic Analysis (TA) defined by Braun and Clarke [12]. More specifically, it is most similar to what they call reflexive TA, which is characterised by embracing the subjectivity of the researcher and the influence of interpretation [13]. However, the analysis process within this research may not fully adhere to the reflexive TA concept. This is because of a differentiation between codes representing themes as “topic summaries” or as “interpretive stories”. As can be seen in the final code trees presented in the subsequent chapter, both kinds of codes exist as a result of my research, whereas reflexive TA should rather use the latter.

⁴<https://www.dedoose.com>, last accessed on 20/11/2023.

My results are therefore not as desired by this framework. However, topic summaries are relevant for answering some of the research questions of this thesis.

Because of this inconsistency, it is important to make the coding process transparent to the reader. Since the user research phase was followed by a design phase, the aim of this project was to “stay closer to the phenomenon” [75, p.122] and identify practical relevance in the data for the research and design context. The exact structure of the analysis procedure thus followed five steps suggested by Vears and Gillam [75], which they refer to as *Inductive Content Analysis*:

1. Read and familiarize
2. First round coding, focusing on the big-picture
3. Second round coding, creating sub-categories
4. Refine sub-categories and optional third round coding
5. Synthesis and interpretation

The familiarization phase involved listening to the audio recordings of the focus group and interview sessions twice. The coding process itself could be applied directly to the audio file in the analysis software *dedoose*. For the codes, English labels were used. The first round of codes resulted in big-picture labels about the discussed topics. The second round of coding followed an inductive approach aiming to “break open” the data (term from Corbin and Strauss, quoted by Vears and Gillam, cf. [75, p.121]). As such, for the second time listening, each audio was coded directly in *dedoose* with labels created inductively on the spot. The next step was to refine the codes in terms of merging similar ones and grouping them into reasonable meaning-units. During this process, selected excerpts were listened to another time to make sure they are rearranged into the correct category, preserving their meaning. Whenever applicable, new codes that had a similar shared meaning with preexisting codes from previous audio recordings were adapted to wear the same label. This is to make it easier for the reader to understand potential connections between different data units across methods. Furthermore, the order of content-categories was rearranged based on their relevance for each of the research questions. This analysis process resulted in content categories and sub-categories containing content codes. The final code tree was then used to interpret the data. Findings are presented in the subsequent chapter.

A similar coding process as described above was also applied to open answers from the online survey, except that overview categories were already given by the questions asked. The survey data was imported to *dedoose* and coded in the software. Due to the large quantity of resulting codes, a different presentation format was required instead of an overall code-tree. As a result, sub-codes are presented in separate tables, each representing a respective code-category.

Quantitative survey data, which included participant demographics and answers to Likert scale as well as multiple choice questions, were analyzed in IBM SPSS v.29.0.0.0. The analysis focused on descriptive statistics and also included the investigation of

relationships between participant answers and demographics, such as age, gender and practiced dance forms.

The findings of the analysis process of user research data are described in section 4. First trials of intermediary design ideas were already made during this phase. However, the final design choices and the selection of a creative process to design for were informed by the complete research outcomes. The following section discusses methodological considerations of the design and evaluation phases. Chapter 5 describes the design process in detail.

3.4 Design and Evaluation

The goal for these phases of the thesis project was the creation of an artifact, which could be probed with users in order to investigate the chosen application scenario in more detail. The approach was based on concepts, such as Research through Design (RtD) and Design Thinking. The latter was rather used for borrowing the procedural framework of divergence and convergence as well as the iterative “empathize, define, ideate, prototype, test” trajectory. The prototype itself was not supposed to be a final product that solves a specific problem, but rather the result of an ongoing inquiry into the intersection of creativity, technology and dance. This rather reflects the overall idea of Research through Design. However, this combination does not pose a contradiction, as described by Bardzell et al.:

“Research through design (RtD) is the practice of using design thinking, processes, and products as an inquiry methodology.” [9, p.96]

RtD originally goes back to Christopher Frayling [28], but was adopted by Zimmerman et al. for the field of HCI [83]. The authors interpret Frayling’s description of RtD as a concept “where design researchers focus on making the *right* thing; artifacts intended to transform the world from the current state to a preferred state” [83, p.497]. They understand it as the production of knowledge rather than a commercial product and highlight its value for overcoming the barrier between HCI research and practice [83].

In the context of this thesis, the preferred state would thus be a state in which dancers can embrace and are supported in their creativity. As described above, the artifact should not represent a commercial product, but a concept that could be translated into a practical tool. Given that many of the examples from literature described in the previous chapter do not exceed the prototype stage, establishing a certain proximity to the practice would be desirable.

3.4.1 Prototyping

Based on this approach, the artifact was created in an iterative prototyping process. It resulted in three stages of the prototype, which evolved based on intermediary evaluation

steps of each version. Since a restriction in terms of not aiming at a screen-based solution was made in the beginning, the first task was the choice of adequate hardware for a tangible or wearable artefact. The specific steps of the development process are explained in chapter 5.

3.4.2 Workshops & Evaluation

In HCI, and especially with dance or movement practices, probing artifacts with people is an integral part in the development and evaluation process of a research prototype or product. Two workshops with dancers accompanied the design and evaluation process of this research project.

For both workshops, a general purpose room in Vienna was used as location for carrying out the workshops. It was thankfully provided by my thesis supervisor for free, while dance studios in Vienna required rental payment and were not available as flexible due to their regular class schedules. Participants were recruited via email, Instagram and direct messages to people of my personal network. They digitally received an information sheet in advance. Upon the start of the workshop session, they were asked to fill in a consent and data handling form in person. The second workshop additionally included filling in short demographic form about their dance background.

Data collected in the workshops included photos of written artifacts, such as mind maps and sticky notes, videos of the dancers performing exercises and an audio recording of the discussion. The videos in the first workshop were taken with my personal smartphone. For the second workshop, a GitUp⁵ Git2 action camera mounted on a tripod was chosen instead. Participants were not reimbursed financially. Some sweets were provided during the concluding discussion and they received a thank you message after the workshop, expressing gratitude for their participation. Moreover, they were offered to keep the written notes they created in the course of workshop exercises.

The first workshop was conducted at the initial stage of the design process and served as a source for understanding the circumstances and application area for the artifact. It contained one first functionality, which was however used as a minor addition to one of the dance exercises only. The second workshop took place at the end of the development process and provided an evaluation possibility of the tool. Aside from discussing the tool and exercises in the end of the session, participants were asked to fill out an online survey on the Soscisurvey platform. It contained the Creativity Support Index (CSI) questionnaire developed by Cherry and Latulipe [18] as well as three open-answer questions as additional feedback to the workshop session.

The CSI questionnaire data was statistically analyzed using provided Python code⁶ for calculating the index. Qualitative data from participants' comments in the workshop were compared to the CSI results as well as the videos taken in the session. Additionally, the

⁵<https://www.gitup.com> last accessed on 12/12/2023.

⁶<https://github.com/axambo/hci-python-utils/tree/master>, last accessed on 12/12/2023.

prototype probed in the second workshop collected accelerometer data from participants' movements, which will be explained in more detail in chapter 5. This data was saved during the session and plotted afterwards, using custom Python code, and served as additional comparison resource. Beyond keeping their created notes as mentioned above, participants of the second workshop were additionally sent photos of other participants' notes, following the group's request, as well as given access to a cloud folder containing the data plots. Some exemplary plots can be found in Appendix C.

3.5 Autoethnography

As explained in the beginning of this chapter, an inquiry into a first-person perspective accompanied the whole research project. Within this thesis, autoethnography is not applied as a stand alone method, but rather an approach to paying attention to experiences, feelings and thoughts of my own person within the topic of study. Although it is only considered a component in this thesis and can therefore not be as thorough, autoethnography as a method is a systematic and analytical approach to harnessing personal experience for establishing an understanding of cultural context. It “treats research as a political, socially-just and socially-conscious act” [24, p.1].

As the name itself suggests, it combines *autobiography* and *ethnography* and is considered a process of research as well as a product of writing [24]. So-called *epiphanies* in autobiographical writing are significant moments in the life of an individual, that are remembered because of their incisive character. Ethnography, as the counterpart, is the study of a culture with the aim of “helping *insiders* (cultural members) and *outsiders* (cultural strangers) better understand the culture” [24, p.2] in terms of practices and values. Taken together, autoethnography leverages a personal narrative of epiphanies for explaining experiences within a studied culture. This is possible if the individual is part of the culture, either permanent or as a guest. The personal narrative is supported by evidence, such as field notes, images or interviews.

Especially with respect to the concepts of kinaesthetic creativity, embodied interaction and somaesthetics, a first-person perspective is a valuable resource. In the context of this thesis, not only is the bodily experience a factor of interest, but also the meaning and influence of technology on dancers and their creative practice. Being a dancer and dance teacher myself and combining my perspective with these points of interest, it was important to me to include self-observations and my own experiences within my personal dance environment in Austria. These can offer more detailed and nuanced insights than reports from a second-person perspective and can deepen the reader's understandings of phenomena, design choices and context of research findings. It provides the possibility to use the own person as a resource for unravelling complex circumstances.

My first-person inquiry was conducted in the context of dance class participation, dance teaching, meet-ups with other dancers, engagement with online dance content, listening to podcast episodes and autoethnographic versions of the workshops explained in the

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previous section. My personal dance experience spans almost 20 years of non-professional⁷ practice, with a recent focus on Hip Hop and House Dance. I have also gained knowledge in various other street and club dance forms, as well as ballet, jazz, contemporary, and commercial dance in the course of a pedagogical dance education programme and workshop experiences. I taught dance at a local studio for approximately six years until an injury occurred a few months after starting this thesis.

As the above mentioned evidence for the autoethnographic accounts in this thesis, I collected audio recordings and digital written notes of self-reflections on my smartphone that resulted from any of the engagements listed above. I also kept a research diary during my thesis studies and frequently used this for taking hand-written notes. Whenever I came across something interesting in the digital space, which was mainly concentrated on Instagram content, I saved it on my private Instagram profile or took a screenshot and saved it in a dedicated photo album on my smartphone. I did not record any profile names of private accounts. All digital data was finally transferred to my computer and separated into different files by type of data and content topic.

⁷I am not a professional choreographer or performer, which is why I describe my practice as non-professional. I have undergone a two-year education programme and have gained professional teaching experience.

Research

This chapter presents the findings from the user research phase of this study. As previously explained, the majority of the data collected was of qualitative nature and was analysed applying a form of thematic analysis. The coding process yielded sets of topics, which are presented separately per method. Each of the following sections firstly outlines the participant demographics and the overall circumstances of the data collection. This is followed by an explanation of the final codes applied to each data set. A summary of the findings and an autoethnographic reflection are provided at the end of this chapter, before moving to the design phase of the thesis project.

4.1 Focus Group

4.1.1 Organisation and Demographics

The target group for this phase of the research comprised dancers who quit or reduced their dancing activities at some point in their dance journey. Subject of interest for this first instance of involving participants was to find out whether support tools could have assisted them to continue or restart dancing. Due to contradictory availability of interested participants, two separate online focus groups were scheduled at different dates. Because of last-minute cancellations, one session eventually resulted in a one-on-one interview. The second session was conducted with four participants, one of which only joined in the second half of the meeting. Both sessions took place online via Zoom and lasted approximately 30 and 60 minutes, respectively. Due to reasons of anonymity, the total of five participants is further labelled as P1 to P5.

Among the participants were four women and one man (P2). Two participants (P3 and P4) had a background in teaching dance, one of whom was still actively teaching, but in a reduced amount compared to earlier times. Participants P1, P2 and P5 used to dance on a regular basis including the participation in competitions or performance of shows. P5

Content-category	Sub-categories	Relevance
Circumstances around distancing from dance	external factors	RQ2
	internal factors	
	community and motivation	
	alternative passion	
Associations with creativity	creating choreography	RQ1
	surprise effects	
	musicality	
Interplay of dance and technology	video material	RQ3
	support ideas	
	reflections	

Table 4.1: Categories resulting from three coding rounds of focus group recordings and code relevance for research questions

has not been actively dancing for about ten years, which was the longest period present. Three participants had quit or reduced their dancing activities only recently prior to the study. The dance styles they engaged in included contemporary and commercial dance (P3, P4), Urban dance forms (P2, P3, P4, P5) as well as ballroom dances (P1). Participants P1, P3 and P4 used to dance primarily in Vienna, P2 and P5 were based in Linz, Upper Austria.

4.1.2 Findings

In the analysis of the focus group data three main content-categories were identified, which are listed together with sub-categories in table 4.1. The first topic of interest was related to why the discussion was organised and concerned the circumstances that led participants to stop their dance activities. The intention was to find out whether their reasons reveal gaps for potential (technological) interventions helping to avoid similar problems in the future. This could inform the development of a novel tool for the design phase of this study. The second content-category was related to creativity in dance, which revealed insights into what kinds of dance tasks a novel CST could support. As a third code, participants' relationships to digital tools in dance were clustered. It contains insights into whether technology played a role in taking the decision to quit or helped them cope with any issues. Moreover, their ideas for potential application of technology in dance were discussed. Each content-category is explained in more detail in the following sections.

Circumstances around distancing from dance

In this regard, four sub-categories were identified: external factors, internal factors, community and motivation, and alternative passion. *External factors*, were reported by P1, P4 and P5. They mentioned temporal and regional reasons for quitting dance, after

moving to another city (P1 and P5) and transitioning into a new phase of life in the form of starting a family (P1), a new employment (P4) or enrolling at university (P5). For P1, having children means that she is unable to attend evening classes, but in many regions there is no alternative during the day. This was brought up as a more structural issue, as was the financial factor of taking regular dance classes for her. Another structural issue was brought up by P5. She mentioned that she struggled to find local dance classes, which were suitable and flexible for her schedule.

The remaining two participants shared that their reasons for leaving dance were more connected to the state of their body or mind than to structural factors, and are therefore labelled as *internal factors*. P3 stated that dancing was not good for her health. She had mostly participated in choreography classes, where warming up was not taken seriously and much time was spent “standing around” while learning choreography. She reported on back pain, which eventually led her to lose interest in dancing. Aside from physical health, her mental well-being was affected by a competitive feeling resulting from comparing herself to others. While competition was not a big concern for P2, the state of mind was still an issue for him, as he found himself stagnating despite active and frequent training.

“It was on a personal level, where something should have been changed, but I have to say, I would not even know what.” (P2)

The third sub-category, *community and motivation*, was addressed by four of the five participants. Especially in the context of ballroom dances, the necessity of a dance partner is given. P1 highlighted the lack of dance partner exchange platforms for connecting individual dancers to form pairs. She was used to consulting these platforms during her time in Vienna, but could not find anything comparable for her new place of residence. But also in other forms of dance, the social aspect plays a role in factors of motivation and growth. For P3, a lack of contact to other dancers would make dance entirely absent for her.

“I hardly dance anymore, except when I meet with friends.” (P3)

For P2, this lack of gathering with his usual dance community resulted from the absence of goals to work towards. He identified that events, such as shows or competitions, were needed as a motivator to learn new skills and practice dance. Especially after the lockdown, he noticed that it was more difficult to motivate his crew-mates to come to practice. P1 compared this to more general situations of procrastinating, which she explains as a natural trait of humans. P5 also remembered positively her past experience with the dance crew, the community aspect and growing together while working on creating a dance piece.

P3 and P4 responded with a contrasting position to a goal-oriented learning approach, expressing that they were rather “dancing for themselves” lately instead of working towards certain events or teaching classes.

“I started taking classes for myself, simply learning choreography and being allowed to forget it immediately afterwards.” (P3)

“I dance for myself at the moment, I participate in several classes.” (P4)

What should be noted here for the reader is that P3 and P4 were talking about taking classes in an open class system. Such a system allows anybody to participate in single dance classes on a drop-in basis, without necessarily having to be a member of a particular dance studio. This kind of model is available in Vienna, where P3 and P4 were based, and where there is a large base of customers with enough demand. In other regions, however, it is more common to have closed groups where dancers commit to coming to practice on a regular basis. This was the fact for P5, for example, who reported on limited flexibility of available programs in her area in Upper Austria.

Participants P2, P3 and P5 each found an *alternative passion* to engage with instead of dancing, which include Yoga, martial arts and horseback riding. While P3 could not imagine taking up dance again in the future, P2 and P5 shifted their attention to their new passion, but reported to be open to restart or intensify their dancing activities again at some point.

Associations with creativity

Participants were asked what creativity in dance means to them. An underlying consensus between several approaches to answer this question was the deviation from a standard. P3 mentioned the creation of choreography, which should be “not like everyone else does it, but something rather extraordinary.” She added that this was something she struggled with when she had to prepare choreography for her students. P2 positioned himself at the “passive end” with regard to creativity, as he had never created or taught choreography before. He switched to the audience perspective instead and explained creativity in terms of “surprise effects or storytelling” in a performance. A third element was brought up by P1, who associated creativity with spontaneity and individual interpretation of the music.

“If you know all building blocks [of a dance], you can press shuffle and arbitrarily line them up. [...] I have music and I can move to it and put it in practice.” (P1)

These different explanations of deviating from a standard were also referred to as avoiding the “copy-paste-effect”. P2 interpreted this effect as a result of the vast amount of available online dance videos, which also played a role in the last identified content-category of the focus group sessions. It explains the influence of digital technologies in participants’ dance-related activities.

Interplay of dance and technology

Building on the previous topic of creativity, the first aspect, which is naturally connected to digital technologies in dance, is music. P1 shared that she created her own playlists on her iPod, which are categorised by rhythm to fit each type of dance she knows. While music clearly did not need to be discussed further in terms of its importance for dance, the use of video material was addressed in different ways. P3 already mentioned competitive thinking as a reason to distance herself from dance. Not only did this feeling come from watching herself and other dancers through the mirror in class, but she pointed out that it was also induced by the way videos and social media transformed dance classes.

“In the past, one filmed choreography for fun and did not take videos for Instagram.” (P3)

Conversely, P1 mentioned video material as a resource for learning or practicing steps outside the dance class. The shift to an increased use of digital technologies induced by the past COVID-19 pandemic boosted the possibilities to learn on your own, independent of specific time or location. Pre-recorded tutorials were offered as well as live online dance classes.

“After the lockdowns the online-offers increased. One can learn a lot and well online.” (P2)

Although these opportunities opened up, participants stated that they made very little use of them. For P5 the access to this online content was still not given, as none of those opportunities were visible to her, neither by word of mouth nor through the digital space. From a teacher perspective, P3 described her experience with online classes as “a catastrophe” and only participated in one online class herself, which she remembers being difficult. P1 complemented the student-perspective and pointed out the lack of space she had in her living room for a proper participation. Beyond that, P1 speculated about the potential of VR as an alternative for dance tutorials.

“You could compare it with playing the piano. You can see which key you have to press. I would need this for dancing. Which step do I have to take where, how much rotation, [...] Maybe combine it with a camera or Kinect and the program checks whether I am performing it correctly.” (P1)

The idea of a correctional system teaching dance foundations was also suggested by P4. She appreciated the availability of YouTube tutorials, but could imagine this having more potential. Other ideas with respect to the combination of dance and technology that resulted from a short brainstorming included smartwatch apps for tracking dance, motion capture, stage visualisations for dance performance, platforms or apps for local course offers, and support for dance teachers, such as formation visualisation and methodical

exercises. Participants, however, not only listed spontaneous ideas but also reflected on some of them, which resulted in two issues. The first one was that technology cannot and should not replace dance educators. The second one ties in with the social aspect described above, favouring technology for bringing people together instead of isolating them.

“[...] something connecting, meaning that we do this together and not that everyone stands in front of their TV or computer [...]” (P1)

4.1.3 Researcher reflection

The first phases of reading literature and listening to focus group participants in the position of a researcher triggered an important question in my dancer-self: *Who do we dance for?* The participants touched upon some potential answers: for an audience, our students or ourselves. As a dance teacher, my answer would be my students. As a dancer, it would occasionally be an audience, but my true answer would always be *myself*. I do it for fun, for the great experience of this passion of mine. Reflecting about participants' comments in the focus group sessions, however, I had to admit to myself that I haven't thought that way for the bigger part of my dance journey. Admittedly, I haven't thought about this question at all.

One key moment, in which this thought was very prominent, was a moment involving technology. It was also a moment that acted as an impetus for pursuing this research topic in the first place. As a final project for the graduation of my dance education, I created an augmented stage performance with background visualizations. I had seen some similar performances before and as part of the audience, I had always been fascinated and curious about trying it myself. *My* audience felt very similar at that time. However, as a dancer I was asking myself, why did I not? While I was proud that I managed to put a piece like this on stage in time, I was disappointed of the fact that dance felt secondary in this moment. Although I harnessed my maximum possible creative potential, I felt like I constrained myself in terms of dance. On top of that, people complimented me for the technical work of the performance. But thinking back, I do not remember any comments about the dance itself. Had I become another “copy-paste” product of the other performances I had seen before? Had I stagnated, similar to what P2 brought up? Had I danced only for the audience, not for myself?

Back in the position of a researcher within the field of HCI, I therefore questioned how the design and application of technology in dance influences the dancer. More than that, I was wondering how it influences the status of dance as a whole. Does dance become secondary? If yes, is this acceptable, because its combination with technology represents a new domain? Or does it also change the dance as I was used to it?

What I witnessed myself as a dance teacher is that TikTok dances have already made it to dance competition stages. The entertainment factor was more important in this case than the dancers' technical skills. As stated by a participant in the focus group,

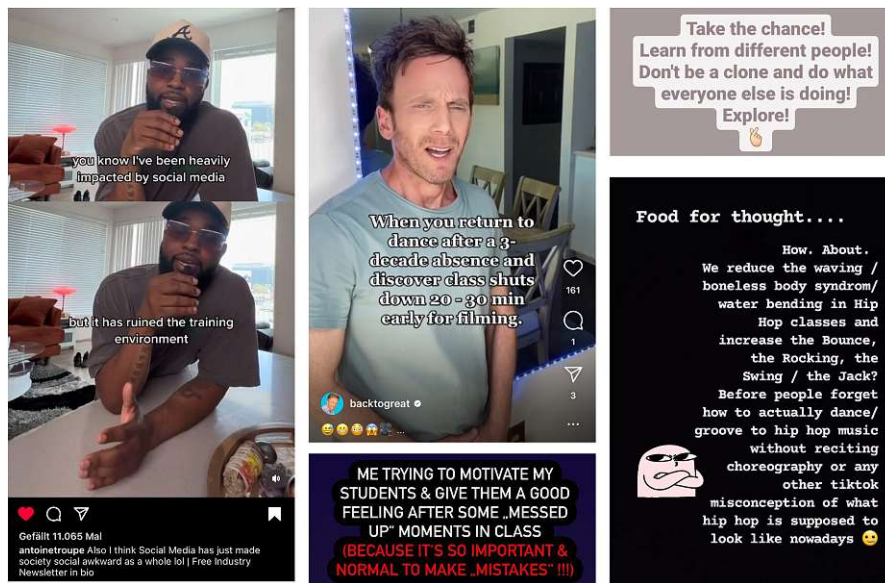


Figure 4.1: Five examples of Instagram content reflecting transitions in the dance training environment

the training environment has also undergone some changes. The constant presence of a virtual stage through the smartphone camera emphasizes performance. It reduces space for feeling comfortable to make mistakes and focus on the fundamentals of a dance form. Collections of video material may encourage imitation and eventually turn dancers into “clones”, as suggested in the Instagram excerpt shown on the top right in Figure 4.1. The figure also shows several other screenshots of example content I came across, reflecting the said transitions in dance practice. These include the emphasis on in-class performance (top center image), students’ struggles in handling mistakes (bottom center image) and a potential loss of foundational movement due to performative trends being reproduced (bottom right image). The resulting questions I asked myself therefore were: *Do we still dance for ourselves? And how could technology mediate that?*

4.1.4 Summary of Focus Group Findings

The discussion with dancers, who reduced or quit their dance practice revealed multiple levels of support opportunities in dance. It was established that at least some of the participants were open to reengage in dance. However, they faced different barriers that they would need to overcome. These include structural, internal and social aspects, which indicates that a technology-centered research into dance can only cover parts of a larger system of issues within dance. While technological solutions could tackle some of those, a designated Creativity Support Tool shall be different to administrative support. It may be suitable to address the mentioned factors of motivation, stagnation, musicality and the social factor of dance.

4.2 Interviews

4.2.1 Organisation and Demographics

Following the previous personal reflection, interviews with dancers who chose to engage with technology in a project of theirs were supposed to provide insights into how the respective technology impacted their dance. Three interviews were conducted, comprising a podcast project and two interactive performances using wearable sensor bands and VR, respectively. As mentioned in the previous chapter, participants gave their consent to be named in the thesis. The first interview was an in-person meeting with the two founders of the Austrian dance podcast *Grenzenlos - dein Tanzpodcast*¹. It lasted for about an hour and was conducted at one interviewee's home, which is also the location where all their podcast episodes are recorded. Without an initial intention for the conversation to appear in the podcast, the founders decided to release it as an episode afterwards.

The second interview took place via Zoom and lasted approximately 40 minutes. It was conducted with Paz Catrina Jimenez, in the dance community also known as Cat, who is a Vienna based dancer, performer and curator. She was approached because of her previous performance *un-ctrl* at Ars Electronica² in Linz, in which she cooperated with a visual and a music artist in an interactive performance using the SOMI-1³ wearable sensor-bands from the company Instruments of Things.

Finally, the third interview was conducted with the dancer Hannah Maria Wimmer and was concerned with a series of VR performances she did together with the befriended visual artist, Maximilian Prag. It also took place via Zoom and lasted approximately 30 minutes.

4.2.2 Findings

Similar to the idea of conducting the focus group, the first topic during the interviews concerned the reason for initiating them. In this case, it was about understanding why the interviewees started their projects and chose a digital component. The intention was to identify motifs for combining the dance and technology and how the work impacted their dance. These and further content-categories established in the analysis process are listed in Table 4.2.

Motivation for the project

The analysis process resulted in two sub-categories describing the motivation for starting the discussed projects: *using technology* and *collaboration*. Each project eventually represents both themes, but with an initial focus on one or the other aspect. In two of the three discussed projects, technology took on the role of initiator for its realization. The

¹<https://grenzenlos.podbean.com>, last accessed on 14/12/2023.

²<https://ars.electronica.art/planetb/de/un-ctrl/>, last accessed on 14/12/2023.

³<https://instrumentsofthings.com/products/somi-1>, last accessed on 14/12/2023.

Content-category	Sub-categories	Relevance
Motivation for the project	using technology	RQ2, RQ3
	collaboration	
Experience combining dance and technology	provided opportunities for the dancer	RQ3
	constrain vs. expand	
	felt dimension of movement and mindset	
	everyday use of tools for dance	
Associations with creativity	individuality	RQ1
	diversity	
	connections in life	

Table 4.2: Categories resulting from three coding rounds of interview recordings and code relevance for the research questions

performance *un-ctrl* was the result of a cooperation between Ableton and Instruments of Things for the Ars Electronica festival 2022 in Linz. These institutions assembled a trio comprising a visual artist, a musician and a dancer to implement the SOMI-1 wearable sensor bands in a performance. In case of the podcast project, each of the founders had been curious about creating a podcast, independently from the other. After finding out this mutual interest and their shared passion for dance, they started working together to put their idea in practice. These two projects therefore shifted from the focus on a specific piece of technology to collaborating with someone in the form of a project. Cat explained the collaboration as the artists wanting to be a “band”, each providing a base for the others to build upon. This opportunity to mutually influence and support the other served as starting point for the third project between a dancer and a visual artist. Their curiosity for the other person’s work was the driving force behind a beginning collaboration, in which technology was not the primary initiator, but became the base on which their collaboration evolved.

Experience combining dance and technology

Technology already played a role in the origins of the projects. In order to understand what influence it had on the interviewees, they shared insights into their experiences working with it. Due to the varying nature of the projects, the descriptions of them differ. The following themes therefore relate to the application of technology at various levels. Nevertheless, they all describe effects of projects enabled by some form of technological system or digital media.

The first common theme concerned technology providing opportunities to the dancers. In case of *un-ctrl* and the VR performance, it was a research and movement exploration opportunity. Hannah reported on using the virtual space for experiencing something that is not possible in the real world.

“I can suddenly alter my body in different directions. In our last version of

the performance I danced a duet with myself. We collected 3D data from myself and captured motion in advance. At the same time, in the real world, we also performed motion capture and with the VR glasses I stood in front of myself and we danced a duet.” (H)

In terms of research, she not only described the merely personal domain, but also the relation to societal topics. For instance, in the initial version of the performance they explored the virtual space for breaking binary structures and discrimination issues. This novel space provided room for a multi-disciplinary debate bodily identities. The research conducted by Cat aimed to investigate the potential use of the new input provided by the project in informing the creative process of generating and integrating new material. An interesting facet to her was the decision-making process of choosing from a vast amount of possibilities arising from mutual influence of the components involved.

“The object, the dancing body and the person with the musical input - the possibilities are multiplied. What decisions do you make at that moment?” (C)

Both examples demonstrate an openness to new knowledge regarding ways to rethink and discover movement and personal reflection. The podcast project focuses especially on the latter and provides the opportunity for the founders as well as the listeners to dive deeper into dance-related topics. Using digital media for spreading information, connecting the community and opening up the diverse facets of dance to the public were reported as intentions behind the podcast. Communication was seen as a short-coming in the Austrian dance scene, so they want to offer their platform to anyone who wants to discuss, share knowledge or raise awareness about problems present in the dance scene. One of the founders mentioned feeling separated before moving to Vienna, due to regional limitations in offers. Since the start of the podcast project, she feels more connected.

“I find it very cute that you can talk to people, who you do not normally get to talk to.” (L)

The dancers’ reflections also painted a picture of a dual nature of working with technology. While it broadened their horizons, it also raised borders. Cat perceived working with the technical set-up as an organisational challenge. Because each of the three collaborating components was being developed from scratch and the location of the performance, the Ars Electronica Deep Space, could not be simulated for rehearsals, the final setup only existed at the time of the performance. Rehearsals with diverse beta-versions had their limits, because at some point coding a new program was necessary. Moreover, the three artists did not live in the same city while creating the piece, which was an additional hurdle they had to cope with. Aside from organizational issues, certain changes in the soundscape triggered by movement sensing were only possible within a fixed time frame of the performance. Cat explained that in one part of the piece the sensor-threshold was

very low, so that she was able to produce sounds from so-called pops, which are sudden muscle contractions. Another part of the piece implementing a higher threshold was explained as follows:

“[The music artist], for example, programmed self-generating beats. This means that every time I exceeded the threshold, and I did this with a slap on my hand, and the threshold had to be very high in order not to activate it accidentally ... I had a very blue hand. And then the beats generated themselves anew.”(C)

While the development phase allowed for exploring all possibilities, it eventually had to be limited and defined in order not to trigger unwanted effects from random movement. Similarly, Hannah described their VR set-up as “unpredictable” at times, due to connection-aspects and still developing expertise in their choice of software. Another aspect in this project was the dual nature of the virtual space, broadening the dancers’ possibilities, views and experience of the own body to a completely different “world”, while at the same time limiting her awareness of the physical space and her real self. She revealed a trick she used in order to regain focus of the real world, which was a double tap to the side of the head mounted display (HMD) that let her see the real space through a transparent version of the virtual image. Beyond the project-specific pieces of technology, another aspect that came up in the interviews with both Hannah and the podcast founders was the personal management of ideas and notes. Personal devices, such as smartphones and notebooks provide various possibilities to record and store information conveniently. However, due to the many possibilities, notes and videos are often spread over various devices, folders and apps, and eventually the information “gets lost”.

Another factor of interest with respect to dancers’ experiences with technology was the felt dimension of working with a digital component. All interviewees mentioned their projects having intimate and personal aspects, which were of importance to them. In the podcast, for example, people share their personal stories and thoughts. The founders explained that it was a good idea to start such discussions in a podcast format, because “you don’t have to show your face” and therefore mitigate initial uncertainties. Recently, however, they introduced a YouTube channel with video-recorded versions of their interviews, because they received the feedback that the audience prefers to see the speakers in order to be able to establish emotional connections. The audience getting insights into personal perspectives was also present for Hannah’s VR performance. The virtual world was presented to the audience on screen, switching between a portrayal of the virtual dancer in the virtual space and the dancers’ personal perspective of the image on her HMD. Although she debated identity questions about her bodies’ boundaries with herself, she felt protected from outside eyes due to the fact that her personal view of the virtual space was repeatedly hidden from the audience.

“For the audience, it eventually resulted in a stage setting, because they cannot enter the space in which I am at the moment. It thus became a safe - I don’t want to say safe space - but a safer space for me, because I was free in many decisions which were not visible to the audience, because it happened in *my* virtual world.” (H)

Contrasting this example, in which the dancer was immersed in the technology and had a certain emotional distance to the audience, Cat reported on an intimate moment she had *with* the audience. She mentioned a short verbal exchange at one point of the performance, which to her was more the result of dramaturgical than technological work. Nevertheless, she explained that moments like this and moments of silence were very important for her to “arrive and understand: here am I, these are the objects. [...] The silent moments have the intention to feel ‘Where are we? What is happening here?’” (C). The sensors, which she referred to as “objects” during the interview, did not have a high significance for her felt experience, directly. She explained, however, that wearing them caused a certain shift in mindset as well as movement execution. She had to rethink how specific moves had to be performed in order to achieve meaningful sensor readings. Finding out what the consequences of her actions were was a crucial process during rehearsals. She called it *calibration of the inner perception* and used the beginning of the performance to remind herself of it.

“It was not such a great hocus-pocus for me. [...] My points of rotation in my body had to change in my head. Everything else had to follow this. For example, if you turn the hand, you normally lead with the thumb or the fingers, but never with the wrist.” (C)

An influence on movement was also noticeable to Hannah, who described that the immersion in the virtual space removed certain habitual movement she executes in usual improvisation settings. The possibility to morph her virtual body challenged a different way of moving that was not imaginable in the real world. Not only did her movement during the immersion change. She reported that she could retain this feeling and resort to it in future improvisation settings.

“It helped me a lot for my general improvisation practice. I can always go back to it. I have this toolbox, I know how it ‘feels’ when the body changes like this and comes to various limits that do not exist in the real world. But it feels so real when I am in there. Even if it does not really happen, but you are so in your head. [...] It helps a lot, especially in situations where you fall back to old patterns in which you always move.”

Because of the different nature of the podcast project compared to the two performances, the influence of this technologically mediated project takes place with respect to a shift in mindset rather than an immediate impact on movement, in this case. The additional

movement component might follow afterwards, which will be discussed in chapter 7, but the direct effect concerns the mind. Pressure, perfectionism and wanting to adapt to trends and norms were factors brought up by Pia and Lisa, which are present in their and many other dancers' lives. Lisa pointed out that the Commercial Dance scene is particularly different to other dance scenes in this regard.

“Commercial is a different topic, because in Commercial we have that image that we want to adapt to, because you want to land jobs. You have certain styles and skills that you are required to know. [...] Of course, everyone wants to be an individual, but we also want to adapt to norms that are trendy at the moment, like TikTok dances. I think it is something natural [...]” (L)

The exchange they have in the podcast interviews helps them mitigate these feelings of pressure and insecurity by providing transparency about professional dancers' career paths and shedding light on imperfect moments that are not visible on their social media profiles.

Beyond their project-specific experiences, the interviewees were also asked about what role technology played in their everyday activities related to dance. Their descriptions clearly indicate a difference in focus between professional dancers working in an artistic context and aspiring professional dancers and dance teachers who focus on the commercial or pedagogical aspects of dance. For Cat and Hannah, the main support they gain out of modern digital technologies is concerned with conducting online research and composing project proposals for funding applications. Hannah even described herself being “dependent” on technology for being able to start a new project at all. She also talked about filming herself a lot, but wanting to start using her new Rokoko⁴ motion capture suit for documenting her movement.

“Of course, we have various notation frameworks, but nobody understands them. I learned Labanotation and I hate it. I would never use it when I create choreography. Now I have the possibility to put on my motion capture suit, perform some moves, save it on my computer and piece it together later. Choreography-wise it offers so many new possibilities for documentation purposes.” (H)

Moreover, Cat was speculating about the level of support an application that manages project-specific parameters could provide. She explained that for her, a “set-up” phase in the beginning of a project is an important process to grasp what resources she is working with and such an application could perhaps automatize this for her. She added, however, “even if I got a tool like that, then I would probably not do with it what it was designed for”. Moreover, she debated whether it would provide more time for her concentrating on doing the creative part or remove a crucial step in delving into the

⁴<https://www.rokoko.com>, last accessed on 17/12/23.

creative process. As this set-up is the starting point of the creative process, outsourcing this initial understanding of project circumstances to a piece of technology could perhaps hide relevant information for the artist to work with. Hannah also brought up several dance performances she attended via Zoom, especially during the pandemic. Dance formation apps were mentioned as a short side-note, as she remembered that a friend in the USA used these a lot. In the interview with Lisa and Pia, in contrast, dancers' social media usage was a more prominent topic. Aside from earlier mentioned feelings of pressure and competition, they also highlighted that it can connect people, as they got to know each other via Instagram. From a pedagogical perspective, they also discussed the usage of digital devices in dance class. For their note-taking in class, they pointed out that they keep using pen and paper instead of digital notes.

“I think it looks nicer, when I’m standing in class while teaching, if I have a piece of paper in my hand than if I used my laptop. That’s my personal opinion. I find this more polite.” (L)

“I once had the situation that I was holding my phone while teaching a class with four-year-olds and I thought, ‘actually, this is not so good’.” (P)

They not only talked about the teacher perspective, but Lisa also pointed out that she sometimes asks her adult course participants to put their phones away. This is to ensure the class is a safe space for movement, a topic that was also brought up by Hannah. However, both acknowledged that they use videos frequently themselves for their personal idea management and self-reflection. The podcast founders also stated to watch TV- and Netflix shows that are related to dance. Since these kinds of digital media already play a regular part in everyday life, it naturally also touches the dance aspect for them.

Associations with creativity

The last item of interest was again in reference to what they perceive as creativity in dance. Pia explained it as something impulsive and imperfect. She also added that she often considers herself not creative. Lisa agreed to the description of impulsiveness and added that one person’s creativity cannot be compared to another one’s. She phrased it as “the way of expressing myself in the purest authentic way” and connected it to an outlet of emotions and personal aspects. With respect to the choreographic process, watching herself in the mirror is a restrictive factor for her. In contrast, both of the podcast’s founders explained that they feel most creative if they are comfortable in their physical environment and have a free head space. Stress, pressure and the physical space of the dance studio were listed as creativity killers.

Hannah described creativity with regard to the diversity in dance. In her opinion, amateurs and professionals all bring their own way of being creative.

“I think it’s a creativity in the body. It is not only the head, the brain, that always does creative work. But it is based on completely switching off

and just looking where it takes you. I think it is a special creativity, which nobody can understand, who does not actively practice it. [...] I think dance is creative in itself.” (H)

Finally, Cat outlined the general idea of a creative process. It begins with the confrontation with a new and unfamiliar input. Through playful exploration you get to know the possibilities and limits. This results in different building blocks to be assembled for a final outcome. She sees this creative process as an analogy to a mycel, which is the complex and branched life form on which mushrooms grow.

“Maybe sometimes we may not know or find the connections within our life, our existence or perception. But this is simply our life and we have to nurture the soil so that these connections come together cognitively, which then creates a mushroom, which is the product. In the Amazon, for example, there are many woods with mushrooms, but in the end it is just one huge mycel. [...] The artistic product can eventually be a video, a production, a photoshoot, etc. But everything originates in the mycel. My process is to get to know the mycel, because then I can pick and choose out of it. The important thing for me is also: to what information do I have access?” (C)

4.2.3 Researcher reflections

I participated in a weekly dance course for two months, in which I experienced many moments of inspiration. In particular, I remember one moment, which I would describe as a creative one. I created an output, but I would not call it choreography. Neither was it a video, a performance or a movement sequence I would hold on to. I would not even remember exactly what I did but I still remember the teacher’s input that led me to create some kind of movement and a feeling that made me smile. What I interpreted as creativity was the surprise I experienced when I was moving in an unusual way. However, I did not quite understand what exactly was unusual. I used moves that I had known before and danced to a style of music that I was familiar with. What was new to me, however, was the way I combined the moves to an organic flow of dance. More specifically, I was able to do so using foundational moves of the specific dance style, instead of using more general movement, such as turning, walking or drawing shapes with my arms. I managed to let the music *guide* my body instead of just dancing to it. It was not something I did consciously, but what my body created from a kinaesthetic memory of movement and rhythm.

Recalling this moment with the knowledge gained in the conducted interviews, it reflects Hannah’s description of creativity as a phenomenon inherent in the dancing body. It also combines aspects of impulsiveness and the access to previous personal experiences. Similarly, elements from the focus group discussions, such as musicality, novelty and surprise, are recognisable. The latter two, however, are understood from an internal

stance rather than an outside perspective. To my teacher, my movement certainly was nothing he had never seen before. To myself, however, it was a moment I will remember.

Following the development of the dance scene, I was reading about Breaking entering the Olympics in 2024. More specifically, I was interested in the judging system for a dance that, unlike other sports, cannot be measured and ranked quantitatively in terms of metrics, such as speed or distance. One element in the so-called *Trivium System* is dedicated to *creativity*. Together with the sub-category *personality* it forms the *Artistic Domain*, which is considered a “product of the dancer’s mind”⁵. In my example before, in contrast, I thought about creativity from an embodied perspective. Moreover, my personal, internal evaluation is replaced by an external judgement in this example. Naturally, these are logical consequences, given the settings in which these examples take place. Nevertheless, it demonstrates the complexities and spectrum of creativity also outlined by the various theoretical models in chapter 3.

Although many different aspects of creativity are inherent in dance, there is a tension between the internal and external perspectives, which was among others addressed in a podcast episode⁶ with B-boy⁷ YNOT. He emphasized that although the Olympics are a sports platform, people will realize that what they see is a dance and that there is more artistry to it beyond the movement. Nevertheless, he expresses worries about a potential imbalance.

“And whoever wins or not, that’s also whatever. Don’t nobody really care about that, to be honest. You know, it’s about the feeling you get. It’s the feeling you project. It’s what other people feel. It’s that energy that remains in the space after you put it out there. So, it’s not about winning or losing. And I think when we start to shift into these things where there’s gatekeepers, there’s people who are pointing to one side or another side [...], that honestly doesn’t really mean much. And I’m just, I’m afraid of that becoming more of an important part of it than anything else.”

What he emphasizes is the felt dimension of dance, which some dancers also advocate for on Instagram, as depicted in Figure 4.2. Since the described instances were not directly connected to a piece of technology, the absence of it makes me wonder how an application of technology may be appropriate in dance. Resulting questions include: *What kind of creativity should a digital tool in dance support? What meaning do I ascribe to the resulting outcome? What impact does it have on the art form and the culture?*

⁵Dance Adjudication Network. <https://danceadjudicationnetwork.com/judging-systems/>, last accessed on 25/01/2024.

⁶DanceSpeak Podcast, Episode 190. <https://www.dancespeakpodcast.com/home/podcast-190-ynot-when-dance-goes-corporate-breakin-in-the-olympics-and-how-to-nurture-creativity>, last accessed on 27/01/2024.

⁷The terms *B-boy* or *B-girl* describe dancers who practice Breaking, a dance form commonly referred to as Breakdance in the media.

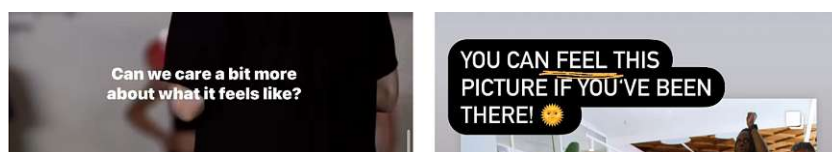


Figure 4.2: Dancers emphasizing the felt dimension of dance on Instagram

As described previously, it can impact the concept of a *safe space*, which has come up twice before. Interestingly, in the case of the VR performance, the technologically facilitated immersion benefited the dancer's experience of feeling protected, whereas the presence of smartphones in the training environment were considered as disturbing. Moreover, I came across said topic in a third instance, when I asked for the possibility to sit in on a dance workshop, which focused on using the smartphone camera lens in exploring new movement. Because of an injury, I could not participate, which is why I asked from a researcher instead of dancer perspective. In the studio owner's reply, I was told that the presence of external observers would disrupt the safe space character of the workshop, which means that this would generally not be permitted in this studio. This last example shows that a technological component was not the element in question for affecting the safe space character of the class. In fact, the video medium can initiate and motivate dancers to come together and create dance. While this is nowadays often used to attract participants for choreography classes, it was also used in this example of an exploratory workshop as well as by a videographer who aimed at portraying the fun of dance and collaboration in a Freestyle setting. When designing new tools for dance, it is challenging to anticipate how technology will be used. However, it is essential to consider that dancers require a non-judgmental environment that allows them to move freely and be creative. Therefore, this aspect should be taken into account during the development of technology.

4.2.4 Summary of Interview Findings

The interviewees shared their experiences of working with technology or using a digital medium in their projects. They explained constraints in working with it, but also highlighted the additional value it provided to them in terms of expanding their movement vocabulary and their mindset. While the previous focus group discussions revealed insights into *what* kinds of creative tasks a novel CST could support, the interviews contributed to a specification of *how* creativity in dance could be supported. More precisely, they raised awareness about potential impacts of bringing digital tools into dance and helped in understanding what to support and what to avoid. The former includes communication, breaking with habits and creating connections between different previous dance experiences. Aspects to avoid include the loss of foundational dance style movement as well as a disturbance of the dancer's safe space.

4.3 Survey

4.3.1 Organisation and Demographics

Given that the first two methods conducted in the exploration phase were directed towards very specific cases of former dancers and dancers with technology-centered projects, the third component aimed at finding out about active dancers in general. From an online survey, a total of 33 response cases were used for analysis. Nine of which, however, terminated the questionnaire early. Nevertheless, these cases were chosen to be included. This was because, aside from information about age, extent of dancing and dance forms, the survey questions were non-mandatory, which means that participants could have left out any questions in any case. Therefore, no difference was made between unfinished cases and those with missing answers. However, the resulting variation in numbers of total responses per question affects the statistical analysis. It is thus preferred to report absolute frequencies instead of percentages in order not to mislead the reader. The total number of responses is stated in each graphic.

The mean age of participants was 26.88 years ($SD = 8.969$) with a minimum of 13 and a maximum of 50 years. 29 participants chose German and four chose English as the language of the survey. Among all participants, 26 were female and 7 male.

Regarding the extent of their dance activities, one participant reported working full time in dance, 7 participants indicated dance as a side job, one participant was in education to become a dance teacher and 10 listed dance as an intensive hobby. An intensive hobby was understood as practicing multiple times per week, participating in dance battles, competitions or the like. These categories are considered a more intensive relation to dance and comprised 57.6% of all participants. Each of the 8 participants working full or part time in dance indicated that one to four proposed job descriptions applied to them. 6 describe themselves as dancers, 6 as dance educators, 5 as trainers/instructors and 5 as choreographers.

12 participants comprised hobby dancers, and those with very irregular to no dancing activities. The remaining two participants chose to use another description, since multiple categories applied to them. One of them reported being a dance teacher as well as active dancer. However, no specification was given whether teaching dance was the main occupation. The second participant used to dance and teach as well, but stated to be taking a break due to child caring duties. All of the above cases were included in further analysis, as creativity was not only something to be studied among professional creatives for this thesis.

The question regarding the region in which the participants are active in dance was answered in 32 of the 33 cases. The majority, 29 participants, reported being active in Vienna, nine of which also selected a second region, which was either Lower Austria, Upper Austria, Styria or German regions. One participant additionally mentioned regularly attending events around Europe. Being active outside Austria only was indicated once. It was assumed that the following answers about the dance scene did not concern Austria

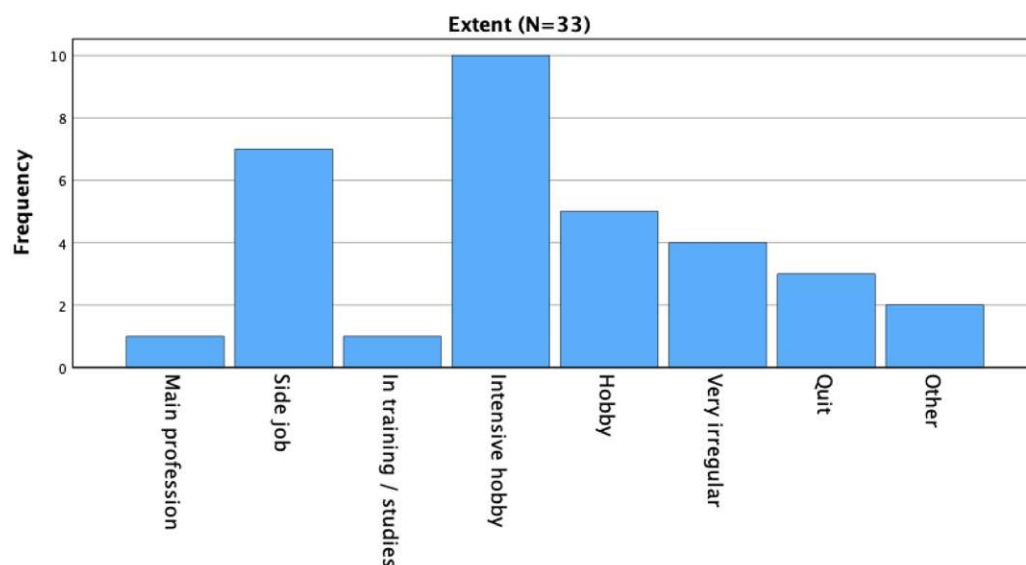


Figure 4.3: Extent of dancing activities among survey participants (N=33)

in this case. Thus, this case was disregarded for this particular set of questions. The general experience with creativity and technology, however, was still of interest and was included in the analysis.

The participants were asked to indicate which dance forms they practice. Each reported between 1 to 10 different dance styles with a median of 3 styles per participant. *Contemporary / Modern Dance* was selected most frequently by 18 participants, followed by *Hip Hop* with a frequency of 15 answers and *Musical / Jazz Dance* and *Commercial Dance* with 11 nominations each.

Other types of dance than the ones provided in the multiple choice set included Zumba, Pole Dance, Contact improvisation, Just Dance, “freely shaking the body to music”, European Dance Sports Program Standard and Latin (10 dances), Twerk, “5waves” rhythm dance, Open Score and Show Dance.

4.3.2 Dance

In order to establish the context of participants’ dance environment, people were asked to describe their relationships to dance. The analysis of qualitative data from their answers resulted in 8 types of relationships: *(close) friend*, *boosting self-confidence*, *challenging*, *complicated*, *hurtful*, *intimate*, *therapy* and *student-teacher relationship*. Exemplary descriptions of complicated relationships are the following:

“Toxic but healing at the same time. It gives you a lot of insecurities and doubts but it can also build you up.”

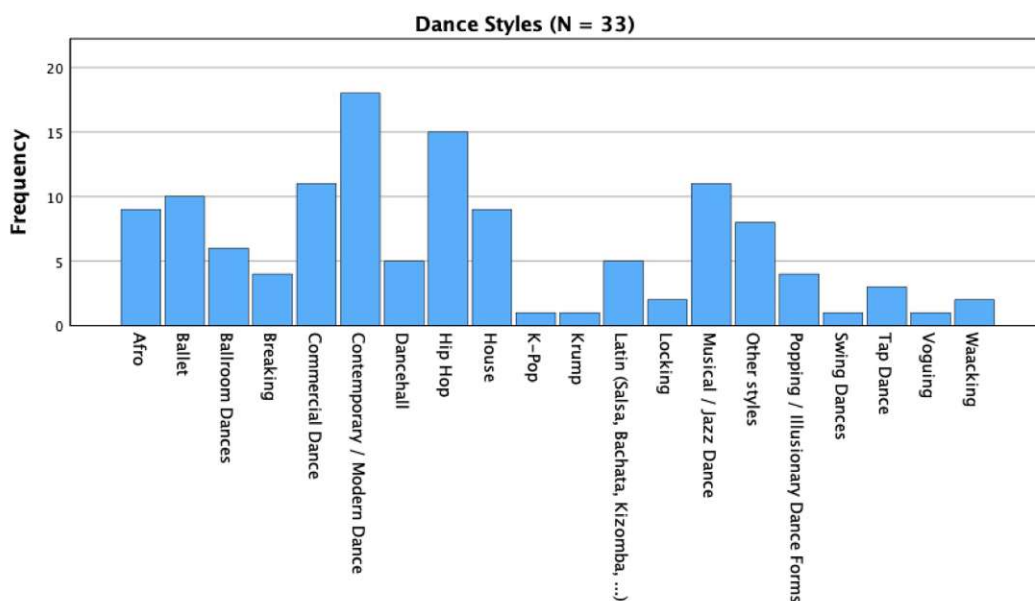


Figure 4.4: Dance styles practiced by survey participants

“I love him more than he loves me and fate/the whole world is against us. It just wasn’t meant to be, but I still think of him wistfully and suffer more than I want to admit. I still can’t give up hope that we’ll be happy together at some point.”

For some participants, a mix of various types was most appropriate to describe their relationship, such as illustrated in the following example.

“Dance fulfils several roles for me and therefore I name several people who I ascribe different roles to: therapist, partner (romantic), friend, teacher.”

Participants were also asked to describe characteristics of the dance scene they find themselves in. Since the majority of participants indicated to be active in Vienna, these descriptions most likely apply to Austria’s capital city. As described in the excerpt below, it should be noted that each dance form, region, studio or collective usually comes with its own scene. Although this statement was made by a participant with a background in swing dances, this applies more generally to any other form of dance as well.

“[T]here are a lot of regional differences in the way dance is taught, in the offer of socials and other dance related activities, in the way dance schools are run and are creating and forming their own communities.”

Themes identified from positive responses about the dance scene concerned the community, offers and quality of dance training, positive energy and support. Negatively connotated descriptions were quite specific and thus grouped into *structural topics*, *community topics* and *diversity*. Structural topics comprised a lack of good organisational work, financial aspects, not enough flexibility in class schedules and a lack of holistic education. The latter concerned, firstly, the passing on of information about the historical and cultural aspects of a dance form, which is reported as still having potential. Secondly, teaching about health was mentioned as being done too little.

“In my opinion, health is often neglected. We only have this one body and if we want to be dancers, we have to take care of it. Unfortunately, in dance, training control, nutrition and regeneration are rarely addressed or taken into account by professional trainers.”

With respect to the community, the lack of exchange between sub-communities, the difficulty to find your way into a community, especially regarding Urban dance forms, and pressure caused by community expectations was mentioned.

“[T]here is a lot of pressure, stress, fomo etc involved. depending on your role in the community, people tend to have expectations that you cannot or don’t want to always fulfil.”

“The dance scene in Vienna is still far too spread out everywhere. Dancing is something that connects and where people can be inspired by each other. That should be much more in the foreground.”

The diversity umbrella included statements about a lack of variety in terms of events and goals to work toward. One participant mentioned the prevailing focus on dance competitions and wished for a better organisation of productions, companies and dance pieces without competitive character. Moreover, this category also applied to a statement about people’s views on children’s dance education. It was stated that boys are often not allowed to participate in dance classes by their fathers, because dance is not considered masculine.

4.3.3 Creativity

The first question in this category enquired about participants’ definitions of creativity in dance. They associated it with *feelings* of being free, inspired, able to release and to express one’s feelings. Other descriptions included the *exploration* of new movement, experimenting, making mistakes, improvising and leaving one’s comfort zone. Some associations were related to *other dancers* and mentioned learning from others and not copying someone else. Finally, participants also defined creativity with respect to creating choreography or surprise effects and finding *new combinations* of existing material. Some exemplary excerpts are the following:

Creative Task	Frequency
Freestyle / Improvisation	15
Creating Choreography	14
Teaching and planning class	13
Performing / interpreting characteristics of dance	4
Choice of music	3
Training (warmup, methods)	2
Organising events	2
Costumes	1
Applying for jobs	1
Editing music or video	1
Filming dance	1
Expressing emotions	1
Realizing dance tasks	1

Table 4.3: Processes in dance perceived as creative by survey participants

Non-creative task	Frequency
Practicing technique	6
Learning/reciting choreography	4
Office work (registrations, invoices, ...)	3
Training/workout	2

Table 4.4: Processes in dance perceived as non-creative by survey participants

“to express yourself and find an outlet for your feelings”

“improvise, add nuances with your own movement patterns and styles, create your own choreographies/variations - spontaneously think of 'suitable' dance moves for a song”

“creativity - new combination of tried and tested, development of own movements, breaking with conventions, questioning rules”

Another question asked about what tasks in their everyday dance activities they consider creative or not. The lists of creative and non-creative tasks mentioned in their responses are presented in tables 4.3 and 4.4, respectively. It has to be noted that the original phrasings varied, but similar concepts were grouped into the presented categories. Moreover, two participants explicitly stated that in their opinion all tasks in dance involve creativity.

Factors influencing their creativity were divided into creativity enablers and creativity killers. Both contained personal (internal), ambient and social factors as well as associated types of tasks in dance, which are listed in table 4.5.

Theme	Creativity Enablers	Creativity Killers
personal	clear headspace	self-doubt
	relaxed state	tiredness
	enough time	stress
	inspiration	monotony
	goal/deadline	pressure
ambient	suitable illumination level	too bright or too dark room
	good music	no music / non-inspiring music
	at home, in nature, in the club	sitting at a desk
	enough space	
social	being alone	
	exchange in jams, workshops, battles	strict rules
	meeting new people	unfamiliar people
dance task	open training	creating choreography
		practicing technique

Table 4.5: Comparison of creativity enablers and creativity killers, categorized into themes identified in the dataset

In additional open answer fields, participants explained some of their last creative situations and the output they yielded. Among many references to creating choreography, the answers also described output in form of feelings:

“Again and again in improvisation lessons, alone or with partner - output: ideas for contemporary pieces, just fun and joy, the feeling of connection with partner; choreography - output choreo”

“A hip hop workshop that showed me that the style suits me relatively well and that it makes me feel good to move in this way.”

The last question for this category comprised statements that participants were asked to rate on Likert scales from 1 (Strongly disagree) to 5 (Strongly agree). The resulting median values are shown in Figure 4.5. Overall, the figure suggests that participants deem creativity important and were content with their frequency of feeling creative. However, 6 participants disagreed and 4 neither agreed nor disagreed to the statement “I feel creative often enough.” They rated the presence of other dancers as supportive, but the level of connection shows potential for improvement. The ratings did not show significant tendencies in terms of specific dance styles or age of participants. Slight differences in their ratings of statements were given with respect to their extent of dancing, however, which is illustrated in table 4.6. Participants who quit or chose other descriptions felt slightly better connected with other dancers than the rest of the participants. Among active dancers, those in education or engaging intensively in dance resulted in the least rating of feeling creative often enough.

Median Values for different Extent of Dancing Activities					
Extent	Creativity is important to me.	I feel creative often enough.	The space in which I usually dance creates a pleasant atmosphere that encourages my creativity.	The presence of other dancers creates a supportive and inspiring environment.	I feel well connected with other dancers.
Main profession, side job (N=8)	5 (6)	4 (6)	3 (6)	3 (5)	3 (5)
In training, intensive hobby (N=11)	5 (7)	3 (7)	4 (7)	4 (7)	3 (7)
Hobby, irregular (N=9)	4 (7)	3.5 (6)	4 (6)	4 (6)	3 (5)
Quit, other (N=5)	5 (4)	2 (3)	3 (3)	4 (3)	4 (3)

Table 4.6: Comparison of median ratings to five Likert scale statements. The first value in each cell is the median value of the respective statement and participant subset. The value in parentheses represents the amount of participants who rated the respective statement. (1=Strongly disagree, 5=Strongly agree)

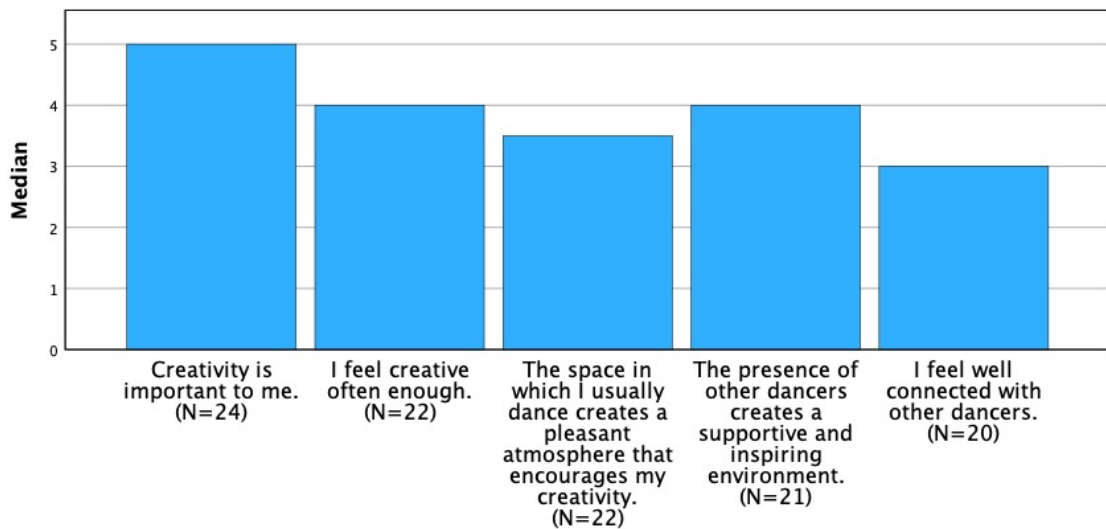


Figure 4.5: Comparison of median values from five Likert scale statements among the whole set of participants (1=Strongly disagree, 5=Strongly agree)

4.3.4 Digital Tools

Finally, participants received questions regarding digital tools in dance. These could be interpreted as any device, digital system, software or app. The first question asked for a description of how participants perceive the interplay between dance and digital technologies. Responses overall provided critical perspectives. Topics identified in this regard include *support effect*, *inspiration and motivation* and *influence on mindset*. The first topic concerns participants' appreciations for the support that digital tools offer with respect to accessing course programs and training possibilities, advertising and planning their lessons and editing or controlling music.

“Valuable support in the classroom, for my training and also for marketing and advertising”

Especially videos on social media were mentioned as a source for inspiration and motivation, as they provide many ideas and encourage dancers. But also dance games can encourage dancers at home.

“I often see dances and moves on Instagram that inspire me incredibly. I get lots of ideas for my own or modified movements. It's also an incredible source of motivation for me. Watching really good dancers motivates me to become just as good.”

“I think of Just Dance first and foremost because it's actually the only tool that gets us dancing together as a family from time to time. It does limit our creativity because it's all about copying, but it's the most accessible for us until my kid is perhaps at an age where we can do a 'parent-child dance' course at the 'Volkshochschule'.”

Responses under the umbrella of an influence of mindset mentioned that dancers unlearn to rely on their bodies. Furthermore, the integration of digital media into the dance world leads to an increased comparison to other dancers. It can create pressure, shifts dancers' focus and they may less frequently attend in-person classes.

“Videos on Instagram, TikTok, YouTube often exert indirect pressure on consumers. Filming in classes must also be handled well by the teacher and student, otherwise the purpose and focus of a class is quickly lost (growing pressure to have a perfect video can lead to you no longer dancing full out, no longer being yourself and other negative influences).”

“Everything is there, everything is available, everyone has to be even more blatant, and yet things have no value.”

Two participants furthermore pointed out the dependency on specific tools and usability issues.

4. RESEARCH

Category	Tools	Frequency
Research/Knowledge	smartphone, laptop	11
	podcasts, audiobooks, YouTube, videos, documentations	
Editing music	laptop	9
	audacity, Nero Soundtrax, CapCut	
Analysis	smartphone	9
	YouTube, videos	
Choreographic process	tools for adjusting music, notation tools, video, Google, YouTube, TikTok, Instagram	8
Teaching	smartphone, tablet	8
	digital file system with tags, music playlists, beamer, social media, YouTube	
Training	smartphone	8
	social media, videos, YouTube, online dance tutorials, Just Dance	
Physical health	smartphone, laptop	6
	blackroll app, TENS regeneration device, yoga platforms	
(Stage-) Performance	video editing software, formation apps, YouTube, instagram, music	5
Fun	videos, instagram, podcasts, Just Dance	4
Collaboration	digital communication channels, search engines, dance partner platforms	2
Improvisation	lights	1

Table 4.7: Categories and tools ordered by frequency of participants (N=25) stating to use them for the respective category

“not everyone likes or know the same tools, there are issues in collaborations when you demand people to sign up for or use tools they are not comfortable with (e.g. facebook, google,...). a lot in the dance world is (only) promoted or disseminated via social media (facebook, ticktock, insta...) which often creates a need to join [or] stay out of the loop (or have very informed friends who constantly have to inform you). tools needed for video and music editing are not easily accessible/usable for everyone.”

“It has helped me at times, but is quite cumbersome/not low-threshold or user-friendly enough”

When asked what kinds of digital tools they use in any activities related to dance, 19 participants of those who answered the question (N=25) reported using digital tools beyond the purpose of playing music. The remaining 9 participants stated that they do not use any other digital tools. 7 of those explained that it is not necessary for them, one

participant said it is too difficult and one chose the *other* option, but did not specify any further. Participants were given multiple choice options of application tasks informed from literature and previous user research. The most frequent category, in which tool examples were listed, was *Research and Knowledge*. It covered smartphone and notebooks as devices and various digital media, such as podcasts, audio books, social media content and video documentaries. This category was followed by *Editing music*, containing different editing freeware and the laptop as the device of their choice. In the category *Analysis*, smartphones, YouTube and videos were listed. The least frequent category was *Improvisation/Freestyle*. Only one participant stated using lights for this activity. Table 4.7 shows a comprehensive list of the resulting categories and tools. Further purposes than the ones proposed as multiple choice options were “follow events” and “festival organisation”, where administrative tools for student sign-up and organizational tasks were mentioned.

What is noticeable when looking at this table and was already illustrated in the quote above, is that YouTube and Instagram are the ‘universal tools’ that participants come back to in various situations within dance, such as creating choreography, finding inspiration, just for fun, research, knowledge, health resources and other. These are essential tools providing assistance in multiple related dance activities.

4.3.5 Researcher reflections

Because of the injury mentioned in the previous section, I was not able to join in-person dance classes or events for a period of approximately five months during this research project. Because of this, reading through participants’ survey answers was one of the few instances, in which I experienced a feeling of real connection to dancers, despite not being able to meet or discuss with them. Although I was in contact with a few individuals and was still following the dance community through various Instagram profiles, I felt like an outside viewer. Therefore, I was wondering in what ways I could still interact with dancers. As I never felt comfortable sharing details about my life and dance on Instagram myself, I tried to focus on text-based virtual interaction. After searching for dance forums, it appeared to me that this type of communication happened only via the Whatsapp messenger. After thinking about it in more detail, however, I noticed that this was actually not the case. Aside from chats with closer friends, each of my personal dance chat groups consists of hundreds of members and has an agenda based on a specific style of dance, the promotion of events or sharing of relevant information only, in order to avoid spam. Consequently, I did not feel comfortable engaging with these chat spaces either, as I did not have anything to offer in this regard. I was merely looking for exchange, but without success. Have I become excluded so quickly? In a time, in which so much communication happens in the virtual space, was there no alternative to engage with dancers beyond sharing Instagram content?

The virtual space, however, still allowed me to observe whether survey responses were also reflected by dancers’ contributions on social media. Indeed, I came across one dancer sharing a novel discovery for creating a comfortable environment for dance. A YouTube

video of disco lights on full screen mode was used in a dark room to subtly illuminate the space. Moreover, I remembered seeing an Instagram story of a dance teacher a few years ago. It showed her using software and creating dance formations for a performance she was planning. I remember that I replied to her story back then, because I had been curious about the software. I decided to look up this conversation again in the app. My message to her, back in 2019, was saying, “Haha nice, is this GeoGebra?” She replied, “Haha yes - old school and for free.” These are just two examples, but they show how dancers solve their problems by reappropriating existing technology for their purposes. Although I do not want to take a techno-chauvinist stance, I believe that technology specifically designed for dancers could make a difference for many issues mentioned by research participants. In contrast to being nudged into a prevailing system of rethinking technology not designed for this target group, dancers’ creative work could be enhanced by meaningful support tools.

4.3.6 Summary of Survey Results

The online survey concluded the exploratory user research phase of this thesis. Participants’ answers provided insights into potential areas for improvement within the Austrian dance scene, such as structural topics, diversity as well as communication in and between the sub-communities. Explanations of creativity together with influential factors enabled a deeper understanding assisting the development of a CST for dance. Moreover, participants’ views on the use of digital tools in their dance supports the consideration of the impact a CST can have on dance as a movement practice, art form and culture.

With this, I moved on to the design phase of my thesis. I remembered *what* aspects could use support and *how* a tool may impact dance from the previous focus groups and interviews. With the survey, I extended these insights by further opinions and drew a personal conclusion *why* the design of novel CSTs for dance could have a positive impact.

CHAPTER 5

Design

The research outcomes provided valuable insights into dancers' experiences that guided the design of the planned prototype. As explained in chapter 3, the research and design phases overlapped, meaning that first trials with the chosen technology were carried out while the research phase was still in process. Moreover, as the design phase was iterative, it involved intermediary research and evaluation steps. For plausibility of design choices, however, these need to be presented in the context of the respective stage in the prototype development. Hence, the design as well as research and evaluation instances conducted within the prototyping process are explained in this chapter. First, the initial requirements for the prototype deduced from user research findings are outlined. Afterwards, the iterative development process is illustrated across three versions of the prototype.

5.1 Prototype Requirements

The first step in the design process was to specify initial requirements to guide the choice of appropriate hard- and software as well as functionality of the prototype. For this, several brainstorming sessions had already taken place during the research phase and an autoethnographic workshop was conducted at the beginning of the design phase. The following questions were central at this stage of the process:

- Which of the research outcomes should be translated into design?
- What is feasible and in the scope of the thesis?
- How would user interactions with the prototype look like?

The following subsections will provide answers to these questions. First, research outcomes relevant for the design process are specified. Second, the brainstorming and workshop

outcomes are presented. A summary of final prototype requirements is given at the end of the section.

5.1.1 Moving to Design

The results from the user research phase of the thesis project touched many areas of dance as well as potential technological implementation scenarios. However, not all insights were considered relevant for a non-screen based CST. The following topics were decisive for the implementation of the prototype.

Confidence: In all instances of the research, participants mentioned recurring self-doubts or pressure because of the many ways of comparing oneself to others in both the physical and digital space. This was considered a natural phenomenon in dance, which cannot be avoided. In fact, it can also fulfil the purposes of motivation and growth. Nevertheless, it was primarily mentioned with a negative connotation, which means that a new tool to support dancers should not reproduce this aspect to become another instance of it. Instead, it should focus on giving people more confidence in themselves and hence provide an alternative to these feelings. This confidence may be built up by helping them reflect more on the own dance practice, improve one's skills or find confidence in the own dancing body.

Interaction: Most of the tools mentioned by participants are video-based platforms. Even those not originally designed for video may eventually transition to this format, as illustrated in the podcast example. An assumption about such an emphasis was already made from personal experience before engaging in this study, which explains the specification on a non-screen based artifact in the second research question. Since it was confirmed by the results, the prototype should therefore contribute to enlarging the heterogeneity of the tool landscape for dancers, probing different interaction modalities. Since survey participants also had the impression of dancers losing connection to their moving bodies and instead focusing more on external factors, the prototype shall probe whether it can mediate an inward attention.

Creativity: Following participants' associations with creativity, the prototype should support dancers in being able to explore movement. Additionally, given that in the presented tables of creative and technology-supported processes in dance, *Freestyle/Improvisation* was the most and least frequent, respectively, this process is chosen as area of interest for the development of the prototype within this thesis. This ties in with the few examples from the body of literature applied in a dance improvisation context. Throughout the remaining thesis, the terms *freestyle*, *improvisation* and *movement exploration* are used interchangeably.

Convenience: The tools mentioned by participants suggested that dancers predominantly use their smartphones or mobile devices, which indicates that mobile apps or platforms accessible on mobile devices could be in demand. However, this contradicts the *Interaction* aspect, which is preferred in this case. Still, the artifact should be transportable and convenient to use. At this point, it shall be noted that an interactive

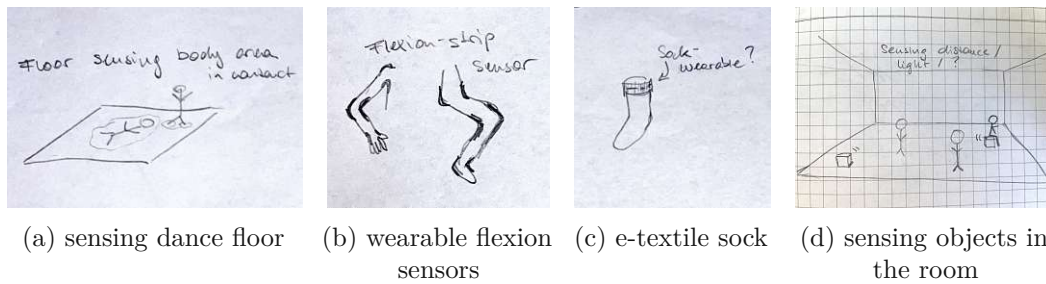


Figure 5.1: Initial sketches

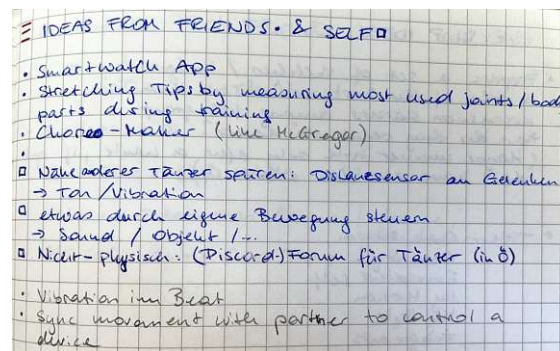


Figure 5.2: Ideas resulting from brainstorming sessions with and without friends

installation or performance is therefore not the goal. This is not only because of functionality, but also due to feasibility reasons. It would require space and hardware resources that I lack access to.

Summarizing these factors, the prototype was decided to focus on the creative process of exploring movement within an improvisational context. It should support self-confidence and a reflective rather than consumerist dance practice. The artifact should be non-screen based and portable.

5.1.2 Sketches and Brainstorm

In several instances of brainstorming, potential interaction possibilities were sketched. Earlier ones focused on putting any ideas on paper, independent of the later defined purpose detailed above. The only restriction from the beginning was that it was supposed to be a physical artifact instead of a digital mobile or desktop application. As such, they contained ideas of artifacts, which are placed in a physical space or on the body, use sensors and trigger some form of reaction to a dancer's movement. Example sketches, such as a sensing dance floor or wearable flexion sensors are depicted in Figure 5.1. Figure 5.2 additionally shows a list of further ideas resulting from brainstorming sessions with and without friends.

Although all ideas were different to some degree, one thing I decided at this stage was

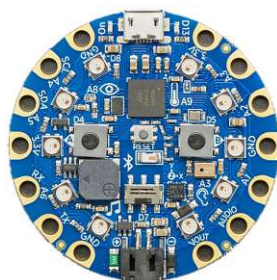


Figure 5.3: Adafruit’s Circuit Playground Bluefruit (image retrieved from the same source as mentioned in footnote¹)

that it should be possible to use the artifact alone as well as in collaboration with other dancers. Furthermore, what was common across all sketches was that some ambient or movement information was supposed to be sensed by the artifact. This led me to choosing the Adafruit Circuit Playground Bluefruit (CPB)¹ microcontroller as the core of the prototype, which is depicted in Figure 5.3. It contains several built-in sensors, provides connection possibilities with alligator clips for convenient prototyping and Bluetooth functionality for wireless connection, which comes in handy when working with movement. This choice offered flexibility in trying out various technological scenarios.

5.1.3 Autoethnographic workshop

After several sketching and brainstorming sessions, I noticed that I was focusing too much about how to implement a prototype and losing sight of finding out how to support the research outcomes explained above. At the same time, I did not think that I could gain more detailed knowledge from further observations or interviews with other dancers. Also, time resources of my dancing friends for engaging intensively in the topic with me were scarce. Therefore, I decided to switch perspectives from researcher and designer to dancer myself and investigate more in-depth what exactly it is that makes me, personally, feel creative while dancing. For this, I conducted a two-hour improvisation session, which was approached in a more strategic and reflective way than the usual scenarios of spontaneously moving to music or explicitly creating choreography for dance class. It was supposed to help me analyse my own dance practice and decide about the appropriateness of the initial ideas.

Procedure:

The first two exercises of the workshop fulfilled the need for turning my attention inwards as well as for establishing a creative mood. The former was done using a body map, attending to my feelings in the moment and drawing them onto the map. The latter was carried out as a short brainstorming exercise, which was based on the Japanese Wabi-Sabi philosophy. It is a holistic approach to life, finding beauty in imperfection and valuing the uniqueness of continuing development. This philosophy has been used as a

¹<https://www.adafruit.com/product/4333>, last accessed on 13/01/2024.

design resource in HCI before [73]. The authors Tsaknaki and Fernaeus refer to Richard Powell [55] and describe it as follows:

“The term Wabi-Sabi consists of two parts: *Wabi* refers to the essence of simplification, of cutting down the things to the important, whereas *Sabi* refers to the passage of time, and more specifically to the fact that the core of something remains the same, even though the facade or surface may change over time.” [73, p.2]

Although I did not apply the concept to the artifact itself, I thought of it as an analogy to dance. I aimed at not striving for perfection and thinking about how my dance developed over time. For the *Wabi* part in my workshop, I hence thought about what the beauty in the imperfection of my dance was and tried to break it down to simple descriptions. This meant creating an awareness of what I like about my dance, what kind of movement I feel confident in and what I think I am good at. Since the *Sabi* part is about development over time, I brainstormed what I would like to improve and what kind of movement I am curious about. All ideas were captured on sticky notes and put aside for the next phase of the session.

I moved to spending a few minutes on warming up my body for movement. I started with a so-called body-scan, moving each joint of my body from top to bottom and focusing on the parts that I highlighted in the body map before. For the rest of the warm-up phase, I used three basic concepts present in many dance forms: I moved through the space, explored levels from standing on my toes to lying on the floor, and played with directions. Before switching to some more structured improvisation exercises, I danced to one song without any concepts in mind. I used this open improvisation round to observe myself, while letting my body instead of the mind lead the movement. I then returned to the sticky notes and wrote down some features that I noticed while dancing. These included repetitive patterns and habits as well as ideas of different kind of movement I could experiment with in the remaining session.

I then turned to exercises, which were guided by more specific concepts that focused on musicality, certain parts of my body and expressing shapes. In between exercises, I came back to the sticky notes again and wrote down observations and ideas about the aspects mentioned above. Additionally, notes about movement that felt novel as well as observations on dynamics and variations extended the range of topics.

The session was completed with another open improvisation round, followed by a second body-scan as cool-down.

Observations:

Upon entering the room the workshop was conducted in, I already noticed several factors distracting me from the dancing task I had in mind. The room had many windows and, although not many people walked by, I felt observed. The ceiling lights were too bright for me to concentrate on myself, which means that I decided to keep them switched off

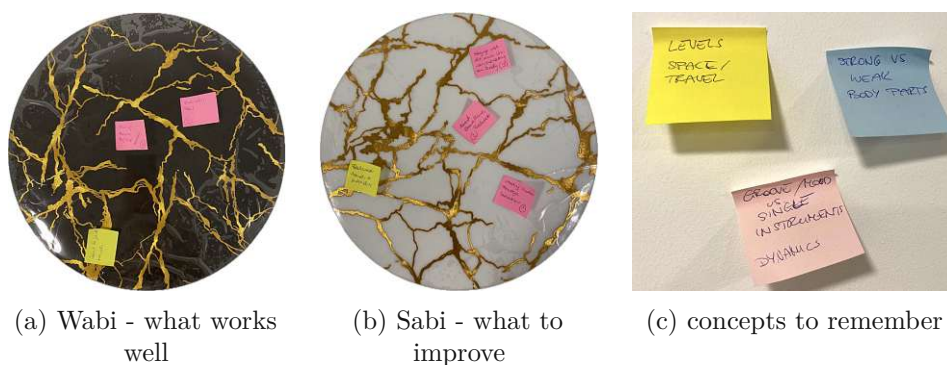


Figure 5.4: Notes created in the workshop

and settle with the natural evening light. There were no mirrors, which I perceived as a pleasant aspect. I found myself lying on the floor and looking at the ceiling, experiencing a change of perspective I did not remember having in many occasions related to dance.

After the first open improvisation, I could clearly point out two parts of my body that I moved frequently: the feet and the shoulders. I also noticed that I did not vary in directions as much as I did in the warm-up phase. Neither did I move my head or arms as much. These features were collected on post-it notes, which are depicted in images 5.4. The thought that staying with the music was difficult while concentrating on a certain exercise was added after playing with some concepts. I had realized that I lost connection to the music, which led me to slow down and take some time to listen closely again.

The final open improvisation exercise resulted in movement patterns that felt new to my body. I was surprised when I found myself moving in a way I did not consider myself good at in the beginning of the session. What made me smile was that I was able to remember the pattern throughout the exercise and repeatedly use it in different combinations. I felt like this had not happened often before, since I remembered several situations in which I spontaneously did a “cool new move” but could not even reproduce it from a video recording of myself. I was able to reproduce my personal definition of creativity in dance, which I had come across in the dance class described in chapter 4: it was an “aha-moment”, a surprise combined with a good feeling when my body did something that was new to me. Only this time, I was able to reach this point myself, without any input from an external teacher. I had become my own teacher, re-using my existing movement vocabulary.

My reflection in the end reminded me of something a dance student once asked me: “How do I manage to think of all this at the same time?” Within this workshop I felt like I was not able to think about everything at once either. But I realized that I did not have to. It reflected the “pick and choose” scenario, as Cat called it in the interview, or the resorting to past experiences from a *toolbox* in Hannah’s words. Which information is accessible to me in a given situation can be different depending on many factors. But being aware of my movement, my habits and my possibilities can open up a space for

Analogies of Creativity Support Tool elements		
Element	CST	Dance-supporting Artifact
Space where creative output is created	Canvas, editing window, text page	Dancer's body, physical space
Provision of potential tools to apply for creating the output	Toolbar	Externalisation of dance foundations and basic concepts across styles
Predefined elements that modify own creation	Filters, effects, fonts	Direct impulses to the dancer or moving body
Collaborate and search	Share-functionality, templates, libraries	Group use functionality, database or exchange platform

Table 5.1: Comparison of elements present in existing creativity support tools to potential elements of the prototype

different concepts and impulses, in which I can select what I need in the moment. Not only did I gain a better understanding of this through the workshop. I also felt like the more often I expressed certain concepts through my moving body, the less I had to consciously think about them. I cultivated my kinaesthetic creativity through building muscle memory.

5.1.4 Summary of Requirements

The combination of user research outcomes, initial sketches and the autoethnographic workshop reflections steered the project into the direction of developing a device to support the personal dance practice. It should prompt a reflection on personal strengths, potentials and interests, and trigger kinaesthetic experiences for dancers to resort to at a later time.

Purpose: The artifact is supposed to be used in a dance practice environment, either by an individual or collaboratively in a group. It should support an understanding and development of personal skills. By doing so, it aims at supporting creative situations in a movement exploration setting.

Design considerations: A rudimentary analysis of the core elements of existing Creativity Support Tools for creative practices such as writing or graphic design resulted in four features to consider for the dance-supporting artifact. Table 5.1 compares how these elements could translate into a prototype for dance.

With these analogies in mind, the artifact should have a wearable-enabled design, which means that it should be a physical device that can be positioned in space as well as worn on the dancer's body. These two modalities are referred to as *tangible mode* and *wearable mode* from here on. It should provide a collection of basic tools to be applied in a dance

improvisation context and be able to influence the moving body directly. Lastly, it could provide the possibility to “browse” through external input and share own work.

The facts that I, firstly, did not restrict the work in this thesis to a specific dance style and, secondly, wanted to support reflection on the personal movement practice, modified how tools and effects were provided within the tool. The design was thus chosen to support creating one’s own movement vocabulary instead of defining specific moves and concepts. The tool was therefore seen as a memory device in its core, which assists the dancer in accessing movement concepts to incorporate in their improvisation. Decisions should be made for the dancer in order to decrease the cognitive load of accessing and remembering information in a situation. This could assist to release tension and gain a free head space. Compared to a dance class, this is usually done by a teacher, who confronts the students with a tasks and gives signals by speaking, gesturing or touching within the exercise. The tool is supposed to make this external input available in situations, where no teacher is present. However, due to the modality of working with personal dance knowledge, it does not replace dancers’ regular participation in classes for gathering information and reaching out to other dancers. Instead, it reproduces what the dancer already knows and thus acts as an addition to their dance education, resulting in them becoming their own teacher.

These requirements are similar to Shneiderman’s design guidelines [65] and CST features suggested by Cherry and Latulipe [18], such as collaboration, exploration and the ability to appropriate the tool individually. Moreover, the extension of prior user research by an autoethnographic workshop especially supported Shneiderman’s eighth and ninth design principles of creating something I would want to use myself as well as listening to participants’ opinions. Furthermore, a focus on the reflection on and development of personal skills represents Amabile’s component of *domain-relevant skills* for enhancing creativity [4].

5.2 Prototype v.1

5.2.1 Design Process

After getting to know the CPB microcontroller, the first choice to make was to decide on its communication modalities. Having defined the requirements for it to be placed either in the physical space or on a dancer’s body, the following options were available:

1. Auditory output: playing sounds or modifying the music played by the dancer
2. Visual output: a classic GUI was ruled out, but there was still the option to use lights as a means of communication
3. Haptic output: when worn on the body, haptic cues could provide the opportunity to turn the dancer’s attention inward and minimise external distraction

While auditory output sounded intriguing at first, I remembered talking about it in the interview with Cat. Her opinion at that time was that the dancer’s possibilities were

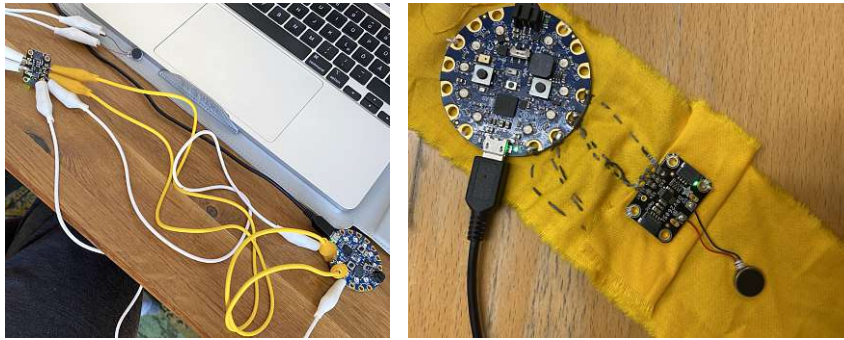


Figure 5.5: First prototyping attempts using alligator clips and conductive thread

heavily dependent on what the sound artist created. Given that I had no prior experience with sound design, I assumed that I could not produce a good base for the dancers to work with in the given time frame for this thesis. Moreover, as I wanted to design a tool for dancers' individual dance training, it did not seem reasonable to provide them with music they do not usually work with. I further thought about using single sounds played directly through the CPB's speaker as impulses, but these could not reach a volume loud enough to drown out any regular music.

With these considerations, the choice of using visual output in the form of colored, built-in neopixel LEDs for the tangible version of the prototype and haptic impulses for the wearable version was made. Lights have been mentioned previously by one survey participant with regard to digital tools for the freestyle and improvisation situation. For the latter, the CPB was combined with the Adafruit DRV2605L haptic motor controller² together with a small vibration motor. The code for the CPB was written using Circuit Python 8 and can be found in Appendix B.

This addition influenced the physical design of the prototype's first version, which was supposed to be flexible to be worn on the body without restricting movement. While the first idea was to 3D print a strap from flexible filament and place the electronics inside a case, I considered this approach to be time consuming and not worth the effort for a first prototype version. Because of this, I chose to look into the creation of e-textiles and decided to sew the electronics on a piece of fabric long enough to be wrapped around various parts of the body. After having tested the connection with alligator clip wires, I soldered the vibration motor onto the haptic motor controller and used conductive thread to connect it to the CPB. Because the pins were not in the same order on the controller and the CPB, I used an additional layer of fabric to insulate the crossing threads. Both stages of the first prototype version are shown in Figure 5.5.

Although the motor vibrated initially, it stopped working after the fabric was moved around. I had been careful to avoid any short circuits while sewing the electronics and securely solder the connections. However, the thread I was using was quite thick and

²<https://www.adafruit.com/product/2305>, last accessed on 13/01/2024.

a little fuzzy, which might have produced contacts somewhere it was not supposed to be. As a novice in working on an e-textile project, the stitching was also not perfect and might have been too loose. Because of a lack of time prior to the first workshop with dancers, I switched my focus to the tangible version for the time being and implemented different light patterns in order to investigate how they could serve as creative input.

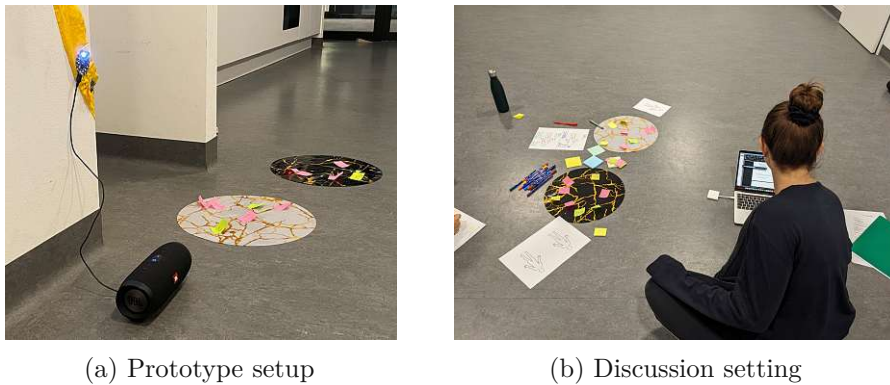
5.2.2 Workshop 1

The workshop conducted at this stage of the development process fulfilled two purposes. First, it provided the opportunity to understand the circumstances of the creative movement exploration setting with other dancers and compare their experiences to my personal ones from the autoethnographic workshop. Second, I wanted to test how light cues could support creativity in this situation.

Procedure

Two female dancers, referred to here as P1 and P2, participated in the workshop. They had prior knowledge in different dance styles as well as in teaching dance. The workshop followed the same structure as the previous one described above and was divided in five phases: setting the scene, warming up, movement exercises, cooling down and a final discussion. To recall and point out differences to the autoethnographic version, a short explanation of each phase is given in the following.

1. **Setting the scene:** Participants were introduced to the topic of the thesis and the purpose of the workshop. They were asked to create a mind-map of their mental, physical and creative state with respect to the momentary setting as well as their current point in their dance journey. A short brainstorm exercise based on the Wabi-Sabi concept completed the first phase. It was used as a way to establish an open and reflective setting for the session, in which they were asked to think about their strengths and ideas for the exploration of novel movement. In between the following exercises participants were asked to add further notes to the collection.
2. **Warm up:** A body-scan and three exercises of travelling through space, using levels and directions prepared the body for further movement. An open improvisation round raised awareness about movement habits and acted as transition to the subsequent phase.
3. **Movement exercises:** A range of improvisation exercises was carried out, which aimed at understanding what kinds of impulses work for dancers. These impulses included active attention to features in the music, variations in the use of the physical space and focusing on the own body by forming connections between different joints of the body. Additionally, the last two exercises used animated LED patterns on the prototype as input for reminding oneself of concepts applied earlier in the workshop session.



(a) Prototype setup

(b) Discussion setting

Figure 5.6: Impression of the workshop

4. Cool down: A second round of open improvisation gave participants the opportunity to explore what they could take out of the previous exercises. To finalize the dance part of the workshop, another body scan was used as cool-down.
5. Discussion: Participants were asked to go back to their mind maps from the beginning and either add or represent in a new one what differences they felt at the end of the workshop. A last Wabi-Sabi brainstorm was done, addressing the newly formed patterns in their improvisations as well as ideas for future movement explorations. Explanations of these created artefacts as well as feelings and thoughts about the exercises in the workshop were finally shared in a verbal discussion, which was recorded and analysed together with observations and notes from the session. An impression of the end of the resulting notes is shown in Figure 5.6.

Analysis

The feedback from the participants touched upon three topics: the personal experience, the prototype and external influencing factors. Notes from my personal observations are reported collectively with participants' comments in the following paragraphs.

Personal experience: Both participants confirmed the previous assumption that in the beginning it was difficult to remember dance concepts, which can be applied in an open improvisation setting. P1 felt like she was repeating the same kind of movement in the first open improvisation round.

“You may already know that you could recall this, but sometimes you do not act on it because you either don't think about it or don't feel like trying something new.” (P1)

She therefore liked the idea of consciously visualizing various concepts on sticky notes and felt naturally more creative due to this, because it structured the “usual clutter” in her

head. She preferred to call this input “pathways” or “branches” instead of restrictions, because she thought of it as having options to move along.

P2 also appreciated the idea of having a tool that can provide creative input when her natural sources of creativity, which she explained as the nature or collaboration with other dancers, is not accessible. She observed that by the end of the workshop, the habitual movement she noticed in the first improvisation was nearly gone.

“I then consciously paid attention to the parts of my body that I don’t move so much. And the things that I do more often anyway were no longer on my mind towards the end.” (P2)

P2 also highlighted that the workshop taught her that her body can be her instrument and that it already provides many tools and movement patterns she could use. For P1, on the other hand, it was important to know that she was allowed to come back to her comfort zone, but to use it as a highlight rather than as a base in her improvisation.

“Because normally it is like ‘don’t do that, step out, step out [of your comfort zone]’, so I liked that a lot.” (P1)

P1 further specified which of the exercises was most valuable to her. It was called *the box* and was a concept that she had known before but had not used in her dance in a long time. It created a special feeling that she did not experience during other, more popular, exercises in dance.

“For example, when I imagine myself with the box. Ok, I’m doing something nice with the box. And then I think to myself, yes, it worked, something nice has been created. And then you realise ‘ah cool’. If I hadn’t had that, it would have been a cool move too, but not such a moment of happiness.” (P1)

This special feeling was also visible from the observer perspective, as her movement looked more articulated during this exercise compared to her rather smooth and graceful way of moving before. Both participants furthermore reported feeling inspired and creative at the end of the workshop. P1, for example, compared her pre- and post-workshop body maps from the mind map exercises shown in Figure 5.7a.

“First: stress, many thoughts in my head, dissatisfied with current creativity, body not fit, but lots of ideas, looking forward to change. And now: thoughts of work etc. are gone, my heart has become even bigger, I feel very inspired.” (P1)

Prototype: As touched upon above, participants liked the idea of the prototype. Due to a technical failure during the workshop, however, only a subset of the implemented

this point the colors had not carried a specific meaning on purpose, but the comment was a valuable feedback for further improvement.

After explaining the idea of the planned wearable version of the prototype, the participants speculated about the effect of haptic impulses on a part of their bodies. P1 thought about an irritation on the body part it is worn and a potential distraction from the original purpose of the prototype. P2 compared the idea to contact improvisation, where the haptic cue acts as an impulse for moving this particular body part.

External factors: The first factor influencing the participants' movement in the session was the illumination level of the room. P1 mentioned that a darker ambience could have helped her focusing inwards, but the brighter light level that was present during the workshop did not bother her. P2 added that she usually feels less observed when the illumination level is low. The second factor concerned the choice of music. They both liked the playlist used during the workshop, which provided a good base for them to explore their creativity. P2 added that a few more up-tempo songs would have been nice, because she experienced many songs as rather slow. This was an interesting comment, since from the observer perspective most exercises seemed to result in a quite quick tempo of movement without taking much time to slow down. Especially the exercise, in which participants were asked to travel across the room seemed rushy and participants looked exhausted afterwards. The only exercise, in which a slower pace was observable, was one in which participants were asked to explore connections between two parts of their bodies, such as elbow to knee or hand to ankle.

5.2.3 Summary of v.1

Idea

The outcome of the workshop supported my idea that a memory and impulse-giving device could be useful for dancers in an improvisation context. The availability of “pathways” to move along is considered a support for creativity. Although dancers basically have knowledge about these pathways, a tool that helps externalise them could bridge the gap of lacking access to it. Moreover, such an approach can trigger positive feelings and a sense of achievement, which is desirable for boosting self-confidence in dancers.

Implementation

Aside from the fact that the prototype was not fully functional, there were two aspects that needed to be worked on. The first one concerned the LED animations. While they were seen as an input that sparked new ideas, some of them were difficult to distinguish. It required watching a pattern for a few seconds to identify it, which was an unwanted distraction from the dance improvisation. Moreover, because of its small size, it was not clearly recognisable from a distance. Shneiderman's sixth design principle of creating something as simple as possible was important to remember at this point. The second aspect was related to the wearable version of the prototype. The participants' thoughts regarding haptic feedback sounded interesting. The sewn circuit therefore had to be renewed for being able to test this on-body scenario.

5.3 Prototype v.2

5.3.1 Design Process

Tangible mode

Because the LED animations were hard to distinguish, the functionality was reduced to lighting up the LEDs in a pure colour and switching colours at random intervals. Through various try-outs, the intervals were set to a duration between 8 and 15 seconds. An amount of two to five different colours to switch between was chosen based on observations and feedback from the previous workshops.

Each colour represented one dance concept, dance move or other input to be used in dance improvisation. This means that in the beginning of the improvisation, these concepts have to be defined and mapped onto the colours shown by the device. This step was implemented via a “randomness wheel”, that randomly switched on up to five of the CPB’s ten built-in LEDs in different colours. This choice was first triggered by pressing a button on the CPB. However, this was later changed to shaking the device, which was inspired by the shaking motion known from other randomizers, such as the magic 8 ball or when shaking up dice before rolling them in a board game.

The feature, which should accompany the dancer in their movement exploration task, was designed to be triggered by double tapping the CPB. Each colour from the set of the mapping outcome before would show for a certain duration defined by the interval range mentioned above and subsequently switch to the next one.

Wearable mode

The first step in creating the wearable mode of the prototype was to redo the sewn circuit, which can be seen in Figure 5.8a. The pins on the haptic motor controller were soldered to short wires that could more easily be separated at the connection point, in contrast to the thread used before. Moreover, the wires could be crossed without the need for another layer of insulation. Conductive thread was used to connect the ends of the wires with the CPB pins. It was sewn using a running stitch, catching the tail of the thread. The knots at the ends of the stitches were secured using clear nail polish in order to avoid them coming loose. This was another slight improvement to ensure better conductivity and create a cleaner appearance. Because the vibration motor had very fragile wires, they had torn off in the first version of the prototype. Figure 5.8b shows that the vibration motor was therefore tucked underneath the haptic motor controller to avoid too much movement. Furthermore, the solder was renewed for this second version of the prototype.

While for the tangible mode the input for the dancer was set to switch at random intervals, the idea for the wearable mode was to react to the dancer’s movement. Therefore, when used in wearable mode and connected to a desktop or mobile device via Bluetooth, the CPB recorded data sensed by the built-in 3-axis accelerometer. This data was supposed to provide insights about repeating movement patterns, which could have been disrupted by the prototype’s vibration impulses.

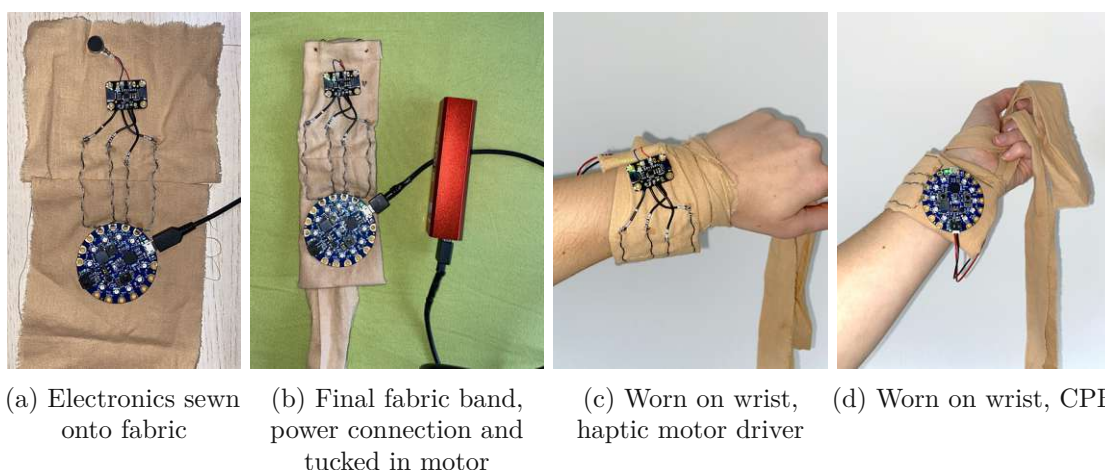


Figure 5.8: Prototype v.2

5.3.2 Autoethnographic Evaluation

As an intermediary evaluation step, I probed the prototype myself at home. In contrast to several tryouts of isolated functionalities during the development process, this instance was again a more structured approach similar to a workshop setting, but with a smaller scope. The use case I chose for the testing was a dancer’s individual movement exploration situation at home.

Procedure

For the initial mapping procedure, I shook the device. Two LEDs appeared, one in red and one in green. I consulted my dance notebook, in which I had occasionally captured dance moves I learned in class and wanted to remember. I opened it at a random page and placed the page on top of the CPB for the LEDs to shine through. I memorized the dance moves highlighted by the LEDs and their respective colour mappings.

Afterwards, I tested the *tangible mode*, in which the device is placed in the space and communicates via changing LED colours. I activated the program by double tapping the device. I played random music and started to move. The device gave me input when to use which of the dance moves looked up before. For a second song, I shook the device again, which resulted in three LEDs. I repeated the mapping procedure using the notebook and started the second round. I took some notes about my observations and moved on to probing the prototype worn on my body.

For the *wearable mode* I repeated the random choice and mapping process as described before. I then connected the CPB to my desktop via the Bluefruit Connect³ application and wrapped the fabric around my wrist, as depicted in Figures 5.8c and 5.8d. I put on random music from my playlist and started to dance. Each vibration was used as an input

³<https://apps.apple.com/de/app/bluefruit-connect/id830125974>, last accessed on 14/01/2024.

to switch moves. Meanwhile, the accelerometer data was recorded and afterwards saved on the desktop. This process was repeated two times, once with prototype placement on the chest and another time on the ankle.

Observations

For the tangible mode, the two colours in the beginning felt like a good start, but soon became repetitive. I therefore extended my “pathways” on the spot with additional concepts that came to my mind, which means that I did not follow the device’s instructions exactly. Nevertheless, the light cues reminded me to come back to the two base moves when I noticed that I drifted off too far. I further realized that I was focusing a lot on the CPB. When I became aware of it, I consciously turned away and kept on dancing. The lights were only used as guidance again when I felt like I needed another input.

I also noticed that no option to turn off the LEDs was implemented at this stage. Furthermore, the shaking and double tap interaction were too similar, resulting in the opposite expected output in some occasions. These types of interaction did not have correct thresholds to be clearly distinctive. Beyond that, the colour changing intervals felt too short sometimes. I was not able to fully explore my possibilities with one move before the device already prompted me to switch to another one.

When using the wearable mode, I could not distinguish the different vibration patterns. In contrast to the tangible mode, I could therefore not use a specific mapping of dance moves. However, I experienced this as an opportunity to a more open exploration of combinations and a challenge for my memory to recall the defined dance moves myself during the improvisation. What I experienced as difficult was tying the fabric around my body. It took several attempts to place the vibration motor on a spot where I could feel the vibration and at the same time not limit my movement due to the CPB being located a few centimeters next to it.

Regarding the detection of movement patterns from the recorded acceleration data, I tried several smoothing filters and visualization types. However, I could not detect any clear patterns, which could have provided universally applicable thresholds or other distinctive features for the program to react to, which would have worked for different dancers. I looked into algorithms, such as Fourier Transforms and approaches from literature about the Laban Effort Framework [44], dance tempo estimation from acceleration data [68] and ballet activity recognition [34]. However, implementing anything similar would have exceeded the scope of this thesis, which is why I decided against acceleration-based feedback for the prototype at this point.

5.3.3 Summary of v.2

Idea

The concept for guiding the movement exploration fit well into my personal approach to dance improvisation. Although I was fond of the idea that the device would react to the user’s movement, I decided to keep the random intervals instead. However, dealing with this issue in more detail could be a potential advancement of the prototype following

this thesis. At the same time, I was not able to ensure that any set thresholds, such as explained in Cat's interview, would have worked for any kind of dancer. In a worst case scenario, the device would either react too often, if the dance was very energetic, or never, if the movement could not reach the threshold value. For the planned workshop setting with several dancers, this was not a desired outcome.

Implementation

Compared to the first version of the prototype, all core functionalities needed for the mapping, tangible and wearable mode worked in version 2. At this stage, it was about refining single features to improve the user's experience with the tool. These included the mentioned timing of intervals, the lack of a button to switch off the lights, the similarities between double tap and shake input and the vibration patterns. Moreover, the physical arrangement of electronic parts was not ideal yet in terms of minimising irritation when worn on the body. Another iteration was necessary, as highlighted in Shneiderman's tenth design principle.

5.4 Prototype v.3 - Movement Xplorer

5.4.1 Design Process

The first improvements for this version of the prototype concerned the features mentioned in the previous section. An off-button was implemented, the duration of intervals was increased to a range between 8 and 30 seconds and the double tap interaction was replaced by a standard button push. The strength of vibrations was increased to make them easier perceptible and patterns were changed to single, double and triple vibrations instead of earlier, more nuanced variations.

Furthermore, the mapping of colours to dance moves was structured more clearly, drafting two paper templates for two corresponding colour patterns shown in Figure 5.9. The templates could be filled in with dance content and replaced the notebook used with the second version of the prototype. The "concepts-template" offers more guidance in selecting moves or concepts for the improvisation session. The second template holds empty spaces for any kind of dance input and suggests an interpretation of LED colors in a given field based on a "build-up" approach.

Although pure colours had already replaced the LED animations in the previous version of the prototype, the colours were still not recognisable well enough from certain angles. Due to the small size of the CPB, an improvement in visibility of the light cues was made. This was solved by enhancing the physical design of the artifact. A laser cut wooden case was created and equipped with a transparent plastic cover, offering a bigger surface for the coloured light to be evenly distributed across, as can be seen in Figure 5.10a.

Because the wooden case was supposed to have a convenient size, it did not fit the whole fabric of the wearable construction inside without lifting the case's lid. Moreover, the extension with the haptic motor was not necessary for the tangible version, which the case was designed for. Therefore, I decided to separate the CPB from the remaining

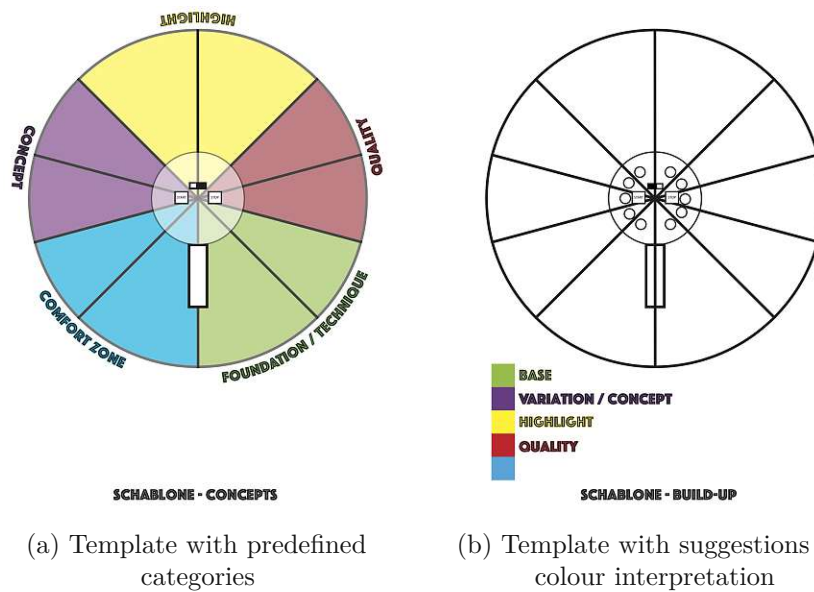
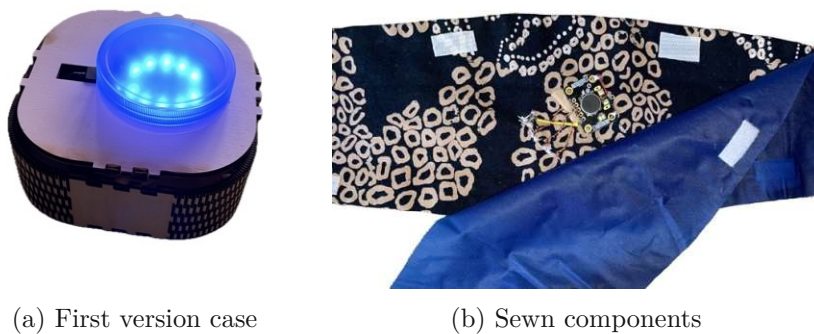
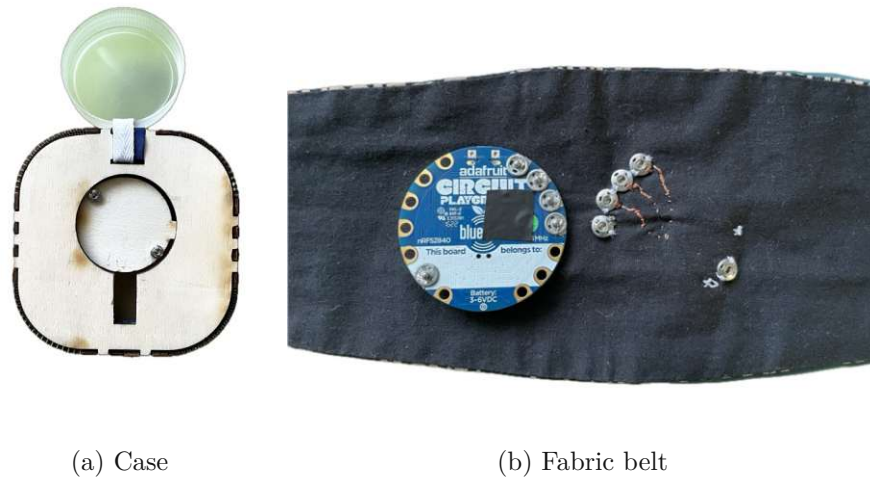


Figure 5.9: Paper templates for mapping dance concepts to colours

Figure 5.10: Improved physical design in the final *Movement Xplorer* prototype

electronics needed for haptic interaction and create mounting spots for the CPB on both the wooden case and the fabric, as can be seen in Figure 5.11. This was done using snap buttons, one side of which was soldered onto the CPB's pins. For the tangible mode, two complementary sides of the snap buttons were glued onto the wooden case. They did not fulfil any purpose of electronic connection, but simply held the CPB in place. A connective function, however, was given in the wearable version, which was now also realized with a more robust fabric belt from an old piece of clothing. The complementary sides of the snap buttons were sewn onto the fabric. This time, copper embroidery thread was chosen over the previously used thread and wires for connecting the snap buttons to the haptic motor controller. The main reasons for this were the lack of fuzziness and reduced potential breaking points, which I considered more robust and less prone to



(a) Case

(b) Fabric belt

Figure 5.11: Snap connections on the case and belt

wearing off or creating unwanted connections to nearby components. Because one of the threads still had to cross the other ones, it was insulated with a heat shrink tubing before sewing it onto the fabric. The sewn components are depicted in Figure 5.10b.

Another adaptation in the arrangement of components was made. This concerned the previous problem, that both the CPB and the haptic motor had to be placed conveniently on the body. Given that wearing only one component can already be irritating to a dancer, the two parts were arranged on top of each other. This was supposed to simplify finding a suitable spot on the dancer's body for placing the device. The final attachment of the CPB on the fabric is illustrated in Figure 5.12.

Final touches to the artifact included equipping the fabric belt with a plastic layer on the body-facing side in order to separate the electronics from sweat on the dancer's skin. It was not sewn in place, but attached using velcro due to the planned use with multiple dancers in a workshop setting (Figure 5.10b). This way, the cover could be quickly replaced for each dancer. Furthermore, a fastener was applied to the wooden lid of the case in order to keep it closed while in use (see Figure 5.13a). Figure 5.14 additionally shows the inside of the wooden case, containing a power bank and the connecting cable for the CPB as well as the back side with the engraved prototype name.



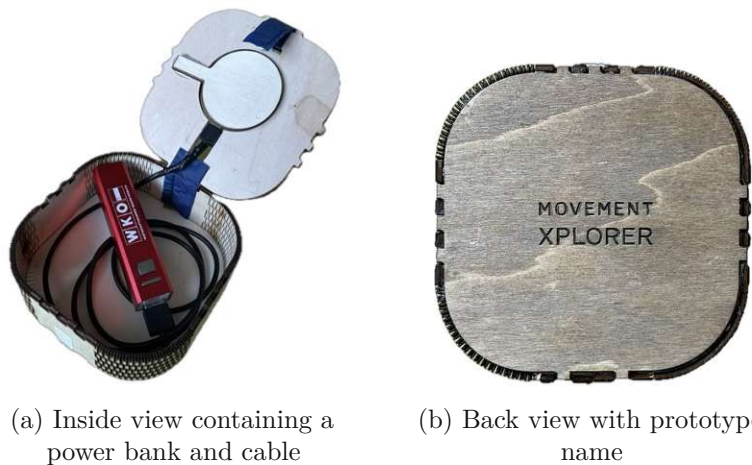
Figure 5.12: Final prototype on the fabric belt for the wearable mode



(a) Attached lid fastener (blue)

(b) Folded back transparent cover for accessing CPB buttons

Figure 5.13: Final prototype in the wooden case for the tangible mode



(a) Inside view containing a power bank and cable

(b) Back view with prototype name

Figure 5.14: Wooden case



Die approbierte gedruckte Originalversion dieser Diplomarbeit ist an der TU Wien Bibliothek verfügbar
The approved original version of this thesis is available in print at TU Wien Bibliothek.

Evaluation

Similar to the ideation phase, the evaluation of the final prototype included two workshops, one of which was autoethnographic and the other one conducted with fellow dancers. The procedure of both workshops was equivalent, again following five phases like in the previous two workshops: setting the scene, warm up, exercises, cool-down and reflection or discussion, respectively. This time, all exercises incorporated the prototype instead of input from a teacher.

6.1 Autoethnographic Evaluation

The present section describes my personal observations from a first-person perspective of using the tool. I will first explain my interaction with the tool and its influence on my movement, before adding further reflections emerging from the session. At the end of the section, I will also mention what features I noticed having potential for minor final improvements in preparation for the user evaluation.

Movement

Tangible mode

The first two exercises involved the *Movement Explorer* case placed in the room. Each exercise employed a different template filled in with dance concepts from my personal knowledge, as shown in Figure 6.1. In the first round, I noticed that I waited for the tool's instructions about what concept I was supposed to use in my improvisation. I also needed some time to find into the music in the beginning and eventually switched to another song. The second one felt good, so I started to play with my moves and concepts according to the tool's prompts. After a few changes, I created a transition between two moves that I liked and it instantly made me smile. I repeated the combination and explored some variations of it. Toward the end of the improvisation, I felt like I did not

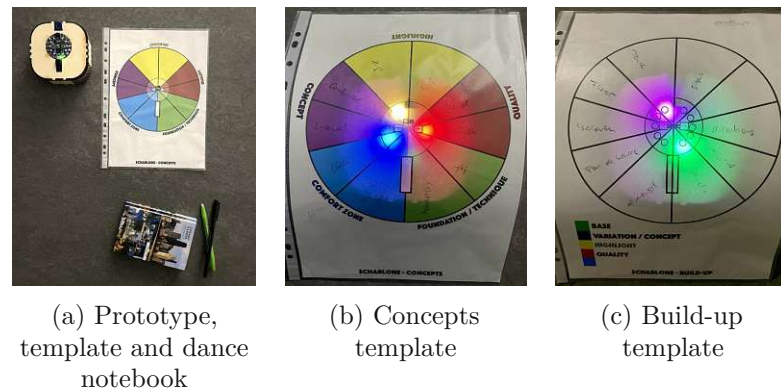


Figure 6.1: Impressions of the mapping with templates used in the workshop

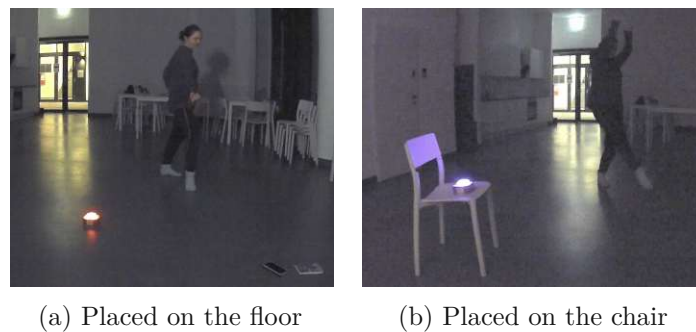


Figure 6.2: Impressions of the tangible mode used in the workshop (screenshots from action camera recording)

need the tool as much. I turned away and only took a glance at it when I felt stuck in what I was doing. For the second round I lifted the prototype off the floor and placed it onto a chair, because I noticed that I was looking at the floor a lot before. Impressions of the two placements are given in Figure 6.2. The tool showed only two LEDs this time, which soon felt tedious. Because I was looking for more input, I decided to shake the tool again. Similar to the first exercise, I was able to find a movement pattern that I liked. However, this time I was not sure whether it was triggered by the tool as well. It felt more like dancing to a specific rhythmical pattern in the music, without too much fixation on the tool's prompt, while still implementing its defined concepts.

Wearable mode

The remaining exercises concerned the wearable version of the tool, which I tested on several body parts. For these exercises, I did not decide on specific concepts at first, but engaged in an open investigation into how I would react to the tool's vibrations. When wearing the tool wrapped around the ankle or the arm, I instantly started to move the respective extremity a lot. I noticed that I lifted my foot more often and in different ways than I would normally do. I also varied my arm movements in quality and speed. Unfortunately, I did not feel the vibrations well on these parts of the body. The other

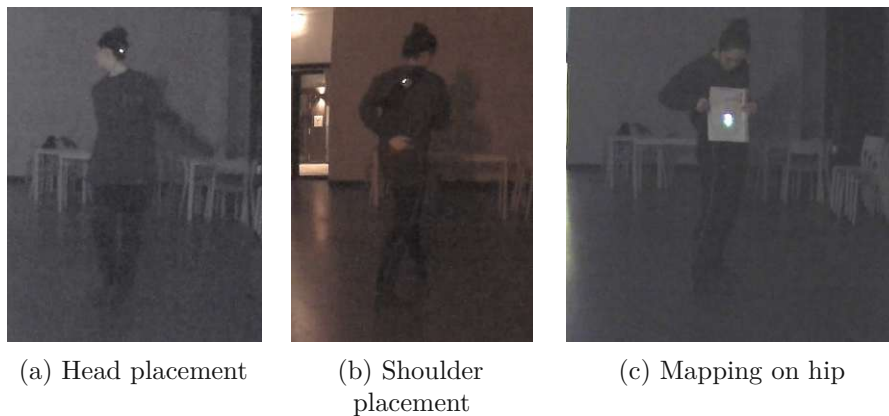


Figure 6.3: Impressions of the wearable mode used in the workshop (screenshots from action camera recording)

placements included the back of my head, the shoulder, and the hip, which can be seen on the screenshots from the action camera recordings in Figure 6.3.

In case of the head-placement, I also started off the round with several turns and tilts of the head. However, I soon let go of fixating on this part of the body and started to use the tool as an impulse for switching between moves, similarly to the tangible version. Because the vibration motor was located near my ear, the stronger vibration pattern was slightly uncomfortable, which is why I adjusted the fabric during the exercise in order to increase the distance to the ear.

In the three cases above, I worked with concepts I either remembered from the template used in the collaborative version before or thought of on the spot. For the remaining two exercises, I wanted to “shake things up” again and use different concepts. My exact words from my post-workshop reflection were the following:

“I checked the template again because I realized I’m somehow dancing without purpose.”

I therefore consulted my template again, but since I was wearing the tool on the hip already, I had to jump up and down and shake my hip in order to activate the mapping functionality. While at first I thought that this would be inconvenient, I actually started to laugh and had fun finding out how quick I had to move for the device to recognize a shaking motion. The resulting mapping procedure to the template notes is shown in Figure 6.3c. After comparing the video recordings of the exercises, this one was the first among the exercises using the wearable mode, which I personally considered more interesting to watch in the first few seconds already. Another aspect visible in the video was that my decisions to switch between moves were no immediate reactions to the tool, but delayed and guided by the music.

I finished the session with a tool placement on the shoulder blade, which led to what I considered the most “genuine” type of movement for my personal dance background. It was not unfamiliar movement. On the contrary, it involved, for example, a back and forth rocking motion of the upper body, which is a foundational movement element in Hip Hop. In combination with a music track that had a convenient beat for this type of movement, it resulted in an organic flow of motion, which I experienced as a pleasant surprise. For me, personally, this rocking motion usually happens either by consciously thinking of it or naturally, in a rather small size of moving. This time, it resulted from a kinaesthetic reaction to the tool worn on the shoulder and I was able to exhaust a bigger size as far as my injury allowed.

Reflection

The workshop not only had an influence on my movement, but also helped me surprise myself with a thought about positioning myself in dance. It reminded me of a similar situation that happened previously in the interview with the founders of the dance podcast described in chapter 4. When I filled in the prepared demographics form for the workshop myself, I hesitated with my answer to the question about previous dance experience. I wanted to write down my work as a dance teacher, but was not sure whether to phrase it in past or present tense. Due to my injury I was not teaching at that time, but I knew that not only within my research, but also in occasional conversations with former colleagues, I still care about dance education from a teacher perspective.

Furthermore, realizing which types of movement came naturally during the improvisation exercises and which did not made me question my foundations and reflect on my personal dance practice. It helped me identify factors, that are important to me, personally, for facilitating a creative process. Evaluating this based on my notes about the workshop, these include having “a purpose” while dancing, being able to interpret the music beyond dancing to the basic, underlying beat or dominant rhythm, and surprising myself with non-habitual movement.

There are, however, two further thoughts that I would like to highlight at this point. First, I am generally a fan of “dancing without a purpose”. It can be a feeling of relief and joy, when I can let go of any thoughts in my head and just move to music. Nevertheless, a certain structured approach apparently helps me trigger my creative potential. Second, I would like to offer a more nuanced interpretation of non-habitual movement. Before, I focused on novel movement in terms of not being present in the body’s movement vocabulary. However, I realized that the upper body rocks were very familiar to myself and present in my dance vocabulary. Nevertheless, I was only aware of not using this kind of movement in my improvisation, until I did. It was triggered by wearing the tool on the upper body. It required the vibration and/or knowledge about recording the acceleration as one side of the communication for the movement to arise. In an earlier instance of wearing only a piece of fabric on the body as a non-technical prototype predecessor, no such observation in movement had been made.

Overall, the workshop setting using the tool reflected three of the four categories identified in Table 4.5: *Personal* aspects were present due to an analysis of my own movement habits and the reassessment of my care for dance education. The prototype also acted as a motivator to engage in the improvisation task, which represents the *dance task* component. Finally, *ambient* factors, such as the adjustment of the room’s illumination but also the increasing concentration on the tool further into the progress of the workshop helped me reach a focused, creative state of mind.

Technical features

On the technical side, both the vibration and LED patterns required slight adjustments. The vibrations were not perceptible and distinguishable well enough for all tested body positions. The tool also occasionally showed colours that were not present in the template-mapping mode before, which caused some confusion during the improvisation. Improvements according to these aspects were made prior to the following workshop with other dancers.

6.2 User Evaluation

A total of five participants, one male and four female dancers, took part in the second workshop. Four participants had completed a dance education program, two of which worked as dance educators at the time of the workshop. All five dancers had experience in multiple dance styles and were open to an improvisation class. Two participants stated that they “love” improvisation, despite one of them admitting that it was hated at first. Other descriptions of their thoughts about improvisation included “interesting”, “important” and “ingenious”. Their usual improvisation practice comprised both structured and spontaneous movement exploration situations. One participant mentioned frequently watching YouTube videos, another one stated that they sometimes play with props, such as balancing a bottle on the head as a challenge for triggering non-habitual movement. Beyond that, the “space problem” was mentioned as a more general issue. In the own home, dancers usually do not have enough space to utilize their full range of motion. Renting a space, in turn, is associated with costs, which is why many dancers choose not to do it. Exploring one’s full potential is therefore not easily possible on a regular basis.

The procedure of the workshop was similar to the description in the previous section. Participants were first asked to each fill in a template with their dance concepts and were introduced to the collaborative version of the tool. Afterwards, the five participants tried the wearable version on a body part of their choice for a duration of one song each. The tested body placements comprised the wrist, hip, thigh and ankle. In contrast to the autoethnographic workshop, the wearable version also included the LED functionality, in order to maintain a form of interaction for the dancers currently not wearing the tool. An exemplary situation is shown in Figure 6.4.

The observations as well as findings from the discussion and open survey questions following the workshop are again explained with respect to the influence on movement

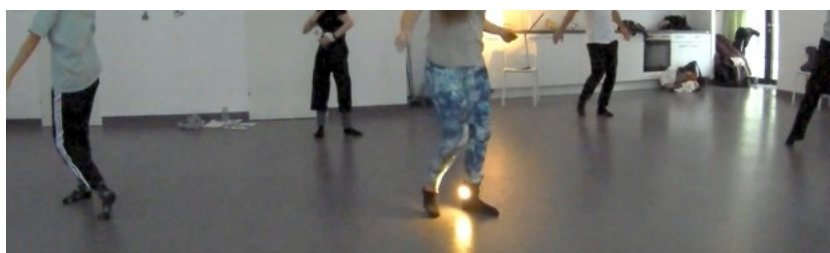


Figure 6.4: LED functionality in wearable mode (screenshot from action camera recording)

and further reflections induced by the session. Because the survey was anonymous, participant labels P1-P5 are only reported for the verbal discussion statements.

Movement

Participants' feedback on their movement flow while using the tool showed differences in how they handled transitions between moves. Some of them used the tool's cues as instructions, which means that they actively paid attention and tried to instantly switch moves according to the new colour of the LEDs. Other participants saw it as a supportive guide offering them options when they felt like they needed new input. Two of them also noted that due to initial difficulties with memorizing the concepts from the template, they did not always react with the proper colour-coded moves, but just continued dancing.

“I looked at the tool a lot because I did not want to miss the transition.”
(P3)

“I often improvised then ... Because I often did not know ... what was that again?” (P1)

“In the end, I didn't completely memorise it either, but then I just did my thing.” (P4)

P2 highlighted that due to the prompts not being synchronised with the music, it could be counter-intuitive to switch to another move in the specific moment. At the same time, this created some interesting transitions which would not have happened without an external impulse. Another dancer also mentioned that these moments of transitions were the most exciting aspect for them.

“Because you often stay in the flow, I'd say. And then when another colour comes along - ah, how do I make the transition to the next colour? [...] And this has led to other movement sequences. I thought that was cool.” (P4)

P3 further described that the tool activated the body part it was worn on. When asked whether P3 also performed this kind of movement in the rounds before, they answered that this movement was different and triggered by the tool. P1 added that it may have originated from the knowledge that an accelerometer was collecting movement data.

“I wore it below on my foot and therefore I did a lot of footwork all the time. Because it vibrated and [...] it was directed to the feet.” (P3)

Reflection

Both the tool itself and the application scenario it was used in had an effect on the participants’ experience. P3 described experimenting with novel footwork as a positive effect. They appreciated the additional LED lights and the excited way of talking about it seemed like it had a positive influence on their mood while dancing.

“It lit up so beautifully. I thought that was super nice.” (P3)

For P4 working with the template played a role in influencing their attitude towards improvising.

“But it’s good to have a template like this. Then you’re braver or more willing to improvise more. You’ve already had more inspiration from before and then you get into the flow.” (P4)

Moreover, P4 explained that the wearable version “opened the room” and provided a change of perspective. This did not only apply to wearing the tool on the own body but also when other dancers wore it. P2 did not experience this effect. They deliberated on an external or internal perspective as a result of the tool’s position on the body.

“Because I wore it more on my stomach, I thought it was more inward-facing. But maybe ... I think you had it on your hand, didn’t you? (P4: Yes.) Maybe that makes you a bit... because of course you also perceive it more visually...” (P2)

Although this inward attention to one’s body was mentioned in the discussion, the contrary was also reported in the survey afterwards.

“It rather distracted me. I was too focused on the colours. I think it would take some time to achieve this approach [of turning the attention inwards].”

“To feel while dancing was easier without the tool. It’s good for reflecting on what the ‘patterns’ are, but I think the exploration is almost inhibited. It is very rational, which makes it difficult to feel.”

The other two participants described the benefit of focusing on single tasks using the tool.

“It gave an impetus to focus on one key point at a time and not to be overwhelmed by too many ideas that you want to realise”

“Sometimes a task has come along that felt very good and could then be pursued intensively.”

The last topic discussed concerned the motivation for using a tool like the prototype tested in the workshop. P2 thought about it in terms of seeking new input as an extension of the usual dance practice, which involves going to (improvisation) classes. This could be realised with a platform for dancers to exchange their templates.

“I would find it really cool, if one would combine it with a platform, where all people can enter their templates if they want to. And then you would have a pool and could maybe sort it by categories or styles. Or if it had a function that gives you something random. Because I think ... When I go to improvisation classes, I go there specifically, firstly, to have space and room and also energy from others, but I also go there to get new input. [...] But it would still be different to a real person who can read the energy in the room.”
(P2)

According to P2, it could also help with setting a focus in situations where one is motivated to improvise but has either too many or too few ideas. P3 and P4 agreed to it being an *additional* way of receiving input and mentioned preparing for championships and creating choreography as further potential application areas.

Further ideas mentioned in the post-workshop survey contained similar opinions about adding variation to the training, collecting ideas and receiving input that extends the current memory. One participant added that it could also be used “to practise and deepen different skills/dance steps”. While these scenarios predominantly resemble individual practice situations, P1 stated that they would rather use the tool in a group than alone.

Similar to the previous autoethnographic version, the *personal*, *ambient* and *dance task* components were present in the group workshop. Additionally, the group setting provided the foundation for the fourth component, which is about *social* connection and exchange.

Technical and conceptual considerations

The first exercises with the tool and template were perceived as challenging, because it was a lot of new information at once for the participants. As researcher in the room this was observable, because several questions were raised and more time than expected was needed for filling in the template. This was also stated as a response to the post-workshop survey question regarding the general impression of the workshop and tool. Similarly, participants also reported on a learning curve with the tool in the discussion.

“I found it quite tough. A lot of freedom on which to apply the system, which is difficult if you are not proficient of the language required for the template. When you have to set it up yourself.”

“In the beginning ... I couldn’t quite remember which colour was which. But that’s ... so if you use it more often, then it gets pretty clear.”

A gradual increase in difficulty would be a reasonable improvement of the tool suggested by P4, starting with few colours or vibration patterns and increasing them over time. This would reflect Shneiderman’s second design principle of a low initial threshold but still offer the possibility to use more complex patterns.

Moreover, participants thought about expanding the LED functionality to a lamp that illuminates the whole room and adding auditory feedback by coupling the tool with the music. One survey-participant additionally explained that they expected the workshop to make use of a different kind of technology.

“At the beginning, I had a completely different idea of what was to come (an AI that imitates me as a dancer and is shown via a computer or projector, which results in various data that is compared). In the end, it was a beautiful dance together, with the support of a tool.”

Some other general feedback to the workshop used language that was also present in advertising the session.

“Interesting opportunity to broaden one’s dance horizon and expand creativity.”

“Very exploratory, creative and communicative.”

6.3 Creativity Support Index

As a post-experiment survey, the Creativity Support Index questionnaire was administered at the end of the user evaluation workshops. As suggested by Cherry and Latulipe [18], the questionnaire was provided online in order to make the following calculation of the index more convenient. Participants were directed to the website via scanning a QR-code with their mobile phones. They were asked to provide their responses as soon as possible after the workshop, because the time for the session did not suffice for an in-person administration. Due to this, one participant unfortunately did not take the survey. Therefore, four cases from the user evaluation were used as a basis for further analysis.

The questionnaire contained 10 questions, in which statements were rated on a scale of 1 to 10. Two statements each belonged to one of the factors *Enjoyment*, *Experience*, *Collaboration*, *Immersion* and *Results Worth Effort*. The pairwise factor comparison

comprised 15 questions, in which participants were asked to select one of two options that was more important to them while performing the improvisation exercises with tool. To recall the detailed context of the evaluation, the following results represent the CSI for an open-ended movement exploration task with the *Movement Explorer* prototype used by intermediate to professional dancers and dance teachers.

6.3.1 Limitations of the CSI evaluation

It has to be noted at this point that the CSI was only an addition to the qualitative feedback from participants and potentially cannot be compared exactly to CSI scores from other Creativity Support Tool evaluations. This is because of two reasons. First, the questionnaire was translated to German, which means that the different wording may have been interpreted differently to the original by the participants. Second, an error occurred in the administration of the questionnaire, which resulted in missing data for the statement “I would be happy to use this system or tool on a regular basis” in the *Enjoyment* scale. The missing data was obtained retrospectively by getting in touch with participants and kindly asking them for the missing response. Again, this resulted in four cases from the same participants, who had taken the survey before.

For the overall CSI score, the data obtained in hindsight was added to the dataset. Because the survey was anonymous, a correct assignment of the values to each participant could not be guaranteed. However, the choice of order was taken based on participants’ previous open answers to the question “How would you use the tool in the future?”. Additionally, the minimum and maximum possible values for the CSI were calculated for an error margin reference. This could be done after determining each participant’s counts of the *Enjoyment* factor from the paired-factor comparison test.

Despite the flawed administration and the low number of participants, it was decided to still calculate the index as a proof of concept in order to demonstrate its potential value for similar research projects in the future. However, I am aware that the following presented values cannot be considered meaningful and do not fulfil all requirements for the performed statistical tests as well as a standardized comparison. I therefore provide a transparent description of my process and advise the reader to treat the results with caution.

6.3.2 Results

The first outcomes are concerned with the language of the questionnaire. Original as well as translated statements are listed in Tables 6.1 and 6.2. The recommended calculation of reliability analysis was performed in IBM SPSS v.29.0.0.0 using the four response cases from the participants. Results are shown in Table 6.3. At least for all scales except the *Enjoyment* scale, the values would suggest that the German translation may have produced reliable sub-scales for the calculation of the CSI.

The average CSI of the four participants in the qualitatively informed ordered dataset was 77.25, which corresponds to a school grade C in a grading scheme from A to F.

English (original)	German
<i>Collaboration</i>	
1. The system or tool allowed other people to work with me easily.	Durch das System oder Tool konnten andere Personen leicht mit mir zusammenarbeiten.
2. It was really easy to share ideas and designs with other people inside this system or tool.	Es war sehr einfach, Ideen und Entwürfe mit anderen Personen innerhalb/mithilfe dieses Systems oder Tools auszutauschen.
<i>Enjoyment</i>	
1. I enjoyed using the system or tool.	Es hat mir Spaß gemacht, das System oder Tool zu benutzen.
2. I would be happy to use this system or tool on a regular basis.	Ich würde dieses System oder Tool gerne regelmäßig nutzen.
<i>Exploration</i>	
1. It was easy for me to explore many different ideas, options, designs, or outcomes, using this system or tool.	Es war einfach für mich, viele verschiedene Ideen, Optionen, Entwürfe oder Ergebnisse mit diesem System oder Tool zu erkunden.
2. The system or tool was helpful in allowing me to track different ideas, outcomes, or possibilities.	Das System oder Tool hat mir dabei geholfen, verschiedene Ideen, Ergebnisse oder Möglichkeiten zu verfolgen.
<i>Expressiveness</i>	
1. I was able to be very creative while doing the activity inside this system or tool.	Ich war in der Lage, sehr kreativ zu sein, während ich die Aktivitäten innerhalb dieses Systems oder Tools durchführte.
2. The system or tool allowed me to be very expressive.	Das System bzw. das Tool hat es mir ermöglicht, sehr ausdrucksstark zu sein.
<i>Immersion</i>	
1. My attention was fully tuned to the activity, and I forgot about the system or tool that I was using.	Meine Aufmerksamkeit war voll und ganz auf die Tätigkeit gerichtet, und ich vergaß das System oder das Werkzeug, das ich gerade benutzte.
2. I became so absorbed in the activity that I forgot about the system or tool that I was using.	Ich war so vertieft in die Tätigkeit, dass ich das System oder das Tool, das ich benutzte, vergaß.
<i>Results Worth Effort</i>	
1. I was satisfied with what I got out of the system or tool.	Ich war zufrieden mit dem, was ich aus dem System oder Tool herausholen konnte.
2. What I was able to produce was worth the effort I had to exert to produce it.	Was ich produzieren konnte, war die Mühe wert, die ich dafür aufbringen musste.

Table 6.1: 12 agreement statements in the CSI questionnaire in the English original [18, p.21:6] and German translation. Each statement is rated on a scale from ‘Highly Disagree’ / ‘Stimme überhaupt nicht zu’(1) to ‘Highly Agree’ / ‘Stimme voll und ganz zu’(10). For the participants, factor names and statement labels were hidden and statements were presented in random order.

English (original)	German
“When doing this task, it is most important that I am able to ...”	“Bei dieser Aufgabe ist es wichtiger, dass ich ...”
1. Be creative and expressive	kreativ und ausdrucksstark sein kann.
2. Become immersed in the activity	in die Aufgabe vertieft sein kann.
3. Enjoy using the system or tool	Spaß daran habe, das System oder Tool zu verwenden.
4. Explore many different ideas, outcomes, or possibilities	viele verschiedene Ideen, Ergebnisse oder Möglichkeiten erkunden kann.
5. Produce results that are worth the effort I put in	Ergebnisse erziele, die den Aufwand wert sind, den ich betreibe.
6. Work with other people	mit anderen Menschen arbeiten kann.

Table 6.2: Six choices for the 15 paired-factor comparison statements in the English original [18, p.21:7] and German translation. The participant is asked to select one description from each presented pair.

Scale	Cronbach’s Alpha (N=4)
Results Worth Effort	0.974
Exploration	0.771
Collaboration	0.947
Expressiveness	0.952
Immersion	0.640
Enjoyment	N/A
Overall CSI	0.835

Table 6.3: Results from Reliability Analysis of the German CSI questionnaire, based on four response cases from participants. The Enjoyment scale was not calculated due to the administration error.

The calculation of the minimal and maximal average CSI resulted in 76.42 and 77.75, respectively, which spans an error margin of 1.33. Detailed results for each participant are listed in Table 6.4.

The paired factor comparison resulted in a ranking of factor importance listed in Table 6.5. It also includes the average statement agreement ratings per factor and its weighted version using the respective factor count from the pairwise comparison test. These results reflect the participants’ verbal and written feedback. A low average score of the *Immersion* factor was expected due to participants’ comments about the tool distracting them and their active attention to the tool’s impulses. However, it did not gravely affect the overall CSI score, because participants did not consider this factor as very important in their improvisation task. Similarly, *Exploration* was rated with highest importance for the task. The tool supported this factor well, according to average factor scores. In the *Collaboration* statements, the tool was perceived as supportive, which was also highlighted in the verbal discussion at the end of the workshop. What is interesting,

ID	Enjoyment-weight	CSI (closest fit)	CSI (max. weighted)	CSI (min. weighted)
1	5	83.0	88.0	81.33
2	4	90.33	86.33	86.33
3	4	50.33	51.67	51.67
4	1	85.33	85.0	86.33
Avg. CSI		77.25	77.75	76.42

Table 6.4: CSI results per participant and average overall CSI values

Factor	Avg. Factor Count out of 5	Avg. Factor Score out of 10	Avg. Weighted Factor Score out of 50
Exploration	4.5 (1.5)	8.375 (1.139)	39.25 (18.122)
Enjoyment	3.5 (1.5)	7.625 (-)	27.375 (16.908)*
Expressiveness	2.75 (0.433)	7.75 (2.278)	22.25 (9.811)
Collaboration	1.75 (1.299)	8.0 (1.541)	12.875 (11.579)
Immersion	1.5 (1.118)	5.0 (1.768)	8.125 (8.967)
Results w. Effort	1 (0.707)	7.625 (2.559)	6.0 (4.143)

Table 6.5: Results from pairwise comparison of factors and average agreement ratings of factors weighted by selection count. Values in parentheses represent standard deviations. The table represents the importance of factors for the given improvisation task and the prototype's level of supporting them, ordered from most important (top) to least important (bottom). *These values correspond to the approximated version of the Enjoyment scale.

however, is that this factor's importance was rated at rank 4 only. Overall, this ranking of factors provides insights into what aspects a CST for dance improvisation shall focus on. The CSI score, combined with qualitative feedback, suggests that the *Movement Explorer* offers a solid foundation to build upon. As a proof of concept, the prototype has fulfilled its purpose. However, for a final CST, the feedback shows that there is still room for improvement.



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CHAPTER 7

Discussion

The present chapter provides a synthesis of research, design and evaluation findings in order to answer the research questions stated at the beginning of this thesis. While the first two questions will be answered rather briefly, the third question leads to a closer examination of the triangulation between dance, creativity and technology, elaborating on their interplay in more detail. This is followed by discussing further topics that arose within the research project and their relation to the body of literature in this field. Lastly, the research at hand is reviewed in terms of contributions, limitations and potential avenues for future research.

7.1 Research Questions

7.1.1 RQ1: How can creative processes in dance be supported through digital tools?

In the course of this thesis, various touch-points between dance and technology, both potential and already existing ones, were encountered. With its many facets, dance comes with different tasks taken on by different roles of dancers, which provide different foundations for applying digital tools. In order to answer this research question, the findings about processes in dance and their use of digital technologies from literature are juxtaposed with user research results in Table 7.1. Using examples from the works mentioned in section 2.1, it provides a comprehensive overview of the various application scenarios, which lays the foundation for discussing overarching characteristics of support tools in dance.

The first step towards answering this question is to determine what creative processes in dance are. Although survey participants did not consider all the listed processes as creative per se, the overall research showed that support in “non-creative” tasks, such as *Entertainment* and *Analysis*, can facilitate inspiration and reflection. This, in turn, can indirectly benefit a dancer’s creativity. However, I would argue for a distinction to classical office tasks and their focus on productivity, rather than support the notion that any task in dance is a creative one based on the overall creative nature of dance.

This latter view may still be acceptable within the broad definition of CSTs. Frich et al. [29] have already pointed out the necessity for a more narrow definition of CSTs, or sub-sets of CSTs, which the dance domain in this area of research could also benefit from. Nevertheless, each definition ultimately depends on the respective understanding of creativity. This can be highly individual, despite certain commonalities between the various creativity theories explained in section 2.3. As the table shows, not only dance practice but also research thus offers a diverse tool landscape resulting from the many tasks, needs and roles in dance. While these “sub-sets” of dance have provided boundaries for task-specific design guidelines, such as for interactive performances [48] and the choreographic process [19], these may still not apply for all dancers in a universal fashion. Because of that, I question whether future attempts to define CSTs in dance in a narrow sense will perhaps not be able to reach a universal truth. However, this may not be

Literature Examples	Participant Data
<i>Choreography & Notation</i>	
Tools for generating or simulating choreography (Living Archive [49], generative algorithms [16, 11, 54], (i)DanceForms [14, 17]) Formal notation tools (MacBenesh [61], Laban-Writer [76], LabanDancer [79]) Other notation tools (Choreographer’s Notebook [67], Knotation[19])	Tools for inspiration (Google, YouTube, Instagram, TikTok) Tools for capturing ideas (smartphone camera, speech memos, digital text editor, MoCap*) Tools for choosing, editing or adjusting music (Free-ware)
<i>Performance</i>	
Interactive Audio-Visual systems (Dance.Draw [46], SKIN [26], Isadora [20])	(Interactive) Audio-Visual augmentation Virtual performance (Zoom/Stream), VR* LED-Costumes Tools supporting video performance (camera, editing software) Dance formation apps Music editing software
<i>Improvisation</i>	
Interactive visualizations (Choreoprobe [37], Choreomorphy [57]) Responsive audio system [2] Soft robotic wearable (Wearable Choreographer [3])	Tools for ambient adjustment (lights) VR*
<i>Education</i>	
VR learning systems [77] Mimetic systems [23]	Dance tutorials (YouTube, platforms from specific teachers, VR**) Tools for class preparation (digital file- and tag-system, music playlists, beamer, social media, YouTube)
<i>Documentation, Research & Analysis</i>	
Motion Capture or video database [8, 22, 49] Video annotation software [67, 22] Kinect [69] or accelerometer sensors [44, 66] for LMA	Motion Capture* Video (on smartphones, YouTube playlists) Podcasts, audio books, videos, documentaries
<i>Entertainment</i>	
Dance games [23]	Just Dance Social media, TV-shows, podcasts
<i>Other</i>	
	Tools for health (blackroll app, TENS device, Yoga platforms) Tools for connection (dance partner plaforms, chat-messengers) Tools for office tasks (job applications, invoices) Tools for organising classes (advertising, class registration, event planning) Smartwatch App** for tracking dance

Table 7.1: Comparison of literature and participant data: types of tools for different processes in dance. *Practical use uniquely reported in the particular VR-project interview. **Future tools imagined by participants.

necessary, if researchers provide enough context with respect to the dance task or process, the definition of creativity, dance forms, user roles and similar characteristics.

As a second step, a closer examination of the types of tools supporting the listed processes is necessary. What is noticeable in this comparison is that tools in the “Participant Data” domain predominantly comprise video-based tools, smartphone apps and only occasionally specific software. The latter is used for tasks, such as music and video editing, which are not as closely related to the moving body itself, but play an important role for realising a dancer’s potential. Moreover, the specific software examples reported by some survey participants are known as freeware, which suggests that dancers may not use them to an extent that would be worth paying for a subscription.

Considering the technologies listed in the *literature* domain of Table 7.1, more resources in terms of money, space and collaborators are needed for their application in dance. These are not accessible to all dancers on a regular basis, but can occur in funded projects. The interactive performances using SOMI-1 wearable sensors or Virtual Reality combined with Motion Capture discussed in two interviews are examples for the latter. In both instances, the artists had financial support and collaborated with technical experts, which laid the grounds for interdisciplinary, creative work. Although this is not comparable to everyday dance practice, similar settings are what research predominantly focuses on. This collection of tools reflects the critique that CSTs for dance from research often remain in prototype stage and do not reach end users except those participating in studies. This was mentioned, for instance, with respect to dance learning systems [23], but also concerns other types of tools, as very few of those mentioned in literature were found in more public contexts beyond the respective scientific paper.

In conclusion, creative processes in dance can be supported in many different ways. While literature has primarily suggested the integration of various visual representations of information, research also offers a few examples of soma-based and kinaesthetic approaches as well as wearable technology using other interaction modalities. The practical domain explained by study participants shows a similar focus on visual perception. In contrast to systems described in literature, this is heavily reliant on social media and video-based interaction in dance.

Because a more concise explanation cannot be given without narrowing the dance field down to a sub-set of the presented tasks, I would like to finalize an answer to this research question by referring to Table 4.5 about factors influencing dancers’ creativity, again illustrated in Figure 7.1. Building on this and connecting it to further autoethnographic and evaluation findings, a tool can support creativity in dance, as defined by this study’s participants, on four levels. The *personal*, by fostering a positive mindset, reflection and motivation. The *ambient*, by helping the dancer in creating a comfortable physical environment. The *social*, by providing exchange opportunities beyond so-called “see and be seen” additionally to an individual use of the tool. And the *task-specific*, by encouraging the dancer to engage in creativity enabling tasks within the given area of dance the tool is designed for. Because the “comfortable environment” and “creativity

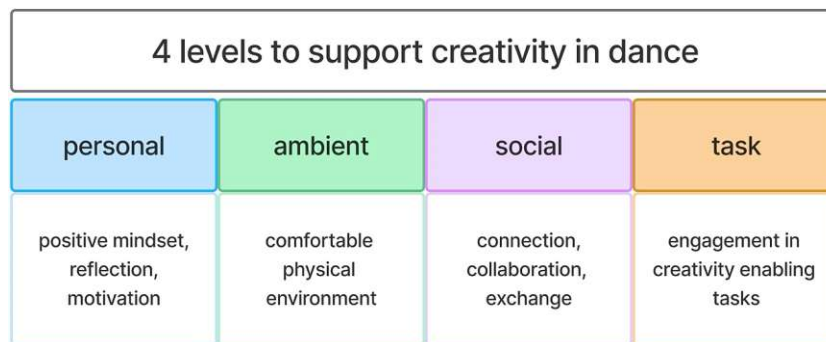


Figure 7.1: Four levels to support creativity in dance

enabling task” is highly individual for each user, the need for possible appropriation [37, 48] is emphasised again at this point.

7.1.2 RQ2: How does a non-screen based digital artifact fit into a creative process in dance as a means of creative support?

Before this question can be answered, two aspects have to be clarified. First, the reason for not implementing a screen-based application or system needs to be recalled. From initial observations and research, the themes of comparing oneself to others, the “copy-paste effect” and the above discussed dominance of the visual realm in dance played a prominent role [3]. Thus, a digital artifact to support a dancer’s feeling of creativity and reflection was supposed to explore other interaction modalities than a common screen-based approach. Second, the choice of *improvisation* as the creative process for applying the artifact was informed by research findings instead of defined right at the beginning. In light of this, the research question should be formulated as follows:

How does the non-screen based Movement Xplorer prototype fit into a dancers’ improvisation process as a means of creativity support?

The answer to this question is approached by evaluating the prototype through two lenses: *interaction modalities* and *creativity support*.

Interaction modalities: Due to feasibility reasons discussed in chapter 5, the visual sense was not completely excluded in the design of the prototype. The light cues were chosen for facilitating a collaborative use of the artifact in addition to the haptic interaction of the individual, wearable version. Both interaction modalities had their advantages and disadvantages. On the one hand, the lights were considered beautiful and seemed to have an uplifting, positive effect at least on one of the workshop participants’ mood. The haptic feedback and knowledge about data collection resulted in a defamiliarization process causing non-habitual movement of the body part the tool was worn on. This is related to Loke and Robertson’s concept of disrupting habits in embodied interaction, referred to as “making strange” [47]. Both the light cues and the haptic feedback were used as impulses for variation in movement, which led to appreciated deviations from

usual movement. On the other hand, the cues were also perceived as intensively attracting the dancers' attention, which inhibited their focus on the own body. Achieving this would have required more time to interact with the tool, preferably in a solo instead of group setting, as done in the autoethnographic workshop. What was considered difficult, but not necessarily problematic, was the specific mapping of dance concepts to light and vibration impulses. Dancers mentioned that they were not always able to remember the respective move for a given impulse. This intended ambiguity was chosen on purpose, as it contradicts the mimetic character of prevailing interactions in dance and has been mentioned as a positive influence on dancers' creative work [48].

Recalling Hsueh et al.'s interaction type taxonomy [37] explained in section 2.2, the prototype can be primarily understood in terms of a *following* interaction, using the tool as guidance for the user to follow. However, since the abstract representation of movement does not allow an imitative interaction, it incorporates other interaction types to a certain extent as well: *Negotiating* behaviour can be present when the user initiates movement on their own instead of waiting for the tool to give instructions. The initial requirement to select dance concepts for the mapping process and the facilitated reflection on movement habits can be interpreted in terms of *expressive* interaction. Lastly, what could not be evaluated in the course of this thesis, but would be possible with the *Movement Xplorer*, is a tool-mediated interaction between two dancers, such as the described *directed* and *co-creative* interaction types. This can either refer to a mutual influence between dancers in a collaborative use of the tool or the intentional control of the tool via Bluetooth by one person, guiding or reacting to the improvising dancer.

Creativity Support: Due to the variety of creativity definitions, both in research as well as among study participants, there can be no universally valid justification of the prototype's level of creativity support. What many possible definitions of creativity had in common, however, was *novelty*. While by some this was interpreted in the context of a whole domain, the approach for the prototype took place on an individual level, representing a "mini-c"-level of creativity support [41]. Especially the two workshop instances at the beginning of the design phase resulted in highlighting creativity as a *feeling* in dance, which creates a "moment of happiness" induced by surprising oneself with movement that feels novel to the own body. The present research showed that this can mean completely new movement patterns, but also the re-discovery of something familiar. The prototype was able to support some of the workshop participants in achieving a similar feeling. The "rationalised" approach of its use, however, was not suitable for one of the dancers. Further investigation, whether this would change along a certain learning curve with the tool, would be needed. This effect was reported by [77], but a closer examination would exceed the scope of this thesis. Moreover, the prototype's core idea and the workshop design focused on the exploration and reflection on personal skills. According to Amabile's creativity theory, the knowledge and development of domain relevant skills is an essential component in achieving a higher level of creativity.

The additionally calculated CSI score confirmed the above mentioned observations. Despite showing potential for overall improvement and neglecting the flawed administration,

the prototype seemed to provide good support for dancers with respect to the *Exploration* and *Collaboration* factors. The index reflects participants' difficulties with becoming immersed in the task and also shows that there is still room for improvement in the *Enjoyment* and *Expressiveness* factors. The CSI framework also provided insights into what factors participants deemed more important in the improvisation process in the workshop. This can act as input for further refinement and future development of CSTs for dance improvisation.

7.1.3 RQ3: In what ways do digital tools affect dancers' creative processes and outcomes?

In contrast to the discussion of the prototype as a designated creativity support tool in the previous question, the present section examines the range of digital tools mentioned in this research, independent of their framing. Considering the broad definition of a CST as “any tool that can be used by people in the open-ended creation of new artifacts” [18, p.21:2], various systems could be categorized under this umbrella. However, rendering them as CSTs would perhaps imply a designed supportive function for creativity, which is misleading. None of the tools used by participants, except the *Movement Explorer*, were initially designed for dancers. Even the prototype developed in this research project is not suitable for everyone. Thus, any tool can influence dancers in multiple ways. Upon closer examination, various factors can steer the answer to this question in different directions. These include the style the dancer is proficient in, the type of tool they engage with, the level of reflection and awareness about the tool's capacities, the dancer's level of experience, the amount of time spent using the tool, and many more dependencies with respect to the dancer or the system in question. Without the intent to simplify any of these complexities, eight topics related to the tools identified throughout the research, design and evaluation phases of this thesis are explicated below.

Creativity: Many tools used in dance can assist in finding inspiration and new ideas. They can create a comfortable ambient environment, connect dancers and help them augment their performances, both on stage and in the digital space. All these aspects were considered enablers of creativity in the conducted survey. At the same time, digital tools can also trigger feelings of self-doubt and pressure in dancers. This is predominantly a result of comparison to others while filming dance in class or watching videos on social media and does not apply to all tools. Nevertheless, I would like to emphasize this issue, because these tools are what accompany almost every dancer on a daily basis and were named among the first associations with “digital tools in dance”. The mentioned negative feelings can act as “creativity killers” instead of supporting it, but dancers can hardly opt out of producing or engaging with this type of content. Some participants reported to depend on it in order to keep up to date with trends and events as well as to advertise their classes and establish a portfolio for potential jobs. Helfand et al. [33] pointed out that the favourism of Big-C contributions may undermine the importance of little-c findings. This, I would argue, is exactly what happens in these digital spaces. Participants mentioned presentations of perfect end-products and a lack of transparency

about the path to get there. However, based on the observations of my personal social media usage throughout this research, I would like to highlight that this is not the only facet. Towards the end of the thesis project, I encountered more and more humorist content about dance, encouraging quotes and honest representations of the ups and downs of doing creative work in dance. The algorithm reinforced my interest in these kinds of dance representations and showed me content that can reassure dancers in trusting their process and rather enable them to engage creatively instead of discourage them. This aspect was taken on in the design of the prototype, directing dancers towards themselves instead of others. Although an immersion in the task could not be achieved, the concept of the prototype helped some participants to achieve moments of surprise and happiness. According to Amabile, similar positive affects can enhance a person's creativity for up to two days [5], which would be a desirable effect for a CST.

Motivation: An uplifting effect can positively influence dancers' motivation to move. However, the numerous sources of inspiration can also lead to a state that has a similar effect to the 'blank page' at the beginning of a writing task. With too many or too few concrete ideas, but a motivated state of mind to do creative work, tools that provide prompts can help in overcoming a feeling of being overwhelmed. The *Movement Xplorer* prototype, in particular, was perceived as a tool that could help dancers focus if they experience something the like. A slight nudge to overcome this situation could potentially enable a high level of creativity in practice. Participants mentioned having experienced similar situations, which would be a good base, because they would profit from an "internal driver for creativity" [74, p.290]. According to Amabile's Intrinsic Motivation Principle, these internal drivers are decisive for people achieving their highest creative potential [4]. However, the research showed that bridging the gap from a motivated state of mind to an actual creative engagement can be a challenge for dancers. Thus, a tool that provides the necessary push or focus might have a positive influence on dancers being able to transform their creative motivation more often. Beyond this application scenario, digital tools can also act as initiators for getting active in dance. Dance games, such as Just Dance, can motivate people at home and act as a first contact point to dance before attending classes or practice on a regular basis. Moreover, the observed instance of a videographer calling for dancers to participate in a dance video would perhaps not have happened without the idea of using the camera as their creative tool.

Collaboration: The previous example is also connected to the collaboration effect digital tools can yield. As much as the camera was needed for generating the idea, social networks assisted as a medium that helped realize it and people were brought together. Great examples of collaborations were also discussed in the three interviews. What was special in case of the podcast founders was that they got to know each other via Instagram and established a friendship and business relationship over time. In the workshop with the *Movement Xplorer* prototype participants also appreciated the collaboration aspect of exchanging concept ideas in the group, although it was not deemed very important for the given task. A consideration was to move this exchange to a digital platform for users of the tool to upload their own templates and find inspiration from others. This could

initiate an alternative virtual space that allows dancers to interact with each other and foster collaboration.

Conversation: Naturally, the factors discussing social connections, such as collaboration or conversation, are closely related to social networks, as this is what these platforms are designed for. Dancers only reported the use of chat messengers in addition to Instagram for getting in touch with other dancers. Even in my position as a researcher in the dance domain, I relied on Instagram as the first instance for contacting dancers. This was because I did not feel comfortable picking out people’s phone numbers from one of the many large group chats and could not find their email contacts elsewhere. The social media platform therefore provided a valuable resource for connecting to other dancers and keeping up to date about their activities.

A downside of these insights into other dancers’ lives, however, is the shift to virtual communication almost as a replacement for real life conversations. Knowing a lot already or the knowledge of being able to look up many things easily yourself could potentially inhibit users asking questions in person. While this may not be true for every dancer, I became aware of this from a first-person perspective in situations where I did have interesting talks with other dancers that went beyond between-class small talk. I noticed that these connections happened very rarely, although I felt like I am constantly immersed in the dance world, virtually. The difference is the way communication is shaped in the online space. Compared to other communities, such as the student community at TU Wien or online Maker communities, dancers in Austria do not use digital channels for open discussions, but rather for advertising and promoting themselves or their events. Advice may be given on personal profiles, but feedback or exchange beyond affirmational phrases or emojis was lacking in my personal virtual bubble. This does not mean that conversation does not exist within dance. It only happens privately, which complicates getting access to in-depth knowledge. No matter the format, it is important that exchange does happen, as highlighted below. From personal experience, people’s willingness to share is increasing. However, I have rarely witnessed asking for or giving constructive feedback in the virtual space.

“In order to move from mini-c ideas to little-c contributions, people need to be willing to share and receive feedback on their personally meaningful insights and ideas.” [33, p.19]

Adaptation: In view of the focus on video representations, one participant explained the urge to conform to perceived trends or standards in order to be accepted within the scene. Again mentioning the “copy-paste effect”, dancers also critiqued a lack of diversity in dance. Creative processes can therefore be influenced by digital technologies in a way that reproduces existing visual standards. The movement, however, not only changes in order to conform to an “ideal” dancer, but also to fit the respective platform or tool. TikTok dances, for example, are characterised by catchy, short and reproducible movement sequences filmed in everyday situations. Instagram, on the other hand, is

rather treated like the artistic portfolio, often involving planning, skilled camera work and sophisticated choreography. At this point, I would also like to mention that for certain dance styles and especially the Commercial job industry, this often critically examined social media aspect is a valuable tool for success. Many dancers make use of these platforms for business purposes, meaning it provides them with a powerful tool for disseminating their art. However, when engaging with these platforms, the lines between business and everyday situations may become blurred, which is why alternatives or awareness about their impact on dance, creativity and well-being are desirable.

Aside from social media platforms, the wearable sensor bands also triggered a change in movement for the dancer. This was illustrated in the example of turning the hand leading from the wrist instead of the fingers, because the sensing mechanism required this restriction. Moreover, some workshop participants tended towards focusing on the *Movement Xplorer* intensively and letting it “dictate” them how to move. I believe that, especially in creative environments, we have to be careful with restricting ourselves. In order for creative work to be acknowledged in a domain, certain rules have to be followed, naturally. But what is highlighted by Csikszentmihalyi is a supply and demand issue with creativity regulated by society. If there is no commitment to novelty, “potentially creative individuals will not be able to flourish.” [21, p.536f].

Efficiency: With the help of suitable tools, tasks can be completed more efficiently by providing a structure or resources to build upon. The activity of creating formations for dance performances was perceived as cumbersome if done with pen and paper. Apps or software for creating formations and simulating transitions could assist with visual imagination and reduce time needed in rehearsals to try out different ideas. A similar effect was reported in [19], where the use of the *Knotation* application outsourced conversation for more efficient use of the training space for movement.

Reflection: Videos and motion capture can facilitate analysis of movement and provide insights into potential execution improvements. On a cognitive instead of physical level, podcasts or documentaries can also assist in reflecting about the meaning of the movement, the creative process and general mindset of a dancer. The focus of the tested prototype aimed at a combination of both, but on an internal level. Reflection about individual strengths and weaknesses, transitioning into constructive disruption of movement habits was supposed to help dancers find confidence and positive experiences in their dance.

Intervention: Finally, I would like to point out the frequency of use for CSTs in dance. Many of the systems described in literature, including the prototype in this study, have “intervention” character. This means they are applied in a single-use situation, or a few times occasionally, but do not support dancers on a daily basis. This is, however, not necessarily a critique. On the one hand, dancers could profit from a tool especially designed for dance. It would support them in their usual tasks instead of force them to continuously adapt their work processes to a preexisting tool. On the other hand, some survey participants also reported that using technology was not necessary for them at all. Hence, I believe that the development of new technology cannot be the solution to all problems in this domain. Within this research, I have come across the

intervention phenomenon in literature, in the interviews, in my own practice with the *Movement Explorer* and in the workshops with participants. Using a tool with intervention character can offer valuable input for the dancer to resort to in further instances of their creative work. The tool can trigger a reflection on the own dance practice, it can provide alternative possibilities, or offer a structure for a specific creative task to follow without a regular use of the tool.

7.2 Artifact Dilemma

The definition of CSTs to support people in their process of creating an artifact raises the question what an artifact in dance may be. When thinking about artifacts, a tangible object may be the first idea, such as a drawing from a painter, a vase formed by a potter or a piece of clothing made by a tailor. In the digital era of creators, this may transform to digital files. A graphic designer creates digital logos, a musician a music track, and a writer saves text files. To an extent, one could say that the analogy for dance would be a video. But then again, the video is actually the artifact of the videographer or editor, who is often the dancer at the same time, but it is not directly the artwork of the dancer itself.

In dance, the artifact does not only originate from, but it *is* the moving body. Hsueh et al. [37] highlighted this in their paper about dancers' kinaesthetic creativity, in which they compare so-called *hylomorphic* practices of shaping tangible material to dancers shaping their movement. I refer to this tension between the CST idea of tool-supported artifact creation and the body not being separable from the artifact in dance as the *artifact dilemma*.

“[...] rather than applying an already existing form to shapeless matter (a ‘hylomorphic’ approach), the maker is attuned to the forces of the materials and grows with them in making. Movements produced in our workshops are interesting materials to consider through this lens because, unlike clay or textile, they do not exist outside of the maker – they are bound up in the dancer’s body, where the movement traces are often *felt* rather than *seen*, effectively resisting a ‘hylomorphic’ treatment with their transience” [37, p.10]

This insight provides two additional layers to the artifact dilemma in dance. First, what a dancer produces is movement. Second, what stays with the dancer is the feeling of the movement. This indicates that, although the first idea when thinking about artifacts in dance may be choreography as seen on stage or in videos, this excludes a whole field of improvisation practice. Moreover, dancers may forget movement sequences, but still remember the feeling while performing them.

With this in mind, there is a conception of creativity from an outside standpoint, but also from an internal perspective. Research participants often started with explaining creativity as something that has not been *seen* before. They mentioned deviations from

a standard, which is an externalised approach that corresponds to the Big-C and Pro-c dimensions of the Four-c model of creativity [41]. When asking follow-up questions, their responses shifted to an emotional level, expressing how creativity *feels* to them. This reflects the little-c and mini-c levels, which should not be disregarded.

“mini-c creativity helps to broaden current conceptions of creativity by recognizing that intrapersonal insights and interpretations, which often live only within the person who created them, are still considered creative acts.” [41, p.4]

The artifact dilemma within this thesis research is therefore that the design of CSTs for moving bodies may have different constraints than in other disciplines, in terms of the outcome the creative process may yield. The creative artifact in dance has to be considered as an abstract concept that exists within the dancer. It can mean novelty to the individual, whether it is something *one* has never seen, done or felt before. It can also mean the re-discovery of an idea, movement, feeling or emotion. In any case, this abstract artifact shapes the intrapersonal creativity. I infer from this that a shift from focusing on output to focusing on process may be necessary for the design of future CSTs in, and perhaps also beyond, dance.

7.3 Perspectives on CSTs in Dance

7.3.1 Research

This previous thought leads to examining the existing CST research more closely. Works like [3] and [37] used the approach of focusing on an individual dancer's process of exploring movement, considering an individual level and inner feeling of being creative. However, the majority of resources found on the intersection of technology-aided creativity support and dance remains on a Pro-C level of creativity, designing for the choreographic process of professional dancers and choreographers in their task to create a dance piece as their artifact. This choice can be seen as a logical conclusion from the general understanding of an artifact. Considering the more abstract conception discussed above and using an approach closer to the practical situation of non-professional dancers, however, showed that there are many more roles in dance which require creative work, but are not represented in research as much.

Not only was the present research project an extension in terms of dancers' professional level, but it was also open to any background related to dance forms. While this also came with limitations detailed in section 7.4, it aimed at gaining a more holistic picture, in this case of the Viennese dance practices. What was observable in literature was that research was done predominantly with contemporary dancers, or similar backgrounds of western concert dance forms, as shown in a study by Jessica Rajko [58]. While doing research in this context is not problematic per se, the author argues that this focus leads

to treating “embodied knowledge and methods deriving from western concert dance as the unofficial norm of dance-based movement expertise in computing contexts” [58, p.1].

I do not claim that my research makes an exceptionally different case, as the study was conducted in Austria, including among others western concert dance forms with participants recruited predominantly via digital communication channels. Moreover, in-depth discussions about certain sub-communities would have exceeded the scope of this thesis. Nevertheless, I hope that my thesis can contribute to making non-academic roles of dancers visible and to portray in what ways technology affects dancers on a practical, everyday level. The approach to this research did not focus on the movement, specifically, but on supporting the individual in harnessing their creative potential. It was about shedding light on a whole “spectrum” [33] or “continuum” [74] of creativity within dance, which is not limited to a specific style or professional role and portrays itself with multiple facets. Neither is it limited to the general notion of a choreographic *output* of dance, which again points to a required extension or shift to the design for creative *processes* in dance. This may call for a re-evaluation of the roles of designers and users in this context, leveraging design as a means to find a definition of creativity in dance.

7.3.2 Study Participants

Although CSTs in dance have only been a growing interest in HCI research in the last decade, chapters 1 and 2 have shown how technological inventions have influenced dance and vice versa throughout history. The interplay of dance and technology has evolved ever since and technology is not separable from dance. In fact, some dancers even explained to depend on it. Course registrations, research, access to dance programs and receiving jobs depends on a dancer’s use of digital tools. However, for many dancers participating in this study, the main purpose of applying digital tools is still concerned with a wider ecology of tasks not directly involved with the bodily movement itself, such as performance technology, music, video and the dissemination of dance and knowledge. CSTs developed for or with dancers have not made it into their practice, which means that their reality is different to and also sceptical about research developments.

As such, study participants reflected about educational technology, such as VR dance tutorials, and questioned how this would influence dance teachers. They would not want to replace them nor reduce people’s opportunities to ask questions and thus connect to their teachers. Notation software is another example, which has the commendable aim of facilitating the documentation of dance. However, notation frameworks such as Labanotation or Benesh Notation are not common to be used outside an academic engagement with dance. Moreover, even those who are familiar with it may choose not to use it.

What was noticeable in this research was that social media platforms play a key role in dance. They were mentioned with respect to almost all possible tasks in dance, ranging from using it as a tool for inspiration, advertising or registering for courses, to a personal

artist portfolio. Having such a high significance in dancers' lives, it is not surprising that it also impacts lives outside the digital space. A closer look at psychological consequences exceeds the scope of this thesis. However, what was observable and will be shortly discussed at this point is how it transforms regular dance practice.

One exemplary observation I would like to recall concerns my reflection about TikTok dances on stage at a dance competition. Aside from an overall critique about the particular platform, which I do not address within this thesis, I personally welcome tools that animate people to dance. However, these kinds of dances do not represent any particular dance form or mix various elements. Dance teachers have expressed their worries in both direct and humorist way on social media that these emerging dance trends overshadow the value of learning foundational movement of particular dance styles as well as their history and meaning. They might also take away the spatial characteristic of dance and transform it to a planar form of movement emphasizing facial expressions and arm movement, considering that the feet are oftentimes not visible in the camera's field of view. Seeing that this kind of movement has made its way to competition stages suggests that there is a transformation in what dancers learn and the standards that are set.

While this is only one specific example, it has a general meaning for the development of digital tools for dance. Researchers and developers are asked to take into account the movement-related, cultural and social meanings of dance in order to be able to genuinely support dancers' creativity within a particular dance form. This would ensure that any "artifacts" created with the help of the tool can have the chance to be accepted by the field, as defined in Csikszentmihalyi's systems model [21], and that dancers can progress along the Four C trajectory to achieving Pro-c or Big-C contributions [41]. The same, if not more, responsibility rests on the dancers themselves. As stated by participants, dancers need to be educated on what values to ascribe to the digital tools they use. A reflective approach to the own dance practice can help their mindset, growth and future collaborations with researchers or developers of CSTs.

7.4 Limitations

Conducting a study with participants requires the researcher to approach and engage with the target group. Due to an injury, I was unfortunately not able to do that to an extent that would have been possible otherwise. For a duration of approximately five months during this research project, I was neither able to teach nor attend dance classes or events where I could have met dancers in person. This prevented the usual between-class small talk, which is valuable for maintaining connections. Moreover, one instance of asking for a chance to sit in on a dance workshop as external viewer was turned down with the reason to ensure a safe space for workshop participants. Instead of in-person contact, I hence used my private Instagram profile for reaching out to dancers and connected to closer dance friends via private messages. This affected the amount and types of participants I was able to reach for this thesis. Because of a rather small

number of participants, the research findings are not representative of the whole Austrian or Viennese dance scene. The majority of non-anonymous participants had a background of practicing dance in studios, where the focus of most classes is on choreography. To my knowledge, no dancers of the Austrian freestyle dance scene participated in the study in a way that would make a closer examination thereof possible. Despite including dance forms practiced with a partner in the early stages of research, the prototype was neither designed nor tested particularly for these dance forms. Based on my personal interpretation of various dance forms I have engaged in over the years and the creativity-instead of technique-centered approach to design, the concept could potentially still be valuable for a wider range of dance backgrounds.

Considering the prototype developed within this research and design project, I would like to point out two aspects about its evaluation. Firstly, the duration of the workshop with participants was set to a time frame common for dance workshops. From personal dance experience, a duration that exceeds two hours is usually perceived as exhausting. Moreover, viewing the workshop from a research participant perspective, asking them to donate more than two hours of their time without being able to offer them compensation did not seem appropriate. This session, however, was too short to achieve a more thorough interaction and exploration of the prototype. A longer workshop duration or additional sessions would have been valuable, but were unfortunately not possible within the scope of the thesis. Secondly, the limitations of the CSI administration prevent the score from being comparable to other CST evaluations in a standardized way. I provided a transparent explanation of how the score was calculated, nonetheless. Whether or not the score itself is considered for further comparison of tools, the CSI framework still provides insights into what factors were deemed important to the participants of this study in their task of exploring movement.

7.5 Future Work

Following the idea of this thesis and the developed *Movement Explorer*, a longitudinal study of a similar prototype supporting movement exploration and reflection is suggested. This is because my personal observation and feedback from workshop participants concerned a learning curve for using the tool, which could not be investigated further within this present research. Factors of interest include how frequently the tool would be used, whether it is better suited for individual or collaborative use and what long-term effects it has on dance as an art form, the community, dancers' creativity and movement.

Furthermore, the table presented with respect to the first research question provides an overview of potential creative processes for which to design future CSTs for dance. These include specific tools for supporting the simulation of dance formations, stage space usage or dance learning tools. Although I eventually chose the improvisation process, the research showed that there is potential in creating several other CSTs or tools to support productivity in not necessarily creative tasks. A specific area of relevance to the dancers contributing to this research might concern personal information management systems,

which were addressed in a study with musicians by Rosselli del Turco and Dalsgaard [60] and could be of interest for the dance domain as well.

Since effects induced by social media played a central role in this thesis, research about how the design of various social media platforms influences dancers' interactions in these virtual spaces presents another potential direction for future work beyond this thesis. This is inspired by [42] and [43] and could aim at identifying, which changes in design would contribute positively to dancers' creativity.

Finally, computational creativity support for dance entails a high level of complexity induced by individually distinct bodies and notions of creativity. In a wider sense, further investigations could therefore include how we can design for creative processes in dance as highly individual activities. This leads to questions about the need to provide adaptability and the notion of design not only as support but as a means to understand creativity. In summary, I offer the following question for future researchers: How should designers and users approach the design space of technological interactions in dance to accommodate individuality and adaptability, and to enhance dancers' creative processes?

Conclusion

This thesis provides artifact and empirical contributions to the body of research within the field of creativity support tools on the intersection with dance. At its core, it describes the design process of the *Movement Xplorer* prototype for dance improvisation. This artifact embodies comprehensive insights and reflections on the definition of creativity in dance and factors that influence it. The generated knowledge informing its design includes creativity as a feeling and process beyond choreographic output, the body-inherent artifact in dance and how technology can affect this interrelationship. It was found that by exploring and disrupting movement habits, kinaesthetic creativity can be enhanced, leading to internal creative feelings such as happiness and surprise. Additionally, the prototype acted as a means to gain a deeper understanding of the difficulties of designing for moving bodies and dance as a community and cultural practice. It offered an engagement especially with the improvisation process in dance, resulting in a list of factors to consider in similar future design endeavours.

Revisiting the methodological trajectory of this thesis, I first described a three-staged research phase into different roles of dancers beyond the professional contemporary dance domain and their views on creativity and digital tools. I transformed these insights into design choices for a tangible and wearable prototype to support dancers' creativity in a dance movement exploration process. Key aspects for the design concerned the above mentioned abstracted notion of a creative product in dance different to a choreographic output, a type of interaction directing the dancer's attention to themselves, the cultivation of personal dance skills and the support of confidence and reflection. These factors emphasize the felt dimension of creativity for dancers as individuals, which represents *mini-c* and *little-c* creativity as defined by Kaufman et al. [41]. The iterative design process was illustrated as a progression across three prototype versions. For the evaluation, the final *Movement Xplorer* was tested in an autoethnographic and a group workshop with dancers. In addition to a qualitative assessment of experiences, the Creativity Support Index was calculated. It extended the examination of the tool's level

of support and served as a framework for identifying further development opportunities of CSTs for dance improvisation.

Insights from the user research, design and evaluation phases were synthesised to elaborate on the meaning of technology in dance practice and the interplay of dance, creativity and technology in the context of this research. The thesis points out the diversity in roles, tasks and needs of dancers beyond the academic dance domain and highlights differences between research and practice. Prevailing digital means of interaction in dance were discussed as well as their influence on kinaesthetic, social and cultural aspects of dance. I consider this a confirmation of the advocacy for more diversity in dance research within HCI in terms of dance practices represented in literature [58].

With respect to the development of novel CSTs for dance, the thesis emphasizes the importance of a thorough understanding of the dance practice in order to design meaningful technology for advancing dancers' creative potential. There is a great value in researchers engaging in dance practice themselves in order to gain insights into first-person perspectives, which are difficult to understand in regular experimental settings with participant dancers.

Not only does the thesis contribute to a better understanding of dance for the design of systems, but it also appeals to the dance community to cultivate more awareness about technology's transformative effects on their practice. The idea of the prototype's application scenario may be an impetus for emphasizing a reflective dance practice and deepening exchange among dancers in the future.

APPENDIX **A**

Survey Questionnaire

The following pages contain the English version of the online questionnaire, which was available between July 17th and August 31st 2023.

Hello!

Thanks for taking about 15 minutes to fill out my survey!

Here's a quick bit of info:

For my master's thesis, I am researching the intersection between dance and digital technologies and, among other things, the question of how creativity in dance can be supported with the help of digital solutions. Therefore, the survey is addressed to dancers (former, hobby or professional) and includes questions on the topics of dance, creativity and digital tools.

A total of 22 questions are waiting for you.

Since I am particularly interested in your experiences, impressions and feelings regarding these topics, you will find free response fields for most of the questions. **I kindly ask you to answer openly and honestly.**

The survey is anonymous. Your data is of course confidential, will only be analysed anonymously and will not be passed on to third parties. Demographic information (such as age or gender) does not allow any conclusions to be drawn about your person.

Your participation in this survey is voluntary. You can cancel the survey at any time without giving a reason.

If you have any questions about the survey or the topic, please feel free to contact me. My email address is linked in the footer.

Thank you very much and have fun!

Silke

Please confirm the following item to proceed to the survey:

- I confirm that I have understood the above instructions and wish to participate in the survey.

1. What is your age?

I am years old.

2. What is your gender?

- woman
- man
- non-binary
- prefer to self-describe
-
- prefer to not disclose

3. To what extent do you currently dance?

- Main profession
- Side job
- in Training / Studies
-
- Intensive hobby (several times/week; championships; battles, or the like)
- Hobby (occasionally to regularly approx. 1-2x/week)
- Very irregular
- Quit
- other
-

4 Active Filter(s)**Filter SD03/F1**

If any of the following options is selected: **2, 1**

Then display question/text **SD04** placed later in the questionnaire (otherwise hide)

Filter SD03/F2

If any of the following options is selected: **7**

Then display question/text **SD05** placed later in the questionnaire (otherwise hide)

Filter SD03/F3

If any of the following options is selected: **6**

Then display question/text **SD06** placed later in the questionnaire (otherwise hide)

Filter SD03/F4

If any of the following options is selected: **7**

Then display question/text **SD09** placed later in the questionnaire (otherwise hide)

4. Which dance form(s) do you practice?

Notes:

- Multiple selection possible.
- The extent to which you practice each dance form may vary.
- If in later questions your answers only refer to a certain dance form, please note this in the respective question.

- Afro
- Ballet
- Breaking
- Belly Dance
- Commercial
- Contemporary / Modern
- Dancehall
- Ballroom Dance
- Hip Hop
- House
- Musical / Jazz
- Krump
- Latin (Salsa, Bachata, Kizomba, ...)
- Locking
- K-Pop
- National / Folklore
- Popping / Illusionary Dance Forms
- Tap
- Swing Dances
- Waacking
- Voguing
- Other:

5. Which of these job titles apply to you?

- Dancer
- Dance teacher / educator
- Judge
- Trainer / Instructor
- Choreographer
- Other

6. Why did you stop dancing?

To what extent do you still get in touch with dancing?

Hint

The wording of some of the upcoming questions is aimed at active dancers. However, please feel free to answer them with your past experiences.

7. Did you use to dance more regularly?

If yes, why not anymore?

To what extent do you still get in touch with dancing?

8. What so-called 'somatic practices' do you engage in?

- Yoga
- Meditation
- Feldenkrais
- Other:
- I used to practice but not anymore

none

9. In what region are you active in dance?

Multiple selection possible

- Burgenland
- Carinthia
- Lower Austria
- Upper Austria
- Salzburg
- Styria
- Tyrol
- Vorarlberg
- Vienna
- Outside Austria

**10. Please imagine dance as a person.
How would you describe your relationship?**

Would you like to share an explanation for your choice of description? What feelings or facts are decisive for your answer?

11. How would you describe your dance environment?

If you are active in different regions, do you notice regional differences?

What do you like?

What don't you like / where do you see potential for improvement?

Other impressions

12. For what dance-related purposes (apart from simply playing your music) do you use digital support? In what form?

Please use the free text fields to list digital tools (e.g. software, apps, devices) that you use for this.

- Choreographic Process
 (Stage-)Performances
 Research / Knowledge
 Analysis
 Teaching
 Training
 Improvisation / Freestyle
 Physical Health
 Fun
 Collaboration
 Music editing
 Other / comment

- I don't use any digital support apart from playing my music.
 I don't use digital support at all.

1 Active Filter(s)

Filter TE02/F1

If any of the following options is selected: **-1, -2**

Then display question/text **TE05** placed later in the questionnaire (otherwise hide)

13. Why don't you use digital support?

Multiple selection possible

Not necessary for me

Too complicated

Too expensive

Distracts from ...

Other reason:

14. Please describe your impression of how the use of digital tools in dance affects you and/or other dancers.

(Digital tools can be apps, software, devices, sensors, or similar).

What positive and negative influences do you notice?

15. Have you ever felt that you lacked support in your dance activities? (digital or analogue)

If yes, for what?

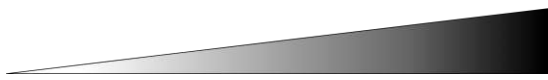
In what form would support make sense for you?

16. What does “creativity” in dance mean to you?

Note: Please answer the following questions based on your personal understanding of creativity.

17. Please rate the following statements on the scale given.

(If you have any comments on the statements, you can use the free response fields of the questions on the next pages).

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	I don't know
						
	1	2	3	4	5	
Creativity in dance is important to me.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel creative often enough.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The space in which I usually dance creates a pleasant atmosphere that encourages my creativity.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
For my creative expression in dance, I make use of the musical quality of a song/track.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The presence of other dancers creates a supportive and inspiring environment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel well connected with other dancers.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

18. Which of your tasks/activities in dance require creativity?

Note: New text fields for further answers appear gradually.

Task 01

Task 02

19. Which of your tasks/activities in dance do not require creativity?

Task 01

Task 02

20. Under what conditions (when/where/how) can you feel creative?

(The opposite question can be found on the next page).

21. Can you describe a specific situation in which you felt creative?

How did you experience the situation?

Did your creativity lead to a specific output?

Did digital tools play a role in this?

22. Under what conditions (when/how/where) do you not feel creative?

23. Do you have a solution for overcoming creative blocks? If so, what is it?

If you have already had creative blocks but have not yet discovered a solution that works for you, just leave this question blank and move on to the next one.

I have never experienced creative blocks.

24. Would you use a chat forum for dancers in Austria?

Yes

No

Already exists:

Other answer:

I don't know



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Prototype Code

The following code was written in Circuit Python 8 using the Mu Editor. The hardware used includes the Adafruit Circuit Playground Bluefruit and the DRV2605 haptic motor driver with vibration motor. Within the thesis, the “teacher mode” mentioned in the code could not be tested due to time constraints.

code.py

```
1 '''
2 This file contains code for the final Movement Xplorer prototype
3 created in the course of the Master's Thesis
4 "Investigating Creativity Support Opportunities through Digital Tools
5 in Dance" by Silke Buchberger.
6 It is a randomizer and memory device for dancers with two settings:
7 wearable mode and tangible mode.
8 The wearable mode includes a 'teacher' mode, in which 4 types of vibrations
9 and 4 LED colors can be controlled via the Bluefruit Connect App.
10 '''
11
12 # IMPORTS
13 # board
14 from adafruit_circuitplayground import cp
15
16 # BLE (bluetooth)
17 from adafruit_ble import BLERadio
18 from adafruit_ble.advertising.standard import ProvideServicesAdvertisement
19 from adafruit_ble.services.nordic import UARTService
20
21 # Bluefruit connect app imports for control pad & color picker
22 from adafruit_bluefruit_connect.packet import Packet
23 from adafruit_bluefruit_connect.color_packet import ColorPacket
24 from adafruit_bluefruit_connect.button_packet import ButtonPacket
25 import board
26 import time
27 import random
```

B. PROTOTYPE CODE

```
28 import adafruit_drv2605
29 import adafruit_lis3dh
30
31 # Busses for identifying whether the CPB is in
32 # wearable mode (connected to haptic motor) or not
33 # List of potential I2C busses
34 ALL_I2C = ("board.I2C()", "board.STEMMA_I2C()", "busio.I2C(board.GP1,
    board.GP0)")
35
36 # Determine which busses are valid
37 found_i2c = []
38 for name in ALL_I2C:
39     try:
40         print("Checking {}".format(name), end="")
41         bus = eval(name)
42         bus.unlock()
43         found_i2c.append((name, bus))
44         print("ADDED.")
45     except Exception:
46         print("SKIPPED.")
47
48 if len(found_i2c) > 0:
49     # Setup HAPTIC MOTOR
50     # See table 11.2 in the datasheet for a list of all the effect names
    and IDs.
51     # http://www.ti.com/lit/ds/symlink/drv2605.pdf
52     drv = adafruit_drv2605.DRV2605(board.I2C())
53     vibr_effects = [16, 118] # also good: 15
54     print("haptic motor connected")
55
56 # Setup PIXELS & define colors
57 # pixels = neopixel.NeoPixel(board.NEOPIXEL, 10, brightness=0.2,
    auto_write=True)
58 pixels = cp.pixels
59 pixels.brightness = 0.5
60 BLUE = (0, 0, 255)
61 BLACK = (0, 0, 0)
62 GREEN = (0, 255, 0)
63 RED = (255, 0, 0)
64 PURPLE = (180, 0, 180)
65 WHITE = (255, 255, 255)
66 YELLOW = (255, 200, 0)
67 # Lists for lighting up pixels
68 light_ids = []
69 colors = [GREEN, PURPLE, YELLOW, RED, BLUE]
70 colors2 = [GREEN, GREEN, RED, RED, YELLOW, YELLOW, PURPLE, PURPLE, BLUE,
    BLUE]
71 current_color = WHITE
72 active_colors = []
73
74 # Setup BLUETOOTH
75 ble = BLERadio()
76 uart_service = UARTService()
```

```
77 advertisement = ProvideServicesAdvertisement(uart_service)
78
79 # Setup TIME
80 last_time = time.monotonic()
81 random_interval = random.randint(8, 20)
82
83 # Booleans for switching modes
84 READY_FOR_WHEEL = False
85 READY_FOR_DANCE = False
86 WHEELING = False
87 ON = True
88 VIBRATION_LEDS = False
89
90 # FUNCTIONS
91 def fill_color(color):
92     pixels.fill(color)
93     time.sleep(0.1)
94     pixels.fill(BLACK)
95
96
97 def vibrate(effect):
98     # Set the effect on slot 0.
99     # Up to 8 slots can be combined
100    drv.sequence[0] = adafruit_drv2605.Effect(effect)
101    drv.play() # play the effect
102    time.sleep(1) # for 1 second
103    drv.stop() # and then stop (if it's still running)
104
105
106 def vibrate_many(effects, pauses):
107     for i in range(len(effects)):
108         drv.sequence[0] = adafruit_drv2605.Effect(effects[i])
109         drv.play()
110         time.sleep(pauses[i])
111         drv.stop()
112         time.sleep(0.1)
113
114
115 def control_from_app():
116     if uart_service.in_waiting:
117         try:
118             packet = Packet.from_stream(uart_service)
119         except ValueError:
120             pass # or continue.
121
122         if isinstance(
123             packet, ColorPacket
124         ): # check if a color was sent from color picker
125             pixels.fill(packet.color)
126         if isinstance(
127             packet, ButtonPacket
128         ): # check if a button was pressed from control pad
129             # buttons 1-4 are colors
```

B. PROTOTYPE CODE

```
130         # arrow buttons are vibration effects
131         if packet.pressed:
132             if packet.button == ButtonPacket.BUTTON_1: # if button #1
133                 pixels.fill(GREEN) # color stays
134             if packet.button == ButtonPacket.BUTTON_2: # if button #2
135                 pixels.fill(PURPLE) # color stays
136             if packet.button == ButtonPacket.BUTTON_3: # if button #3
137                 pixels.fill(YELLOW) # color stays
138             if packet.button == ButtonPacket.BUTTON_4: # if button #4
139                 fill_color(BLUE) # color vanishes
140             if packet.button == ButtonPacket.UP: # if button #up
141                 vibrate(vibr_effects[0]) # single medium vibration
142             if packet.button == ButtonPacket.RIGHT: # if button #down
143                 vibrate(vibr_effects[1]) # single strong vibration
144             if packet.button == ButtonPacket.LEFT: # if button #left
145                 # triple medium vibration
146                 vibrate_many(
147                     [vibr_effects[0], vibr_effects[0],
148 vibr_effects[0]], [0.3, 0.3, 0.3],
149                 )
150             if packet.button == ButtonPacket.DOWN: # if button #right
151                 # double strong vibration
152                 vibrate_many(
153                     [vibr_effects[1], vibr_effects[1]], [0.5, 0.5]
154                 )
155
156 # For template 'build-up':
157 # base - variation - highlight - extra1 - extra2
158 def randomness_wheel():
159     # Suspense animation
160     while time.monotonic() - last_time < 3:
161         pixels.fill(BLUE)
162         time.sleep(0.5)
163         pixels.fill(RED)
164         time.sleep(0.5)
165     # turn pixels off
166     pixels.fill(BLACK)
167     time.sleep(2)
168     # choose 2-5 random pixels and subsequently turn them on
169     nr_of_choices = random.randint(2, 5)
170     pixels_range = list(range(10))
171     i = 0
172     while i < nr_of_choices:
173         id = random.randrange(len(pixels_range))
174         if pixels_range[id] < 10:
175             light_ids.append(pixels_range[id])
176             pixels_range[id] += 10
177             pixels_range = list(filter(lambda x: x < 10, pixels_range))
178             i += 1
179     # print("light_ids = ", light_ids)
180     global current_color
181     current_color = colors[random.randrange(len(light_ids))]
```

```

182     global active_colors
183     for l in range(len(light_ids)):
184         pixels[light_ids[l]] = colors[l]
185         # for combination of vibration+led mode
186         active_colors.append(colors[l])
187         time.sleep(1)
188     # print(current_color)
189     time.sleep(0.5)
190
191
192 # For template 'concepts':
193 # 5 fixed colored categories
194 def randomness_wheel2():
195     # Suspense animation
196     while time.monotonic() - last_time < 3:
197         pixels.fill(BLUE)
198         time.sleep(0.5)
199         pixels.fill(RED)
200         time.sleep(0.5)
201     # turn pixels off
202     pixels.fill(BLACK)
203     time.sleep(2)
204     # choose 2-5 random LEDs and subsequently turn them on
205     nr_of_choices = random.randint(2, 5)
206     pixels_range = list(range(10))
207     i = 0
208     while i < nr_of_choices:
209         position_id = random.randrange(len(pixels_range))
210         led_id = pixels_range[position_id]
211         light_ids.append(led_id)
212         pixels_range = list(filter(lambda x: x != led_id, pixels_range))
213         i += 1
214     # print("light_ids = ", light_ids)
215     global current_color
216     current_color = colors2[random.choice(light_ids)]
217     global active_colors
218     # print(current_color)
219     for l in light_ids:
220         pixels[l] = colors2[l]
221         active_colors = colors2
222         time.sleep(1)
223     time.sleep(0.5)
224
225
226 # MAIN LOOP
227 while True:
228     '''
229     wearable and 'teacher' mode only work when connected to bluefruit app
230     collaboration mode works without BLE
231     '''
232
233     # Advertise when not connected
234     # set CPB up so that it can be discovered by the app
  
```

B. PROTOTYPE CODE

```
235     ble.start_advertising(advertisement)
236
237     # collaboration / LED mode
238     while not ble.connected:
239
240         # if cpb is shaken, set booleans and time accordingly
241         # so that randomness wheel can be executed
242         if cp.shake(shake_threshold=20):
243             READY_FOR_WHEEL = not READY_FOR_WHEEL
244             READY_FOR_DANCE = False
245             if WHEELING is False:
246                 WHEELING = True
247             last_time = time.monotonic()
248             time.sleep(0.5)
249
250         # if cpb button b is pressed, set booleans and time accordingly
251         # so that the dance mode (LED-changing setting)
252         # for improv can be executed
253         if cp.button_b:
254             READY_FOR_DANCE = not READY_FOR_DANCE
255             READY_FOR_WHEEL = False
256             last_time = time.monotonic()
257             time.sleep(0.5)
258
259         # pause / exit the programs
260         if cp.button_a:
261             READY_FOR_WHEEL = False
262             READY_FOR_DANCE = False
263             pixels.fill(BLACK)
264
265         # execute randomness wheel
266         # build-up mode = CPB switch on left position
267         # predefined 5 categories = CPB switch on right position
268         if READY_FOR_WHEEL is True:
269             if WHEELING is True:
270                 light_ids = []
271                 active_colors = []
272                 if cp.switch: # switch is on the left
273                     randomness_wheel()
274                 else: # switch is on the right
275                     randomness_wheel2()
276                 WHEELING = False
277                 time.sleep(0.5)
278
279         # execute dance mode
280         # (LEDs switch colors according to wheel outcome)
281         elif READY_FOR_DANCE is True:
282             # switch on the left -> build-up template
283             if cp.switch:
284                 col = colors
285                 c = random.randrange(len(light_ids))
286             # switch on the right -> concepts template
287             else:
```

```

288         col = colors2
289         c = random.choice(light_ids)
290
291     # light up LEDs
292     pixels.fill(current_color)
293     t = time.monotonic()
294     if (t - last_time) > random_interval:
295         if len(light_ids) > 0:
296             if current_color == col[c]:
297                 current_color = col[(c + 1) % len(light_ids)]
298                 # index of the color in colors array
299                 # print((c + 1) % len(light_ids))
300             else:
301                 current_color = col[c]
302                 # index of the color in colors2 array
303                 # print(c)
304             # Blink 4x when colors are changing
305             for _ in range(4):
306                 pixels.fill(BLACK)
307                 time.sleep(0.3)
308                 pixels.fill(current_color)
309                 time.sleep(0.3)
310                 pixels.fill(BLACK)
311                 time.sleep(0.3)
312             last_time = time.monotonic()
313             random_interval = random.randint(8, 20)
314         else:
315             pixels.fill(BLACK)
316
317     # stop advertising once connected
318     ble.stop_advertising()
319
320     while ble.connected:
321         if cp.button_b:
322             VIBRATION_LEDS = True
323         if cp.button_a:
324             VIBRATION_LEDS = False
325             pixels.fill(BLACK)
326
327         # if switch is left, enable vibration and
328         # color setting from bluefruit app
329         if cp.switch:
330             cp.red_led = False
331             control_from_app()
332
333         # if switch is right, enable accelerometer data collection
334         # via plotter/uart in bluefruit app
335         else:
336             cp.red_led = True
337             # Read accelerometer values (in m / s ^ 2).
338             # Returns a 3-tuple of x, y, z axis values.
339             # Divide them by 9.806 to convert to Gs.
340             t = time.monotonic()
    
```

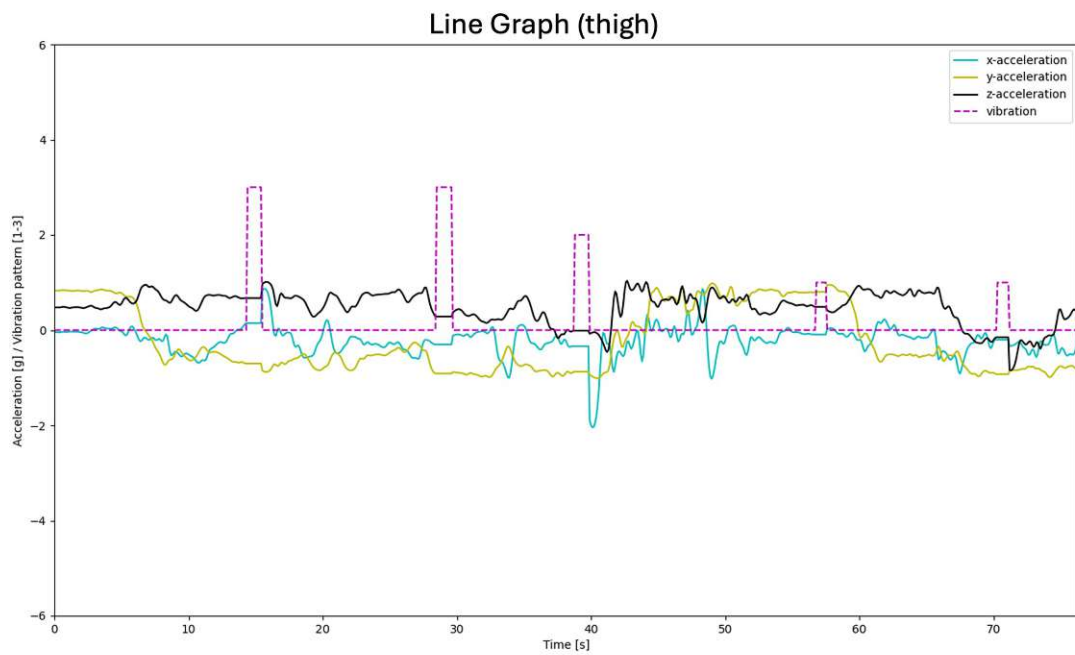
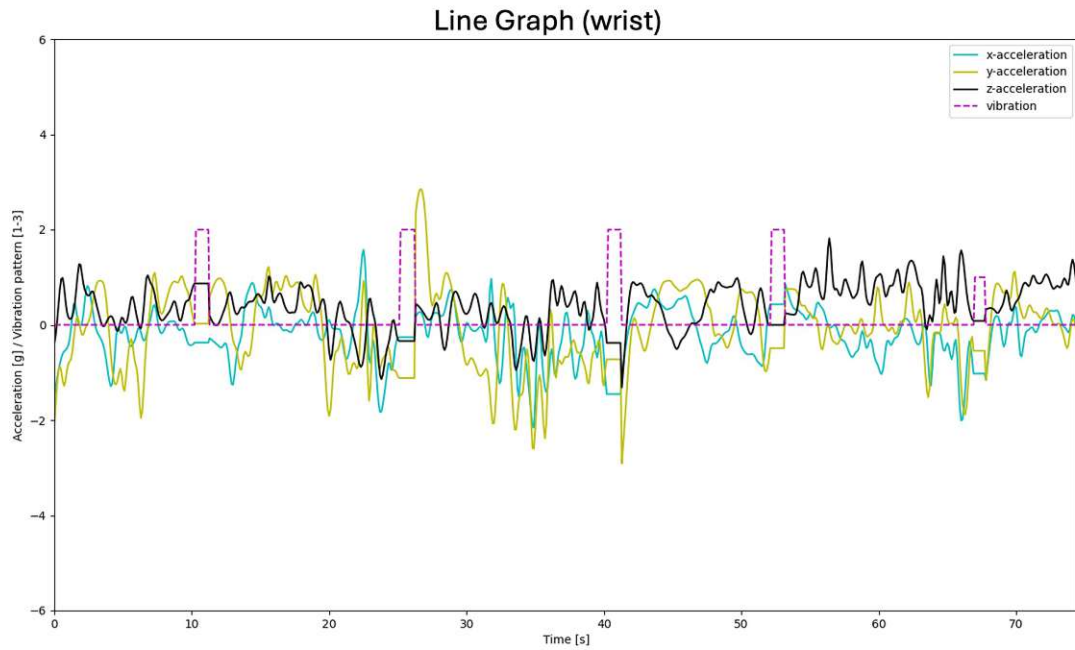
B. PROTOTYPE CODE

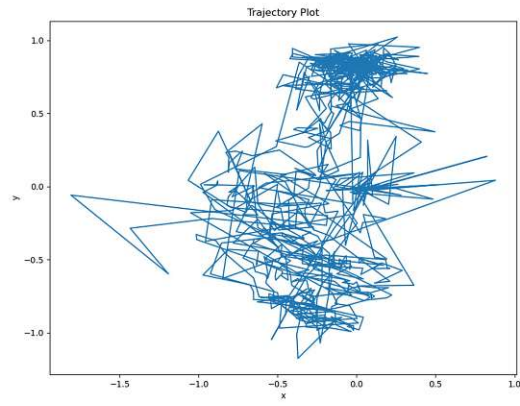
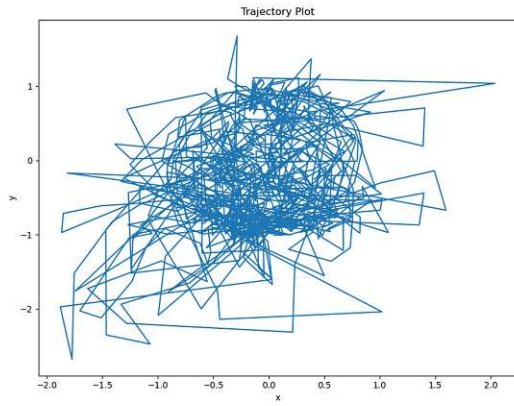
```
341         x, y, z = [
342             value / adafruit_lis3dh.STANDARD_GRAVITY for value in
cp.acceleration
343         ]
344         uart_service.write("{} ,{} ,{} ,{}".format(t, x, y, z))
345         time.sleep(0.1)
346
347         # vibrate in random intervals between 8 and 30 seconds
348         # with a random vibration effect
349         if (t - last_time) > random_interval:
350             # vibrate (choose one of three patterns)
351             v = random.randint(0, 2)
352             if v == 0:
353                 # single strong
354                 vibrate(vibr_effects[1])
355             elif v == 1:
356                 # double strong
357                 vibrate_many(
358                     [vibr_effects[1], vibr_effects[1]], [0.5, 0.5]
359                 )
360             else:
361                 # triple medium
362                 vibrate_many(
363                     [vibr_effects[0], vibr_effects[0],
vibr_effects[0]], [0.3, 0.3, 0.3],
364                 )
365             # print(v)
366             # print(VIBRATION_LEDS)
367             if VIBRATION_LEDS and len(active_colors) > 0:
368                 if active_colors == colors2:
369                     newcolor = active_colors[random.choice(light_ids)]
370                 else:
371                     newcolor =
active_colors[random.randrange(len(light_ids))]
372             # Blink 4x when colors are changing
373             for _ in range(2):
374                 pixels.fill(newcolor)
375                 time.sleep(0.1)
376                 pixels.fill(BLACK)
377                 time.sleep(0.1)
378                 pixels.fill(newcolor)
379             last_time = time.monotonic()
380             random_interval = random.randint(8, 20)
381             uart_service.write(",{}".format(v + 1))
382         else:
383             uart_service.write(",0")
384
385         uart_service.write("\n")
```


Acceleration Data Plots

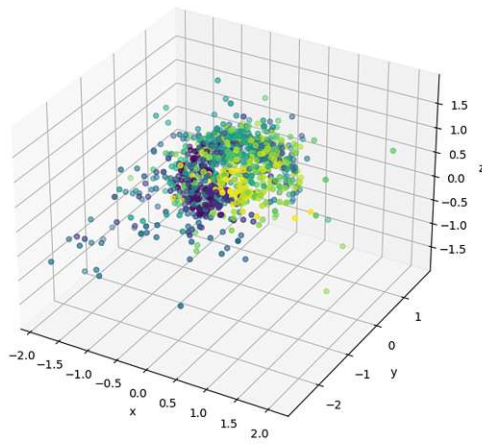
The following plots are visual representations of two exemplary accelerometer data recordings. They correspond to two randomly chosen participants of the group workshop in the evaluation phase of the prototype. On the next page but one, the plots on the left stem from data collected in the wearable mode with the prototype worn on the wrist. The right side represents a thigh-worn case. The visualizations were created as an attempt to detect patterns in participants' movement. Since they did not provide meaningful insights, they were chosen to be understood only as a souvenir for participants and can perhaps be considered an artful representation of the movement data.

C. ACCELERATION DATA PLOTS

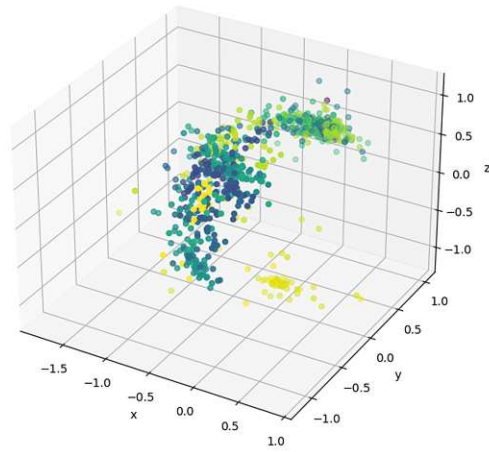




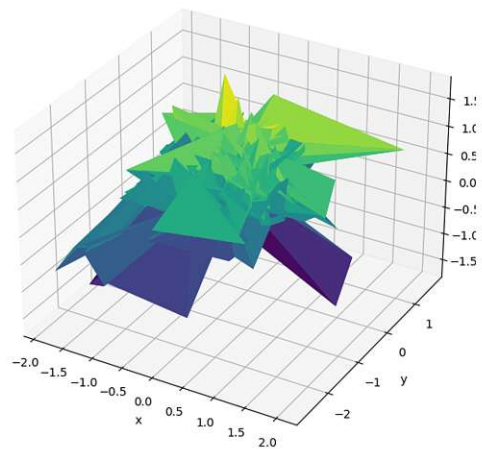
3D Scatter Plot



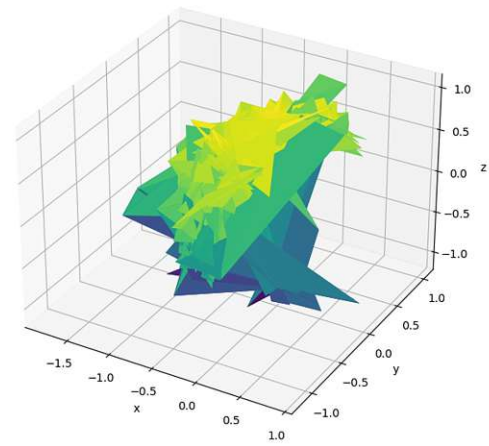
3D Scatter Plot



3D Surface Plot



3D Surface Plot





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Bibliography

- [1] A. Adams, P. Lunt, and P. Cairns. A qualitative approach to hci research. In P. Cairns and A. L. Cox, editors, *Research Methods for Human-Computer Interaction*, page 138–157. Cambridge University Press, 2008.
- [2] J. Akerly. Embodied flow in experiential media systems: A study of the dancer’s lived experience in a responsive audio system. In *Proceedings of the 2nd International Workshop on Movement and Computing*, MOCO ’15, page 9–16, New York, NY, USA, 2015. Association for Computing Machinery.
- [3] C. Allen d’Ávila Silveira, O. Kilic Afsar, and S. Fdili Alaoui. Wearable choreographer: Designing soft-robotics for dance practice. In *Designing Interactive Systems Conference*, DIS ’22, page 1581–1596, New York, NY, USA, 2022. Association for Computing Machinery.
- [4] T. M. Amabile. Componential theory of creativity. Working paper, Harvard Business School Boston, MA, Apr. 2012. No. 12-096.
- [5] T. M. Amabile, S. G. Barsade, J. S. Mueller, and B. M. Staw. Affect and creativity at work. *Administrative Science Quarterly*, 50:367 – 403, 2005.
- [6] T. M. Amabile and M. G. Pratt. The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning. *Research in Organizational Behavior*, 36:157–183, 2016.
- [7] M. T. Anguera, A. Villaseñor, J. Losada, P. Sanchez-Algarra, and A. Onwuegbuzie. Revisiting the difference between mixed methods and multimethods: Is it all in the name? *Quality & Quantity*, 52, 11 2018.
- [8] A. Aristidou, A. Shamir, and Y. Chrysanthou. Digital dance ethnography: Organizing large dance collections. *Journal on Computing and Cultural Heritage*, 12(4), Nov. 2019.
- [9] J. Bardzell, S. Bardzell, P. Dalsgaard, S. Gross, and K. Halskov. Documenting the research through design process. In *Proceedings of the 2016 ACM Conference on Designing Interactive Systems*, DIS ’16, page 96–107, New York, NY, USA, 2016. Association for Computing Machinery.

- [10] C. Biele. *Human Movements in Human-Computer Interaction (HCI)*. Springer International Publishing, 2022.
- [11] D. Bisig. Granular dance. In M. Carvalhais, M. Verdicchio, L. Ribas, and A. Rangel, editors, *Proceedings of the 9th Conference on Computation, Communication, Aesthetics & X*, Proceedings of xCoAx International conference on Computation, Communication, Aesthetics & X, pages 176–195, Portugal, July 2021. i2ADS.
- [12] V. Braun and V. Clarke. Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, and K. J. Sher, editors, *APA Handbook of Research Methods in Psychology*, volume 2, pages 57–71. American Psychological Association, Washington, DC, Jan. 2012.
- [13] V. Braun and V. Clarke. Toward good practice in thematic analysis: Avoiding common problems and be(com)ing a knowing researcher. *International Journal of Transgender Health*, 24(1):1–6, 2023.
- [14] T. W. Calvert, A. Bruderlin, S. Mah, T. Schiphorst, and C. Welman. The evolution of an interface for choreographers. In *Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems*, CHI '93, page 115–122, New York, NY, USA, 1993. Association for Computing Machinery.
- [15] Y. Candau, J. Françoise, S. F. Alaoui, and T. Schiphorst. Cultivating kinaesthetic awareness through interaction: Perspectives from somatic practices and embodied cognition. In *Proceedings of the 4th International Conference on Movement Computing*, MOCO '17, New York, NY, USA, 2017. Association for Computing Machinery.
- [16] K. Carlson, P. Pasquier, H. Tsang, J. Phillips, T. Schiphorst, and T. Calvert. Cochoreo: A generative feature in idanceforms for creating novel keyframe animation for choreography. In *Proceedings of the Seventh International Conference on Computational Creativity*, June 2016.
- [17] K. Carlson, H. H. Tsang, J. Phillips, T. Schiphorst, and T. Calvert. Sketching movement: Designing creativity tools for in-situ, whole-body authorship. In *Proceedings of the 2nd International Workshop on Movement and Computing*, MOCO '15, page 68–75, New York, NY, USA, 2015. Association for Computing Machinery.
- [18] E. Cherry and C. Latulipe. Quantifying the creativity support of digital tools through the creativity support index. *ACM Transactions on Computer-Human Interaction*, 21(4), June 2014.
- [19] M. Ciolfi Felice, S. Fdili Alaoui, and W. E. Mackay. Knotation: Exploring and documenting choreographic processes. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18, page 1–12, New York, NY, USA, 2018. Association for Computing Machinery.

- [20] M. Coniglio. Isadora. <https://troikatronix.com/>, last accessed on 01-03-2024.
- [21] M. Csikszentmihalyi. *The Systems Model of Creativity and Its Applications*, chapter 25, pages 533–545. John Wiley & Sons, Ltd, 2014.
- [22] K. El Raheb, N. Papapetrou, V. Katifori, and Y. Ioannidis. Balonse: Ballet ontology for annotating and searching video performances. In *Proceedings of the 3rd International Symposium on Movement and Computing*, MOCO '16, New York, NY, USA, 2016. Association for Computing Machinery.
- [23] K. El Raheb, M. Stergiou, A. Katifori, and Y. Ioannidis. Dance interactive learning systems: A study on interaction workflow and teaching approaches. *ACM Comput. Surv.*, 52(3), June 2019.
- [24] C. Ellis, T. E. Adams, and A. P. Bochner. Autoethnography: An overview. *Forum Qualitative Sozialforschung / Forum: Qualitative Social Research*, 12(1), Nov. 2010.
- [25] C. Erkut and S. Dahl. Embodied interaction through movement in a course work. In *Proceedings of the 4th International Conference on Movement Computing*, MOCO '17, New York, NY, USA, 2017. Association for Computing Machinery.
- [26] S. Fdili Alaoui. Making an interactive dance piece: Tensions in integrating technology in art. In *Proceedings of the 2019 on Designing Interactive Systems Conference*, DIS '19, page 1195–1208, New York, NY, USA, 2019. Association for Computing Machinery.
- [27] M. H. Fogtmann, J. Fritsch, and K. J. Kortbek. Kinesthetic interaction: Revealing the bodily potential in interaction design. In *Proceedings of the 20th Australasian Conference on Computer-Human Interaction: Designing for Habitus and Habitat*, OZCHI '08, page 89–96, New York, NY, USA, 2008. Association for Computing Machinery.
- [28] C. Frayling and R. C. of Art (Great Britain). *Research in Art and Design*. Royal College of Art research papers. Royal College of Art, 1993.
- [29] J. Frich, L. MacDonald Vermeulen, C. Remy, M. M. Biskjaer, and P. Dalsgaard. Mapping the landscape of creativity support tools in hci. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, page 1–18, New York, NY, USA, 2019. Association for Computing Machinery.
- [30] J. Frich, M. Mose Biskjaer, and P. Dalsgaard. Twenty years of creativity research in human-computer interaction: Current state and future directions. In *Proceedings of the 2018 Designing Interactive Systems Conference*, DIS '18, page 1235–1257, New York, NY, USA, 2018. Association for Computing Machinery.
- [31] G. Gibbs. *Analyzing Qualitative Data*, volume 6 of *Qualitative Research Kit*. SAGE Publications Ltd, United Kingdom, 2nd edition, Oct. 2018.

- [32] T. Gunning. *Loïe Fuller and the Art of Motion: Body, Light, Electricity, and the Origins of Cinema*, pages 75–90. Amsterdam University Press, 2003.
- [33] M. Helfand, J. Kaufman, and R. Beghetto. The four-c model of creativity: Culture and context. In V. P. Glăveanu, editor, *Palgrave handbook of creativity and culture research*, pages 15–36. Palgrave, New York, NY, Jan. 2017.
- [34] D. Hendry, K. Chai, A. Campbell, L. Hopper, P. O’Sullivan, and L. Straker. Development of a human activity recognition system for ballet tasks. *Sports Medicine - Open*, 6(1), Feb. 2020.
- [35] K. Höök. Transferring qualities from horseback riding to design. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries*, NordiCHI ’10, page 226–235, New York, NY, USA, 2010. Association for Computing Machinery.
- [36] K. Höök, M. P. Jonsson, A. Ståhl, and J. Mercurio. Somaesthetic appreciation design. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI ’16, page 3131–3142, New York, NY, USA, 2016. Association for Computing Machinery.
- [37] S. Hsueh, S. F. Alaoui, and W. E. Mackay. Understanding kinaesthetic creativity in dance. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI ’19, page 1–12, New York, NY, USA, 2019. Association for Computing Machinery.
- [38] K. Höök, B. Caramiaux, C. Erkut, J. Forlizzi, N. Hajinejad, M. Haller, C. C. M. Hummels, K. Isbister, M. Jonsson, G. Khut, L. Loke, D. Lottridge, P. Marti, E. Melcer, F. F. Müller, M. G. Petersen, T. Schiphorst, E. M. Segura, A. Ståhl, D. Svanæs, J. Tholander, and H. Tobiasson. Embracing first-person perspectives in soma-based design. *Informatics*, 5(1), 2018.
- [39] E. Jochum and J. Derks. Tonight we improvise! real-time tracking for human-robot improvisational dance. In *Proceedings of the 6th International Conference on Movement and Computing*, MOCO ’19, New York, NY, USA, 2019. Association for Computing Machinery.
- [40] S. Jürgens, N. N. Correia, and R. Masu. The body beyond movement: (missed) opportunities to engage with contemporary dance in hci. In *Proceedings of the Fifteenth International Conference on Tangible, Embedded, and Embodied Interaction*, TEI ’21, New York, NY, USA, 2021. Association for Computing Machinery.
- [41] J. C. Kaufman and R. A. Beghetto. Beyond big and little: The four c model of creativity. *Review of General Psychology*, 13(1):1–12, 2009.
- [42] K. Kender. Tumblr is queer and twitter is toxic: Speculating about the vibe of social media spaces. In *Nordic Human-Computer Interaction Conference*, NordiCHI ’22, New York, NY, USA, 2022. Association for Computing Machinery.

- [43] K. Kender and C. Frauenberger. The shape of social media: Towards addressing (aesthetic) design power. In *Proceedings of the 2022 ACM Designing Interactive Systems Conference*, DIS '22, page 365–376, New York, NY, USA, 2022. Association for Computing Machinery.
- [44] B. Kikhia, M. Gomez, L. L. Jiménez, J. Hallberg, N. Karvonen, and K. Synnes. Analyzing body movements within the laban effort framework using a single accelerometer. *Sensors*, 14(3):5725–5741, 2014.
- [45] A. T. Larssen, T. Robertson, and J. Edwards. How it feels, not just how it looks: When bodies interact with technology. In *Proceedings of the 18th Australia Conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments*, OZCHI '06, page 329–332, New York, NY, USA, 2006. Association for Computing Machinery.
- [46] C. Latulipe and S. Huskey. Dance.draw: Exquisite interaction. In *Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction - Volume 2*, BCS-HCI '08, page 47–51, Swindon, GBR, 2008. BCS Learning & Development Ltd.
- [47] L. Loke and T. Robertson. Moving and making strange: An embodied approach to movement-based interaction design. *ACM Transactions on Computer-Human Interaction*, 20(1), Apr. 2013.
- [48] R. Masu, N. N. Correia, S. Jurgens, I. Druzetic, and W. Primett. How do dancers want to use interactive technology? appropriation and layers of meaning beyond traditional movement mapping. In *Proceedings of the 9th International Conference on Digital and Interactive Arts*, ARTECH 2019, New York, NY, USA, 2019. Association for Computing Machinery.
- [49] W. McGregor and B. Girschig. Living Archive by Wayne McGregor. <https://experiments.withgoogle.com/living-archive-wayne-mcgregor>, last accessed on 01-03-2023.
- [50] L. E. Miller. Cage, cunningham, and collaborators: The odyssey of "variations v". *The Musical Quarterly*, 85(3):545–567, 2001.
- [51] L. Molina-Tanco, C. García-Berdónés, and A. Reyes-Lecuona. The delay mirror: A technological innovation specific to the dance studio. In *Proceedings of the 4th International Conference on Movement Computing*, MOCO '17, New York, NY, USA, 2017. Association for Computing Machinery.
- [52] R. Oppenheimer. A strange dance: the creative collaborative origins & processes of "9 evenings: theatre & engineering". In *Proceedings of the 5th Conference on Creativity & Cognition*, C&C '05, page 137–143, New York, NY, USA, 2005. Association for Computing Machinery.

- [53] P. Palacio and D. Bisig. Piano&dancer: Interaction between a dancer and an acoustic instrument. In *Proceedings of the 4th International Conference on Movement Computing*, MOCO '17, New York, NY, USA, 2017. Association for Computing Machinery.
- [54] M. Pettee, C. Shimmin, D. Duhaime, and I. Vidrin. Beyond imitation: Generative and variational choreography via machine learning, 2019.
- [55] R. Powell. *Wabi Sabi Simple: Create beauty. Value imperfection. Live deeply*. Adams Media, 2004.
- [56] U. Proske and S. C. Gandevia. The kinaesthetic senses. *The Journal of physiology*, 587(17):4139–4146, 2009.
- [57] K. E. Raheb, G. Tsampounaris, A. Katifori, and Y. Ioannidis. Choreomorphy: A whole-body interaction experience for dance improvisation and visual experimentation. In *Proceedings of the 2018 International Conference on Advanced Visual Interfaces*, AVI '18, New York, NY, USA, 2018. Association for Computing Machinery.
- [58] J. Rajko. Geocultural precarities in canonizing computing research involving dance: The effects of treating western, euroamerican concert dance as universally applicable across geoculturally diverse movement computing research efforts. In *Proceedings of the 8th International Conference on Movement and Computing*, MOCO '22, New York, NY, USA, 2022. Association for Computing Machinery.
- [59] J. Rajko, M. Krzyzaniak, J. Wernimont, E. Standley, and S. Rajko. Touching data through personal devices: Engaging somatic practice and haptic design in felt experiences of personal data. In *Proceedings of the 3rd International Symposium on Movement and Computing*, MOCO '16, New York, NY, USA, 2016. Association for Computing Machinery.
- [60] E. Rosselli Del Turco and P. Dalsgaard. "i wouldn't dare losing one": How music artists capture and manage ideas. In *Proceedings of the 15th Conference on Creativity and Cognition*, C&C '23, page 88–102, New York, NY, USA, 2023. Association for Computing Machinery.
- [61] R. S. Ryman and R. Hughes-Ryman. The macbenesh editor: A 'word processor' for benesh notation, 1986. Retrieved from <https://drive.google.com/file/d/0B8Q3wiYtY7OCLWVwQ0pWVnpELVU/edit?resourcekey=0-qdAcZFv1awdz2eMtoaH9WA>, last accessed on 30-01-2024.
- [62] A. D. P. d. Santos, L. M. Tang, L. Loke, and R. Martinez-Maldonado. You are off the beat! is accelerometer data enough for measuring dance rhythm? In *Proceedings of the 5th International Conference on Movement and Computing*, MOCO '18, New York, NY, USA, 2018. Association for Computing Machinery.

- [63] B. Shneiderman. Creativity support tools: Accelerating discovery and innovation. *Communications of the ACM*, 50(12):20–32, Dec. 2007.
- [64] B. Shneiderman. *Creativity Support Tools: A Grand Challenge for HCI Researchers*, pages 1–9. Springer London, London, 2009.
- [65] B. Shneiderman, G. Fischer, M. Czerwinski, M. Resnick, B. Myers, L. Candy, E. Edmonds, M. Eisenberg, E. Giaccardi, T. Hewett, P. Jennings, B. Kules, K. Nakakoji, J. Nunamaker, R. Pausch, T. Selker, E. Sylvan, and M. Terry. Creativity support tools: Report from a u.s. national science foundation sponsored workshop. *International Journal of Human-Computer Interaction*, 20(2):61–77, 2006.
- [66] D. Silang Maranan, S. Fdili Alaoui, T. Schiphorst, P. Pasquier, P. Subyen, and L. Bartram. Designing for movement: Evaluating computational models using lma effort qualities. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '14, page 991–1000, New York, NY, USA, 2014. Association for Computing Machinery.
- [67] V. Singh, C. Latulipe, E. Carroll, and D. Lottridge. The choreographer’s notebook: A video annotation system for dancers and choreographers. In *Proceedings of the 8th ACM Conference on Creativity and Cognition*, C&C '11, page 197–206, New York, NY, USA, 2011. Association for Computing Machinery.
- [68] S. Stančič and S. Tomažič. Dance tempo estimation using a single leg-attached 3d accelerometer. *Sensors*, 21(23):8066, Dec. 2021.
- [69] G. Sun, W. Chen, H. Li, Q. Sun, M. J. Kyan, Muneesawang, and P. Zhang. A virtual reality dance self-learning framework using laban movement analysis. *Journal of Engineering Science and Technology Review*, 10:25–32, 2017.
- [70] D. Svanæs. Interaction design for and with the lived body: Some implications of merleau-ponty’s phenomenology. *ACM Trans. Comput.-Hum. Interact.*, 20(1), Apr. 2013.
- [71] P. Tennent, J. Marshall, V. Tsaknaki, C. Windlin, K. Höök, and M. Alfaras. Soma design and sensory misalignment. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, page 1–12, New York, NY, USA, 2020. Association for Computing Machinery.
- [72] E. Tomas, T. Gorbach, H. Tellioglu, and M. Kaltenbrunner. Material embodiments of electroacoustic music: an experimental workshop study. In M. Queiroz and A. X. Sedó, editors, *Proceedings of the International Conference on New Interfaces for Musical Expression*, pages 1–6, Porto Alegre, Brazil, June 2019. UFRGS.
- [73] V. Tsaknaki and Y. Fernaeus. Expanding on wabi-sabi as a design resource in hci. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, CHI '16, page 5970–5983, New York, NY, USA, 2016. Association for Computing Machinery.

- [74] K. Unsworth. Unpacking creativity. *The Academy of Management Review*, 26(2):289–297, 2001.
- [75] D. F. Vears and L. Gillam. Inductive content analysis: A guide for beginning qualitative researchers. *Focus on Health Professional Education*, 23(1):111–127, 2022.
- [76] L. Venable. Archives of the dance: Labanwriter: There had to be a better way. *Dance Research: The Journal of the Society for Dance Research*, 9(2):76–88, 1991.
- [77] M. Vialle, S. Fdili Alaoui, M. Skouras, and E. Schwartz. Supporting perception of spatiality in dance in augmented reality. In *Proceedings of the 15th Conference on Creativity and Cognition, C&C '23*, page 441–453, New York, NY, USA, 2023. Association for Computing Machinery.
- [78] G. Wallas. *The art of thought*. Harcourt, Brace and Company, New York, NY, 1926.
- [79] L. Wilke, T. Calvert, R. Ryman, and I. Fox. From dance notation to human animation: The labandancer project. *Computer animation and virtual worlds*, 16(3-4):201–211, 2005.
- [80] N. J. Wilson-Small, L. Pancoast, K. Petersen, and S. Azenkot. Exploring human-drone collaboration through contact improvisation. In *Companion of the 2023 ACM/IEEE International Conference on Human-Robot Interaction, HRI '23*, page 97–101, New York, NY, USA, 2023. Association for Computing Machinery.
- [81] J. O. Wobbrock and J. A. Kientz. Research contributions in human-computer interaction. *Interactions*, 23(3):38–44, Apr. 2016.
- [82] Q. Zhou, C. C. Chua, J. Knibbe, J. Goncalves, and E. Velloso. Dance and choreography in hci: A two-decade retrospective. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, CHI '21*, New York, NY, USA, 2021. Association for Computing Machinery.
- [83] J. Zimmerman, J. Forlizzi, and S. Evenson. Research through design as a method for interaction design research in hci. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI '07*, page 493–502, New York, NY, USA, 2007. Association for Computing Machinery.