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CUXC: a collaborative user experience curve for evaluating digital technologies over time

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Abstract

Evaluating long-term user experience (UX) presents methodological challenges, particularly when multiple technologies intersect with complex processes. Retrospective approaches are vulnerable to memory biases and often rely on individual recall. This paper introduces the Collaborative UX Curve (CUXC), a three-phase method designed to address these limitations by combining constructive and value-account recall with cue-dependent anchors, transactive memory, and collaborative cross-cueing. The method was evaluated in a palliative care setting, where three groups of practitioners applied the CUXC across two processes: pain management and psychological well-being. Participants identified technologies through collaborative discussion, plotted individual experiences over a 3-year timeline, and collaboratively reviewed outputs. Across groups, 14 technologies were identified, 92 experiences annotated, and 9 themes generated. The collaborative format enhanced recall, reduced memory biases, and enabled evaluation of multiple technologies within complex processes. The method was efficient, with three groups completing the process in 4.5 hours, producing rich and contextualized data.

RESEARCH HIGHLIGHTS

- Introduces the Collaborative User Experience Curve (CUXC), a method for evaluating long-term UX.
- Combines individual recall with collaborative cross-cueing to reduce memory biases.
- Enables evaluation of multiple technologies that support organisational processes.
- CUXC demonstrates efficiency: three groups completed the full method in 4.5 hours.

Keywords long-term user experience, collaborative user research, user experience (UX), longitudinal studies, technology

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User experience (UX) has been formally defined by ISO 9241-210 (2010) as a "person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service"; however, there is no agreed definition of long-term UX (Varsaluoma & Sahar, 2014). User experience has been recognized as dynamic, and evolving over time with early interactions often characterized by hedonic enjoyment, which later shifts toward pragmatic concerns as novelty fades (Karapanos et al., 2009; Kujala et al., 2013). Hassenzahl et al. (2006) describes UX as a process made up of multiple moments, where users may feel excited, frustrated, stimulated or bored, often within the same usage episode. Research has described long-term UX as temporal, context-driven, and cumulative, integrating multiple episodes of use into broader assessments, influenced by interactions with a product, system, or service (Kujala et al., 2013; Martinelli et al., 2024; Melo and Andrade, 2022; Roto et al., 2011). The cumulative perspective is fundamental as methods that capture only momentary impressions risk providing unreliable or incomplete accounts of technology use (Kujala et al., 2011). Long-term UX has therefore emerged as a key consideration, with evaluations spanning weeks, months, and even years.

Several methods have been developed to evaluate UX over time, based on two paradigms, repeated measures, and retrospective methods. Repeated measures capture data at multiple points in time, with methods including Experience Sampling (Hektner et al., 2007) and Day Reconstruction (Kahneman et al., 2004). These methods may provide detailed insights, but could be costly, time-intensive, and vulnerable to participant dropout (De Leeuw & Lugtig, 2014; Dufraisse et al., 2024; Jain & Boyce, 2012; Mkpojiogu et al., 2022). Retrospective methods could offer an efficient alternative, grounded in theories of human memory such as constructive and value-account recall,

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which explain how people reconstruct or summarize experiences (Barsalou, 1988; Betsch et al., 2001). Retrospective methods require participants to recall their experiences using survey, graphing, and interview techniques. Methods include UX Curve, iScale, Draw UX, and MemoLine (Flanagan, 1954; Karapanos et al., 2012; Kujala et al., 2011; Sim et al., 2016; Varsaluoma & Kentta, 2012). Researchers have also suggested that to achieve meaningful results from retrospective methods, incorporating visual aids can serve as effective anchors for retrospection and reflection (Huang & Stolterman, 2014). Such aids could support participants to recall experiences more accurately by providing cues that facilitate memory recall.

Retrospective methods for assessing long-term UX could be susceptible to memory biases. Users may reconstruct experiences inaccurately when reporting events months or years after they occurred (Kahneman et al., 2004). Individual methods may be time-consuming to administer; for example, the iScale study required 48 participants to attend two sessions lasting approximately 40 min each. These were separated by a week and amounted to 64 hours of data collection in total (Karapanos et al., 2012). Beyond resource demands, individual retrospective data are usually aggregated, which can raise further challenges. Aggregation can obscure context, flatten peaks and dips, and weaken unique personal trajectories, thereby reducing the richness of data (Maas-Hebner et al., 2015). In applied domains where understanding diverse experiences is vital, such loss of nuance risks overlooking important differences in how technology support or hinder processes.

Organizations may use multiple technologies to support processes; for example, in higher education, multiple technologies are used to support learning (Timotheou et al., 2023), and staff may use different functionalities depending on their role. In addition, accessing staff to administer individual retrospective methods may be challenging in certain organizations such as schools or hospitals whereby the availability of staff may be difficult to predict. For instance, utilizing the iScale individually could be resource intensive; if a large number of participants were scheduled one per day, data collection could take months, with such delays potentially introducing biases. In contexts such as palliative care, where hospices in the U.K. often rely on charitable donations and practitioners frequently encounter time constraints (Lehto et al., 2020), such efficiency is vital in a long-term UX study.

To address the challenges of long-term UX methods that are administered individually, this paper makes a methodological contribution, a Collaborative UX Curve (CUXC). In this context, collaborative retrospective tools could provide a practical means of understanding how multiple technologies support critical processes, such as pain management and psychological well-being, within an organization and, in this case, palliative care. The decision was to adapt the UX Curve (Kujala et al., 2011) to work in a collaborative context. It was conjectured that the UX Curve may be an appropriate method to adapt since it assists users in recalling UX and has been shown to be an efficient and easy-to-use measurement technique long term (Feng & Wei, 2019). This study therefore asks: How effectively does the adapted CUXC capture UXs in the context of palliative care over time? While demonstrated in palliative care, the methodological insights could extend to other domains where multiple technologies, resource pressures, and complex processes make individual long-term studies impractical. The palliative care context serves as a case setting, illustrating how the method operates under conditions of time pressure, multiple technology use, and complex processes. While the empirical findings provide contextual evidence, the papers' primary contribution is methodological, offering a theory-informed, collaborative approach to evaluating long-term UX that may be applied in other domains.

1.1 Related work

This section is structured into three parts. The first considers why long-term UX evaluation is needed and how it has been approached in human-computer interaction (HCI), highlighting the strengths and limitations of repeated measures. The second reviews retrospective methods, outlining their development, techniques, and application contexts. The third examines the theoretical foundations of retrospective evaluation, focusing on how memory theories such as constructive and value-account recall explain both the potential and limitations of such methods. Together, these strands provide the foundation for the methodological adaptation presented in this paper.

1.2 Evaluating long-term UX

UX research has tended to focus on evaluating momentary UXs during or after a user has interacted with a system (Marti & Iacono, 2016). Short-term measures risk producing unreliable or incomplete accounts because they capture only momentary impressions (Kujala et al., 2011). However, UX research has emphasized that experience is not static but evolves across time. Hassenzahl et al. (2006) argued that UX should be conceptualized as a dynamic process, comprising individual moments that evoke diverse emotional and cognitive responses. Users may enjoy, become frustrated with, or adapt to a product at different points of interaction, reflecting the inherently temporal and contextual nature of UX. Empirical studies support this, showing that early interactions are often hedonic and curiosity driven but later shift toward pragmatic concerns as novelty diminishes (Karapanos et al., 2009; Kujala et al., 2013).

When examining UX over time, the duration of the interaction being evaluated is important. Four stages of UX have been identified (Roto et al., 2011), starting with anticipated UX, which refers to the expectations users form before engaging with a product, shaped by their experiences with similar technologies. Momentary UX captures the immediate perceptions and feelings users experience during an interaction as it occurs. Episodic UX involves the evaluation of a specific usage event or session. Finally, long-term or cumulative UX represents the overall perception of a product formed over time, integrating momentary and episodic experiences into a broader reflection of sustained usage (Marti & Iacono, 2016). Two main approaches have been used for evaluating long-term UX, repeated sampling, and retrospective methods (Kujala et al., 2011).

Research tools used in repeated sampling capture data on the same variable(s) with the same participants on more than one occasion. Researchers have used repeated measures to capture momentary or episodic experiences using different techniques, including, but not exclusively, questionnaires, diaries, self-reports, and psychophysiological measures. For instance, Walsh et al. (2014) used the AttrakDiff questionnaire once a month over 3 months to assess evolving perceptions of usability and hedonic qualities. Similarly, Biduski et al. (2020) employed conversational questionnaires embedded in mobile apps to capture experiences over 12 weeks. These approaches highlight the strength of repeated measures in producing fine-grained data on experiential change. However, they also reveal limitations; for example, in the study by Walsh et al. (2014), the attrition rate was

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25%. Von Wilamowitz-Moellendorf et al. (2006) classified repeated measures by temporal resolution: micro (hr), meso (weeks), and macro (years). While micro-level studies capture short-term fluctuations, macro-level designs are rare due to cost and feasibility constraints. Sustaining engagement over extended periods places heavy demands on both researchers and participants, making such designs challenging in applied domains such as healthcare. Jain and Boyce (2012) also highlight the managerial burden of sustaining long-term studies, noting the difficulties of aligning data collection with participants' daily lives. Collectively, these findings underline the strengths of repeated measures in capturing temporal detail, but also their limitations in terms of practicality, efficiency, and feasibility in real-world contexts. An alternative paradigm to repeated sampling is retrospective methods, which are designed to support the user to recall experiences.

1.3 Retrospective evaluation methods

To address the challenges of longitudinal studies, retrospective measures have been developed to support users recall experiences. Rather than requiring repeated measures at multiple points of use, retrospective methods ask participants to recall and reflect on their experiences after they have occurred. These approaches aim to capture the dynamics of long-term UX and could reduce the logistical and financial demands of extended fieldwork.

Early methods relied primarily on self-reporting. The critical incident technique (Flanagan, 1954) asked participants to describe specific experiences in relation to a defined activity, while the CORPUS method (Von Wilamowitz-Moellendorf et al., 2006) used interview-based recall to elicit detailed accounts of product use. These methods provided useful insights but depended on verbal reporting alone and lacked visual or structural aids to support memory retrieval, potentially increasing the risk of incompleteness or distortion when participants struggled to recall experiences from months or years earlier.

Later developments incorporated graphing and sketch-based techniques to anchor memory retrieval. The UX Curve (Kujala et al., 2011) was originally applied to mobile phones, asking participants to plot how their experiences with a device evolved over time, marking peaks and dips with explanatory notes. Validation against satisfaction and loyalty questionnaires demonstrated consistency, confirming its utility for charting dynamic experiences. Building on this, the iScale method (Karapanos et al., 2012) was also developed in the context of mobile phone adoption, where participants sketched their evolving experiences in two sessions held a week apart. By combining sketching with episodic annotations, iScale operationalized the value-account model of memory, allowing participants to provide assessments while surfacing episodic details. Draw UX (Varsaluoma & Kentta, 2012) utilized this principle by encouraging participants to use free-form drawing to reconstruct experiences with digital services, enabling more personal and creative reconstructions, albeit with increased interpretive demands for researchers. MemoLine (Vissers et al., 2013) further adapted sketch-based recall for children, embedding simplified visuals and temporal cues to help them reflect on their experiences with educational and entertainment technologies.

Together, these approaches demonstrate the versatility of retrospective evaluation methods across different user groups and domains. However, most have focused on a single technology at a time, such as a mobile phone, a digital service, or a specific application. This presents challenges for applied contexts where multiple technologies intersect to support complex processes, as in healthcare or education. Capturing long-term UX in these environments requires methods that can reflect not only the trajectory of a single product but also the interplay between several systems and practices.

Despite developments, retrospective methods can pose several challenges. Individual administration can be resource intensive, as shown by the iScale study, which required 48 participants to attend two 40-minute sessions each, amounting to 64 hours of researcher time (Karapanos et al., 2012). When results are later aggregated, there is also the risk that unique trajectories and contextual nuances are flattened, diluting the richness of the data. Moreover, recall is subject to cognitive biases such as the peak-end rule, where memories are disproportionately shaped by the most intense and final events (Kahneman et al., 1993), or where intrusive but irrelevant memories distort retrieval (Schacter, 1999). For these reasons, researchers have suggested that retrospective methods should incorporate visual anchors. Huang and Stolterman (2014) emphasized that visual tools such as diagrams and sketches can act as effective cues for retrospection, while Roto et al. (2011) highlighted the potential of co-experience and group reflection to deepen understanding of how experiences are constructed over time. Challenges that currently occur during retrospective evaluation methods allow us to rethink how such methods can be further developed and adapted.

1.4 Theoretical foundations of retrospective methods

To understand why retrospective methods function as they do, it is necessary to ground them in theories of human memory. Human memory is typically distinguished into working, short-term and long-term forms (Tulving, 1972). Within long-term memory, two subsystems are recognized, sematic and episodic. Episodic memory refers to the recollection of context-specific experiences and events, whereas semantic memory refers to general knowledge, facts, and concepts (Tulving, 1972). Episodic memory is particularly relevant for evaluating UX, since it provides access to past events situated in time and place. Many theories have been derived to understand how such information is retrieved within individual and collaborative settings.

To recall memory, there are several approaches. The constructive approach views memory as a process of reconstruction in chronological order, and when recalling experiences, people often proceed sequentially, with one episode triggering the next (Barsalou, 1988). Episodic memory is essential here, as this houses events and experiences. For example, in the UX Curve (Kujala et al., 2011), the horizontal axis represented the time dimension from the beginning of use to the current moment evidencing a constructive approach. In contrast, the value-account approach assumes that people do not necessarily remember every episode in detail but instead retain a general impression shaped by the frequency and intensity of positive or negative experiences (Betsch et al., 2001). This perspective has been applied in the development of the iScale tool (Karapanos et al., 2012), which allows participants to record long-term trends in experience based on these overall affective judgments, while still providing a means to surface episodic detail during recall. However, retrospective recall is also subject to biases, Kahneman et al. (1993) suggested that recollections are often distorted by the peak end rule. This is where the most intense and final moments disproportionately form memory. While individual recall theories could explain how episodic details and affective impressions are reconstructed, they also highlight vulnerabilities to bias. In applied contexts, especially where memories

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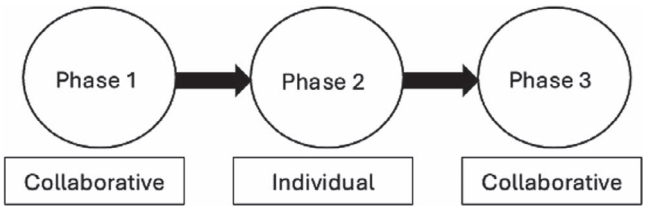

Figure 1 CUXC phases—demonstrating phase 1–3.

must be retrieved months or years after the fact, relying on individuals alone may produce fragmented or distorted accounts.

Collaborative memory approaches, by contrast, explicitly use interaction to enhance recall. Transactive memory theory (Wegner, 1987) and its organizational extensions (Austin, 2003) propose that groups operate as distributed memory systems, where one person's recollection can act as a retrieval cue for others. Research on collaborative recall supports this, showing that group discussion enhances memory completeness through cross-cueing (Rajaram, 2007; Weldon & Bellinger, 1997). The Ugly Sister Effect (Schacter, 1999) describes how competing but incorrect memories can intrude during recall, while Tip-of-the-Tongue occurs when recall feels imminent but inaccessible. In collaborative settings, group members can help to resolve these challenges by offering confirming or corrective cues, thereby surfacing details that may otherwise remain unrecalled. In adapting the UX Curve for collaborative use, these theories provide a rationale for reducing individual memory demands and bias, while enabling rich and contextually grounded accounts of experience.

1.5 CUXC design

The CUXC method was developed to evaluate the long-term UX of practitioners as they engaged with multiple technologies to support a specific process. In this study, "technology" referred to software, hardware, or services such as WhatsApp, Oculus Virtual Reality (VR), and push notifications. A challenge when evaluating long-term UX is the reliability of retrospective recall, which declines over extended periods (Kujala et al., 2011). Memory is also susceptible to biases, including the peak end rule, where recollections are disproportionately influenced by the most intense and final moments of an experience (Kahneman et al., 1993), and the Ugly Sister Effect, where intrusive memories disrupt retrieval (Schacter, 1999). When recalling experiences, people may reconstruct them in chronological sequence (constructive recall), or they may draw on a general affective impression of the event (value-account recall) (Anderson & Conway, 1993; Barsalou, 1988; Betsch et al., 2001). To mitigate these limitations and enhance recall accuracy, the CUXC combined individual plotting with collaborative discussion across three phases (see Figure 1).

The design was informed by several theories: cue-dependent memory theory (Tulving, 1972), transactive memory theory (Wegner, 1987), the constructive approach (Barsalou, 1988), value-account approach (Betsch et al., 2001), and collaborative recall (Rajaram, 2007). The decision to use job-specific groups was informed by extensions of transactive memory theory to organizational settings (Austin, 2003), recognizing that specialized professional knowledge and experience operate as a distributed memory system.

The objective of the CUXC was to engage participants with their relationship to an identified process and to understand to what extent digital multiple technologies supported the process, documenting the positive and negative aspects of each technology over time. To accomplish this, we adapted the UX Curve (Kujala et al., 2011) to be completed both individually and collaboratively within a group context, as shown in Figure 2.

1.6 Phase 1: framing (process and technologies)

In the first phase, participants worked in job-specific groups such as community and inpatient practitioners to identify the technologies they had used within a specified process, such as pain management or psychological well-being to establish a shared reference framework to support later recall. Participants, working in small groups, began by discussing the process and listing the technologies they had used in relation to it.

The group discussion at this phase was informed by transactive memory theory, which suggests that individuals within a group act as distributed memory systems. By sharing and comparing technology use, participants acted as external memory cues for one another, helping to surface technologies that might otherwise have been overlooked. This phase also helped mitigate the Ugly Sister Effect (Schacter, 1999), where intrusive but incorrect memories disrupt recall, by enabling participants to compare recollections and validate them collaboratively. In this way, distributed memory systems not only surfaced overlooked technologies but also reduced the likelihood of distorted retrieval. Each identified technology was recorded in the boxes on the left of the CUXC sheet (1a). The participants would then describe the functionality for each technology. Given that multiple technologies were likely to be identified, a unique identifier was required to enable facilitators to link the different technologies to the experiences within the next phase. In this study, the decision was made that the facilitator would mark up each technology with a unique colored sticky dot. For instance, green was assigned to WhatsApp. This ensured that whenever a participant referred to WhatsApp in phase 2, they would use the corresponding green Post-it notes to document their reason.

1.7 Phase 2: contextualizing (plotting and responding)

In the second phase, participants individually plotted their experiences of each technology over time. The *x*-axis of the CUXC represented the 3-year study period, divided into quarterly segments, capturing experiences before, during, and after the COVID-19 pandemic. Significant anchor events, such as the beginning and end of national lockdowns, were marked along the axis as temporal retrieval cues. Prior research highlights that anchor points can reduce retrieval effort and minimize timeline distortion (Vissers et al., 2013). The y-axis presented a 15-point scale ranging from positive to negative experiences, with the neutral midpoint visually represented by a transition from purple (negative) to green (positive). Each participant was provided with red sticky dots to plot their experiences along the curve. To ensure individual traceability, participants were assigned a unique letter, which they combined with an incremental number on each sticky dot (e.g., A1, A2, B1). By asking participants to plot their experiences chronologically while simultaneously reflecting on their overall affective impressions, this phase operationalized both constructive recall (Barsalou, 1988) and the value-account approach (Betsch et al., 2001). The dual process allowed participants to either reconstruct events in sequence or draw on their general evaluative impressions, increasing the completeness of the recall.

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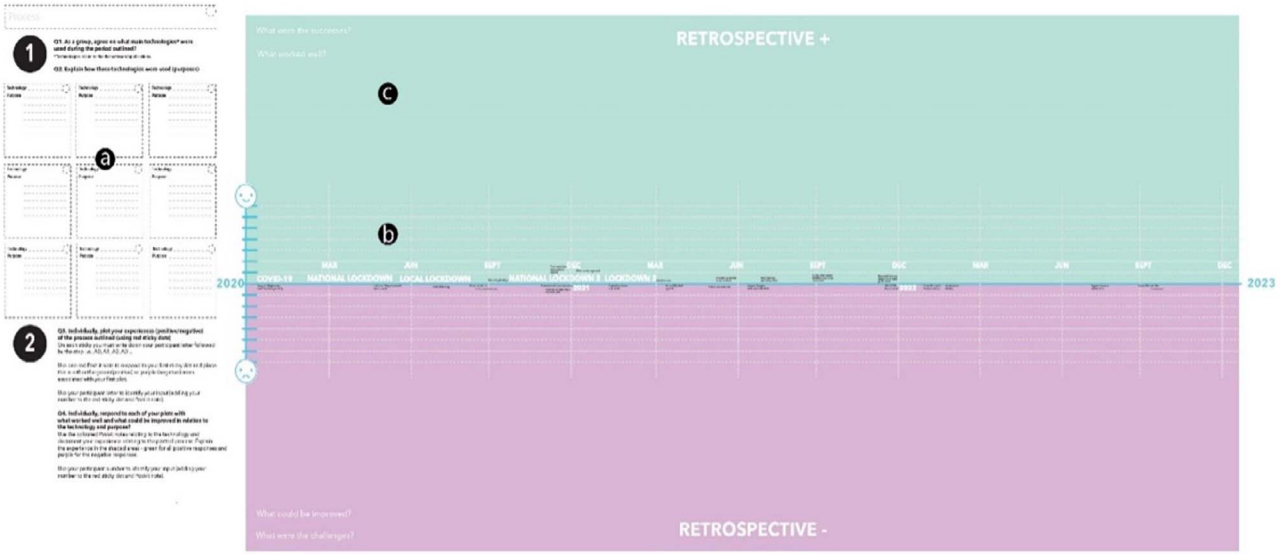

Figure 2 CUXC sheet for capturing positive/negative experiences for the selected process and identified technologies.

While plotting, participants were encouraged to discuss the timeline and anchor events with their group to aid memory recall and reduce temporal ambiguity. However, their plotted experiences remained individual. After placing their dots, participants recorded the reason for each plotted point on a Post-it note in the corresponding technology color from phase 1. These notes were then aligned with the sticky dot on the curve and placed either in the green or purple panel. For example, one participant wrote on a purple-colored Post-it note representing Microsoft Teams: A1 "Distressing video calls on IPU between patient and family." Another participant, also using a purple note for Microsoft Teams, wrote: B2 "Teams, speedier meetings, smarter working." By the end of this phase, individual trajectories of technological experiences were captured in both visual (dots on the curve) and narrative (annotated Post-its) forms. These outputs provided the foundation for the collaborative discussion in phase 3.

1.8 Phase 3: understanding (collaborative discussion)

In the final phase, participants collectively reviewed the plotted data. The curve was broken into manageable time segments, a design choice intended to facilitate recall in smaller cognitive units. The facilitator guided the discussion using principles from collaborative recall research, which emphasizes structuring group interaction to maintain accuracy while encouraging cross-cueing, where one participant's memory detail prompts recall in another (Rajaram, 2007; Weldon & Bellinger, 1997). This process also aligns with transactive memory theory, whereby groups build a more complete account by sharing distributed knowledge. During this phase, participants examined the CUXC collaboratively to identify clusters of significant events and to compare similarities or differences across individual trajectories. The facilitator prompted reflection on whether experiences were shared or divergent, encouraging participants to elaborate on the underlying reasons for positive or negative evaluations. By the end of this phase, participants had co-constructed a richer narrative of how technologies were experienced over time, what events influenced these trajectories, and why shifts in perception occurred. This collaborative reflection provided contextual depth beyond the individual plotting in phase 2, producing insights that reflected both commonalities and diversity in experience.

2 Method

This study applied the CUXC method in the context of palliative care to evaluate its effectiveness as a retrospective tool. The research was conducted with inpatient unit practitioners (IPU) and community nurse specialists (CNS) at St. Catherine's Hospice in the Northwest of England. Palliative care provided an appropriate context for testing the method because practitioners rely on multiple, interdependent technologies under conditions of time pressure, resource constraints, and sensitivity of care. Two processes central to hospice practice were selected to structure the evaluation: pain management and psychological well-being.

2.1 Research context

Globally, the palliative care sector has incorporated various technologies to support patients, caregivers, and practitioners in processes such as pain management and psychological well-being. Palliative care is an approach that aims to improve quality of life for patients and their families who are facing life-limiting or life-threatening illnesses. It focuses on preventing and alleviating suffering through early identification and through assessment, providing treatment for pain, as well as addressing other physical, psychosocial, and spiritual needs (World Health Organization, 2020). Palliative care is provided in both hospice settings and within the broader community. A process in palliative care is a dynamic, iterative approach that adapts to the ever-changing needs of patients and caregivers. Processes such as pain management and psychological well-being often involve multidisciplinary teams (MDT) working collaboratively to enhance quality of life and alleviate suffering caused by physical and psychological pain (Merluzzi et al., 2024). A wide range of technologies are used to support processes including tablets for pain reporting (Schoppee et al., 2020), mobile applications (Al-Mondhiry et al., 2022), communication systems (Kreps, 2018), virtual reality (Nwosu et al., 2024), and Internet of Things (IoT) devices (Rahman et al., 2019), amongst others. However,

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evaluations of such technologies often focus on short-term or episodic use, overlooking how experiences evolve over time.

In palliative care, to determine the effectiveness of the technology, evaluation methods have been drawn from HCI. For instance, Schoppee et al. (2020) involved 465 participants in a study, inclusive of patients and caregivers, who used internet-enabled tablets with PAINReportIt daily for a week. After the first day, the participants provided feedback on their experience using the Computer Acceptability Scale. While the findings offer valuable insights, such evaluations are limited in capturing how UXs change over time or how interactions with technology evolve in changing circumstances. This is also evident in studies that have used the System Usability Scale survey tool to evaluate the usability of technology in palliative care (Klebbe et al., 2022; LeBaron et al., 2022), despite its criticism within the HCI community (Lewis, 2018). Although primarily used to assess usability, the results can provide insights into UX, reflecting how users interact with and perceive the technology (Borsci et al., 2015). These studies require participants to complete the survey after short episodic periods of use, which does not reflect the dynamic and temporal nature of UX.

Evaluating long-term UX could also be important in palliative care to understand how different contexts influence UX. For example, the physical form factor of the technology and its location may influence evaluation results. In a study conducted in a hospital and outpatient unit, when patients reported their pain initially on a laptop and in a subsequent study on an iPad, they found the iPad preferable (Jaatun et al., 2013). The portability and ergonomic design of the iPad allowed patients to use it comfortably from their resting place, eliminating the need to balance a laptop or sit at a table. Another challenge in evaluating technology in palliative care is that it can exclude key stakeholders, such as healthcare practitioners, caregivers, and patients. In some instances, stakeholders are not part of the evaluation of technology due to difficulties in accessing appropriate participants (Walshe et al., 2024). This highlights the importance of evaluation methods that are inclusive and context sensitive, particularly for long-term UX studies. In domains such as palliative care, sustained access to patients, caregivers, and staff over extended periods remains a significant challenge (Lehto et al., 2020). Drawing on methods from the HCI community, there appears to be a need for methods to be adapted to evaluate long-term experiences of multiple technologies to support processes within an organization including the palliative care sector.

2.2 Participants

Before the recruitment of participants, The National Health Service (NHS) ethics committee approved the study, and the process was examined by an independent research advisory board consisting of various stakeholders within palliative care. Participants were recruited through St. Catherine's Hospice's internal team by email and word of mouth. The rationale for this selection approach was to ensure participants were in groups according to their roles within the hospice and that their duties aligned with the identified processes. For example, the inpatient unit team needed to have experience in delivering pain management over the timeframe under investigation. A total of three group collaborative discussions were held in January 2024, totaling 10 participants from two teams (IPU, community practitioners), exploring two processes. Demographic information such as age was not captured, but all participants were female.

In terms of researcher presence, each practitioner team had a dedicated researcher to facilitate the study. An additional researcher was present to observe the study in practice. This provided an extra level of rigor to ensure each researcher followed the agreed protocol and to document any methodological issues.

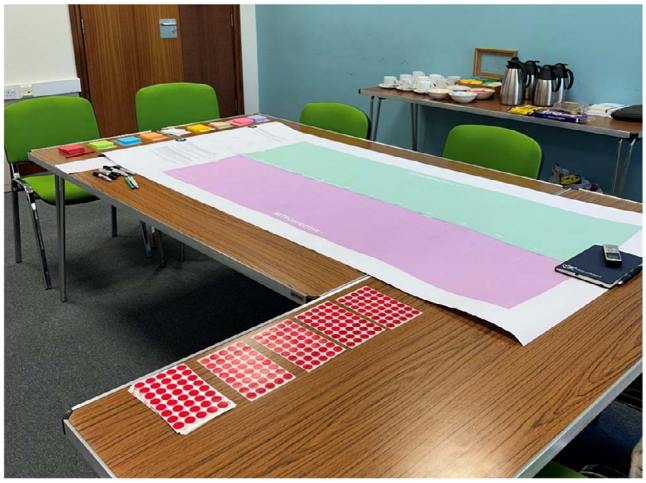

Figure 3 Photograph showing the method apparatus.

2.3 Apparatus and materials

The CUXC was printed using a 2.8 m × 1 m rolled up sheet (Figure 3). This sheet is where all the interaction occurs and contributes to phases 1 to 3.

Participants were positioned around the sheet with the facilitator. In addition to the printed sheet, the materials in Table 1 were used.

2.4 Procedure

The studies took place in a quiet room within St. Catherine's Hospice over several weeks. This was necessary to avoid disruption within the hospice by taking staff away from their main duties. Participants were grouped as either IPU or CNS and attended the session as a team voluntarily after coming forward from the call for participants.

Each session lasted approximately 90 min. During this time, participants were welcomed and introduced to the method by viewing a presentation consisting of:

- Rules of engagement: Inclusive participation, valuing everyone's contribution, data capture, and researcher involvement were clearly explained to the participants.
- Explanation of the CUXC and key terminologies (e.g., what is a technology). The researcher provided a detailed explanation of the CUXC. Each phase of the process was thoroughly explained, and an example video was shown to demonstrate the CUXC procedure, helping participants understand how to complete each phase.

After the presentation, each team gathered around a large table (see Figure 3), where the materials were provided, and a researcher facilitated the delivery of the method. The group began phase 1, with the researcher reiterating the process and then asking the participants, as a group, to identify and list the technologies. One participant documented the technologies on the CUXC chart during this initial discussion. Once the list had been exhausted, the researcher assigned colored sticky dots to each technology listed and transitioned to phase 2.

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Table 1 Equipment used in the study and the rational for its use.

Item	Rationale
Marker pens	The marker pens had medium nip and black ink to try and ensure legibility when analyzing the data. Other studies have reported poor handwriting as a problem (Horton et al., 2019).
Colored Post-it notes	In phase 1, each technology is given a color, and these are used to ensure comments are mapped to specific technologies.
Red sticky dots	These are used in phase 2 to reference both the participant and be placed on the curve to indicate their experience over time.
Dictaphone	A Tascam DR-40X Dictaphone was used to enable the collaborative discussions to be recorded and transcribed.
Research protocol	The research protocol enabled researchers to follow the same script, explaining the necessary steps to the participants. The research protocol included the following: • The aims and objectives of the study. • Expected understanding from the presentation. • Materials. • Preparation and the procedure.

In phase 2, participants were given an individual code (e.g., A1), and they were reminded to write their code on the red sticky dots before they attached them to the chart. They plotted their experiences, either positive or negative, using the dots for the period. During the plotting, the researcher encouraged open discussion amongst the group. Once the participants had finished plotting, they were asked to write down the reasons for their experiences on Post-it notes, ensuring these were placed within the positive and negative areas on the chart. Participants were required to write on a colored Post-it note that matched the color code for the technology they were discussing. For example, in phase 1, WhatsApp may have been assigned the color blue, and therefore, blue Post-it notes would be used. Once this was completed for each red sticky dot, the researcher transitioned to phase 3. Here, the researcher divided the chart into smaller segments based on the number of Post-it notes within an area, and a collaborative discussion occurred reflecting on their collective experiences during this period. Once this segment was completed, the discussion was moved to the next segment, and the process was repeated until the entire chart had been discussed.

The researcher was responsible for ensuring that all phases were completed properly, noting errors and keeping track of time. An example of an error included using the wrong-colored Post-it notes relating to the technology. The timing and procedure are shown in Table 2. There was flexibility in the timings of each phase depending on group dynamics and discussions.

At the end of the session, the participants were thanked, and they were notified of how the findings would be disseminated back to them.

2.5 Analysis

The analysis was conducted in three parts, starting with an analysis of the data from phase 1, quantifying the range of technologies used within the different processes. Descriptive statistics were used to show the frequency with which the technology was used for a particular purpose, across all processes such as pain management or psychological well-being. In this analysis, certain processes and purposes were merged; for example, communication was expanded to include related activities such as texting, the advice line, and the living well hub. Pain distraction was merged with pain management, while audio books, TV, and music were merged under entertainment. Psychological well-being encompassed counseling and the Living Well Hub, while Remembrance Day was merged with bereavement support.

Each participant's timeline was individually coded based on the location of the red stickers they attached to the chart. Curves were categorized as showing improvement, deterioration, or stability across the evaluation period. This allowed us to identify temporal patterns in UX. Each sticker was given a code from 1 to 15 (1 being very negative and 15 being very positive). The chart was divided into 12 segments, each representing a quarter of the year, from January 2020 to December 2023. For example, a red sticker placed in February 2020 would be year 1, quarter 1. If a participant did not place a sticker in a segment, then the score from the previous segment was used to indicate no change of experience over time; thus, it remained stable. In addition, the group's experience was calculated by computing the mean score for each of the 12 segments.

Audio recordings from phases 1, 2, and 3 of the CUXC were transcribed, with transcripts reviewed to ensure familiarity with the data. An inductive thematic analysis (Braun & Clarke, 2006) was conducted on data from phases 2 and 3. Line-by-line coding was applied for phase 2, resulting in 32 codes. In phase 3, in addition to the 32 codes already identified, a further 9 codes emerged, making a total of 41 codes. The codes from both phases were reviewed and refined to remove overlaps, leading to the identification of final codes that applied to both phases such as access to technology. These codes were then merged into seven overarching themes for phase 2, and an addition of two themes emerged for the data in phase 3. The codebook combining codes from both phases was given to an additional researcher to perform interrater reliability coding. A random selection of pages, representing 10% of the data set, from phase 2 and 3 was given to another researcher to code using the codebook. The reliability of the codes was established using Cohen's kappa statistic (Cohen, 1960), and this yielded a kappa score of 0.74, indicating substantial agreement between coders. Discrepancies were addressed through code refinement and merging of codes where necessary.

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Table 2 Summary of the different stages in the CUXC method.

Phase	Activity	Individual/collaborative	Timings
0	Presentation and explanation of study.	Facilitator	15 min
1	Q1: What are the main technologies that have been used for the process during the period outlined on the CUXC.	Collaborative	10 min
	Q2: List all purposes for the main technologies that were used. Note that each technology may have multiple purposes, and lines have been allocated in each box to write in.	Collaborative	5 min
2	Q3. Individually plot experiences (positive/negative/neutral) of the process outlined. Using red sticky dots in the spaces between the lines on the CUXC.	Individually	10 min
	Q4. Individually respond to each of their plots with what worked well and what could be improved in relation to the technology and purpose?	Individually	10 min
3	The designated facilitator for a group will facilitate the discussion on the plots and elaborate on the responses generated. The researcher will identify trends within the curve, which are used to form the basis of the discussion.	Collaborative	40 min

3 Results

The following section summarizes the results from the three phases of the study, which were successfully completed by all participants. The results highlight the impact of COVID-19 and the U.K.'s national lockdown on technology use among staff over time, particularly within such a sensitive domain.

3.1 Phase 1: process and technologies

A total of 14 different technologies were identified as supporting pain management and psychological well-being. In the group focusing on psychological well-being, eight different technologies were identified, and these overlapped with those used within pain management (see Table 3). Of the 14 technologies identified, six were bespoke to the hospice sector, while the remaining technologies were generic and reappropriated to support hospices deliver their services. The mobile phone was widely used to assist in a range of different processes within the hospice, whereas technology such as the transcutaneous electrical nerve stimulation (TENS) machine was solely used for pain management.

It was evident that the discussion aided recall. Initially, the participants did not think they had used a range of technologies to support the process, but after a collaborative discussion within the group, they identified technologies that they had not initially considered. For example, one participant said, "We got quite a few, I didn't think we had. I think it's nice that when you're having a discussion amongst you, you remember things that you did and you think, aah, you might not feel like it now, but it was significant at the time." The discussion also helped validate their responses, ensuring the accuracy of the data. For instance, during the discussion on pain management, one participant said, "I can't think what it was called. Did you see it on the phone?" Another responded, "Yeah. Is it not that EMIS?" A third added, "Your surgeries use EMIS, don't they? You would use that then don't forget." The group in psychological well-being had the same experience in collectively helping each other prompt memory recall to identify the technologies they had used. One participant said, "What do you call it, where we could see the patient, but they quite often put it just on the lap?" Another replied, "Facetime video?" Someone corrected, "No, we did WhatsApp video." Another added, "Mine was not like that, mine was text messages, counselling."

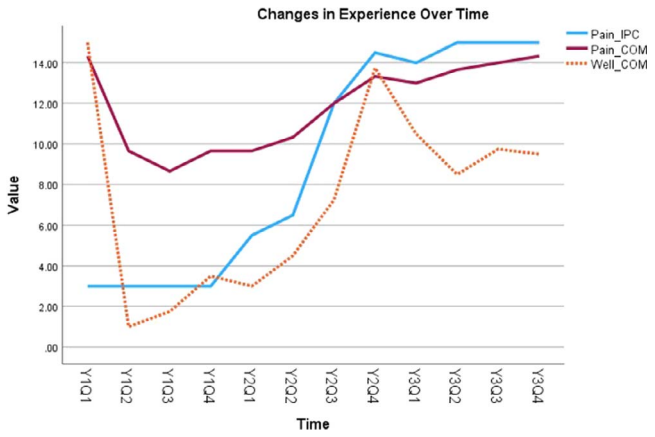

Figure 4 Mean group scores for each quarter are plotted on the CUXC chart.

3.2 Phase 2: plotting, responding

All the participants were able to complete phase 2 by attaching red stickers to represent their experiences over time and attaching Post-it notes indicating the reason for change on the three CUXC charts. The red stickers provided a visual representation of episodic UX, showing how their experiences changed over time. For each group and process, the mean score for each quarter was calculated, illustrating the episodic UX for that period, as shown in Figure 4.

The community practitioners' experience of technology supporting psychological well-being, represented by the orange dashed line, started very positively. However, COVID-19 had a significant negative impact on their experiences, and this became more positive post-COVID-19 in year 2. The experiences of the two different stakeholders regarding technology to support pain management differed at the start, with the inpatient unit having a negative experience until year 2. During year 2, the inpatient units' experience surpassed that of the

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Table 3 The identified technology, purpose, and frequency of purpose utilized.

Purpose	Mobile phone	WhatsApp	FaceTime	MS Teams	Email	VR	System 1 (app and desktop)	TENS	Entert.	Comp.	EMIS	SCE	ACCUPIX	Brigid
Communication	4	1	2		1		2							
Visibility	1													
Carer support	1			1										
GP liaison	2													
Psychological well-being	3				1	1			1					
Bereavement support			1	1										
Patient support	1				1	1				1				
Pain management		1	1			1		2	2	1				
Comfort		1	1					1						
Video link	1												1	
Consent							1							
Medications	1						1							
Electronic records							1				1	1		1
Meetings				4										

community care practitioners' score, and they remained more positive throughout the remaining period.

In total, 92 Post-it notes were attached to the three charts by the participants. Fifty Post-it notes were placed on the chart for psychological well-being, and 42 were placed on the two charts for pain management (see Table 4). All the technology identified in phase 1 was discussed.

There was a higher proportion of negative feedback, indicating significant challenges faced by participants documented on the Post-it notes. For psychological well-being, the mobile phone received 27 comments, with 23 being negative. Participants cited difficulties such as "Difficult to see facial expression over the telephone," highlighting the limitations of voice-only communication within palliative care services. MS Teams, despite being widely used, had all five comments marked as negative. These were for similar reasons to the mobile device, including connectivity issues with the technology impacting the quality of care that could be provided. For example, one participant stated, "We had bereavement groups by MS teams, but it used to crash, so they were discouraged, they felt it was impersonal."

Unlike psychological well-being, mobile phones did not appear to be as influential on participant experience with pain management; it was only mentioned four times out of the 42 Post-it notes placed on the chart. One participant appreciated the mobile phone stating "GP giving out mobile number for ease of contact re patients and MDT." However, challenges were also evident, relating to connectivity, as one person explained: "With pain management when you're there to help a patient, if they're in a lot of pain, excruciating pain and you can't hear them and I went, can you hear me now, can you hear me now? You can't hear them, a barrier is partially the signal of where you live, if you're expected to work from home, then that's essentially a big barrier for you."

The group discussion in phase 2 aided the recall of memory and prompted participants to remember external events that impacted the hospice technology use and service provision. For example, system 1 received a negative response due to a cyber-attack, leading to poor access to patient records, which prompted a discussion around the impact that had on different services. However, EMIS received the most positive responses for enabling functionalities such as e-prescribing and improving communication with GPs. Entertainment technologies, although predominantly viewed negatively, with comments such as "TV used more—no visitors," emphasize how technologies were used for entertainment due to restricted or no visitation during the COVID-19 pandemic.

In phase 2, the thematic analysis of the collaborative discussion when participants were documenting their experiences on the chart yielded seven themes; these are discussed in Table 5.

3.3 Phase 3: collaborative discussion

In phase 3, individuals shared their experiences, prompting other participants to reflect and question their own plotting decisions. The thematic analysis of the collaborative discussion yielded two additional themes, which are discussed in Table 6. The seven themes identified in phase 2 were discussed in phase 3; it was here that the group elaborated on these themes, creating a deeper understanding of the domain. Additionally, two new themes emerged during the stage, which were further explored and contextualized by the group. Discussions in this phase focused on the Post-it notes, with one group stating, "It was negative because you had to do it by phone," and

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Table 4 The frequency of Post-it notes mapped to technology identified for the two processes and whether they were positive or negative.

		Psychological well-being		Pain management	
Technology	**Total Post-It notes**	**Positive**	**Negative**	**Positive**	**Negative**
Mobile phone	31	4	23	2	2
WhatsApp	10	2	3	3	2
Email	6	2	4	0	0
VR	4	1	1	1	1
FaceTime	4	1	1	1	1
MS Teams	11	0	5	3	3
Video call	1	0	1	0	0
System 1	5	2	0	1	2
ACCUPIX	1	0	0	1	0
EMIS	4	0	0	3	1
Transcutaneous Electrical Nerve Stimulation (TENS)	2	0	0	1	1
Brigid	1	0	0	1	0
Entertainment	6	0	0	1	5
Computers	6	0	0	2	4

Table 5 The themes and definitions that emerged from the collaborative discussion analysis.

Theme	Definition and supporting quotes
Communication methods	It is vital in palliative care services and can be in person or facilitated with technology. Limitations are highlighted in the use of virtual meetings "I think there's nothing better than face to face, because you're seeing people in their own home as well, and you get so much from that. They say I'm not in pain then they stand up and go to the bathroom and hobble off, when they are saying no, I'm not in any pain."
Technology challenges	Relate to issues or difficulties with using or integrating technology in hospice and community care. For example, "The difficulty in connecting with, particularly the elderly, because it had to rely on maybe a daughter or somebody." Another participant stated, "A lot of patients are elderly and not into technology."
Psychological well-being	Refers to the mental health or emotional well-being of staff, patients, and additional stakeholders. Pandemics or other events such as cyber-attacks can cause this, as families experience significant distress from being unable to visit their loved ones in person, resulting in video calls or having to see families through hospice windows. A practitioner stated, "They came to the window or it was a video call, it was awful that."
Hospice care	Encompasses the overall standard of care and operational running of the hospice and community palliative care service. There was discussion on the lack of training to use technology integrated into hospice care. A participant stated, "Without a volunteer, we are limited to what we can offer." Another participant added, "During lockdown, we didn't have any volunteers, the volunteers do the VR."
Understanding the functionality of technology	Refers to how technologies were adopted and used to support processes across the different services. A participant explained, "The GP app, so the patients have got to give consent for you to be able to see their information, some people haven't given consent."
Shared devices	Concerns about the restrictions of sharing devices and equipment among staff and patients due to infection control concerns. For example, "The TENS couldn't go from patient to patient" and "They were so anxious about infection control and moving anything from a to b."
Remote working	Is the practice of working from home or another space and encompasses remote consultations. Problems discussed include, "They'll be on teams and then I'll have to drive to find somewhere where I can park and then, although I'll have the meeting on, I'll have to drive somewhere because I'm frozen. Then I use my hotspot on my phone to use it, it takes you about 10–15 minutes to get on if you're not lucky, then it'll kick you off. In the car, my laptop is not overtly big and I'm not overtly big, but when you're in the car, they're not user friendly."

another person challenged this by stating, "But it was a positive impact on their psychological well-being because some people haven't seen the relatives for weeks."

Phase 3 highlighted the value of collaborative discussion in exploring long-term UX, with participants actively engaging in the discussion. One participant reflected, "It's more interesting than you think this, because it gets you thinking," while another participant stated in agreement, "when you start, memories start coming back."

4 Discussion

Our research focused on studying how effectively the adapted CUXC captures UX over time in contexts where multiple technologies intersect with a process, in this case, palliative care. To facilitate this, the CUXC tool was developed to enable a collaborative approach to capturing long-term UX. One of the criticisms of retrospective methods is the susceptibility of memory biases (Kujala et al., 2011); the

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Table 6 The themes and definitions that emerged from the collaborative discussion analysis.

Theme	Definition and supporting quotes
Technology efficiency	Relates to the time-saving benefits of using technology that can enable more tasks to be completed. A participant explained the efficient use of Facetime stating, "Rather than me going out to do a visit, they've dialed me up and I've seen the patient, and the patient can see me. That meant that I hadn't had to travel to that patient's house and travel back to another. So, it's more efficient in time, as in jobs."
Post-pandemic continuation of technology	Refers to how technology has had benefits and sustained its use post-COVID-19. A practitioner explained, "We still, we do a lot of face to face, but we can offer it as an alternative now, whereas we never would have thought about it, and that was only in the period after COVID-19." Another practitioner contributed to the discussion stating, "We question ourselves more of could this be a telephone call? Rather than assuming it's a face to face."

collaborative nature of CUXC was designed to help mitigate this. The CUXC tool is process driven rather than technology driven, as originally demonstrated by Kujala et al. (2011), and consists of three phases.

Reflecting on the decision to use job-specific groups based on the extension of transactive memory theory to organizational settings (Austin, 2003), it was felt that this was necessary within this context as the roles and user cases varied significantly. Without this shared experience, it is conjectured that the collaborative discussion would have been less effective and cross-cueing would not have occurred naturally.

In phase 1, participants were required to identify the technologies used to support complex processes such as pain management and psychological well-being. A total of 14 different technologies were identified, 6 of which were bespoke to the hospice sector, while the remainder were generic technologies reappropriated for service delivery. Communication emerged as central, with 11 technologies underpinning this process. The collaborative discussion in this phase was strongly aligned with transactive memory theory (Austin, 2003; Wegner, 1987), where groups acted as distributed memory systems. This allowed participants to surface technologies they had initially forgotten, validating and clarifying recollections through peer prompting. For example, technologies such as EMIS were recalled only after colleagues helped reconstruct the context of use. This collective prompting reduced the risk of recall errors such as the Ugly Sister Effect (Schacter, 1999). The evidence shows that group discussion not only aided recall but also reassured participants, giving them confidence in the accuracy of the data.

Phase 2 enabled the capture of individual episodic UX trajectories by plotting experiences on the CUXC chart. Participants attached Post-it notes to explain their reasoning, generating 92 annotated points across the three charts. The results showed the dynamic nature of UX over time when evaluating processes and were comparable to other long-term UX methods (Law et al., 2009). It should be noted that experiences appeared to be affected by significant events, in this case, COVID-19 or cyber-attacks, and this is supported by findings from other studies (Karapanos et al., 2012). Context of use also impacted the UX; for example, when evaluating psychological well-being, the use of mobile phones was viewed very negatively. This was because they could not always physically see the patients.

This phase operationalized both constructive recall (Barsalou, 1988) and the value-account approach (Betsch et al., 2001). Participants reconstructed experiences chronologically while also relying on affective impressions. Temporal anchors acted as cue-dependent supports (Tulving, 1972; Vissers et al., 2013), helping participants locate memories within the broader pandemic timeline.

Analysis of this phase yielded seven themes, including communication methods, technology challenges, and shared devices. These themes contextualized the Post-it notes, explaining why technologies were experienced positively or negatively. For instance, VR was noted as beneficial for psychological well-being but dropped during COVID-19 due to infection control concerns. Shared devices could have implications for the design of technology for use in a hospice. Technology including mobile phones and VR has potential threats to infection control (Shakthivel et al., 2017).

In the final phase, participants collectively reviewed their plotted data. This phase draws on collaborative recall theory (Rajaram, 2007; Weldon & Bellinger, 1997), where group interaction enhanced accuracy through cross-cueing. Participants questioned, refined, and elaborated on one another's accounts, resulting in a more complete reconstruction of long-term UX. For example, telephone consultations were debated as both negative (due to loss of face-to-face interaction) and positive (for enabling family contact during lockdown).

Two further themes emerged during this phase, technology efficiency and postpandemic continuation. These highlight how collaborative reflection extended the analysis beyond individual experiences. The themes illustrate how technology could result in time-saving efficiencies and continued use of technology post-COVID-19. The requirement for technology to deliver efficiencies is well documented in other studies (Lomenick et al., 2021). Efficiencies could be gained with technology to support virtual visits, which have become important within palliative care services post-COVID-19, with researchers proposing best practice guidelines (Webb et al., 2021). The insights gained from the CUXC method would enable designers of technology to understand the barriers to adoption, the challenges faced by the different stakeholders in the organization, and the wider ecosystem that their system would need to integrate into.

Across all three phases, the theories underpinning CUXC translated into practice, enabling the retrieval of rich, contextualized, and meaningful long-term UX data. Compared to existing methods such as iScale (Karapanos et al., 2012), which rely on individual recall and post hoc aggregation, the CUXC embeds collaborative interpretation into the evaluation process itself. This directly addresses the challenge identified by Hokkanen and Väänänen-Vainio-Mattila (2015): the difficulty of interpreting retrospective UX data without context.

The palliative care case demonstrated efficiency in a resource-constrained environment, suggesting the method can be deployed without disrupting services, even in settings where staff face significant time pressures (Lehto et al., 2020; Walshe et al., 2024). The three phases of the CUXC method provided an understanding of the array of technologies used to support processes within palliative care.

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This method of evaluating long-term UX could aid designers in other domains, such as education where there are multiple technologies used to support student learning (Timotheou et al., 2023).

5 Limitations

The effectiveness of the CUXC tool was examined within a single palliative care organization, focusing on two different processes with three groups of practitioners. Consequently, its generalizability to other domains remains untested. Additionally, the CUXC was used in isolation rather than in comparison with other long-term UX evaluation tools, such as UX Curve, limiting insights into its relative effectiveness. Furthermore, long-term UX in palliative care was assessed solely from the perspective of hospice practitioners, excluding patients and other stakeholders. This omission may restrict understanding of how UX evolves over time and its broader implications. Patients, who are a key user group in palliative care, pose potential recruitment challenges due to their varying medical conditions. This tool may be unfeasible to use. The method also requires practitioners to be absent from clinical duties simultaneously, making participation difficult. Staff shortages on the study day could reduce group sizes, highlighting the challenge of requiring multiple participants. Additionally, the reliance on color-coded materials may present accessibility issues for individuals with visual impairments. Future adaptations could incorporate alternative markers, such as symbols or shapes, to enhance inclusivity. Despite these limitations, the study highlights the potential of the CUXC in evaluating long-term UX and provides a foundation for refining and adapting the method for future work.

6 Conclusion

This study designed and evaluated the CUXC as a method for evaluating long-term UXs with multiple technologies that support organizational processes. Grounded in theories of memory and collaborative recall, the method operationalized constructive and value-account recall, cue-dependent anchors, transactive memory, and collaborative cross-cueing within a practical three-phase tool.

The case study in palliative care demonstrated the efficiency and effectiveness of the CUXC. Fourteen technologies were identified, 92 annotated experiences were captured, and 9 themes were generated, illustrating how the method surfaces both episodic and affective evaluations as well as contextual influences such as the COVID-19 pandemic and cyber-attacks. The process-driven design allowed participants to evaluate multiple technologies within a single framework, reflecting how technologies are used in practice rather than in isolation. The collaborative format enhanced recall, reduced susceptibility to memory biases, and minimized the time burden, enabling three groups of practitioners to complete the process within 4.5 hours, an efficient alternative to individual interviews or surveys that would have required significantly more resources, while still producing rich and contextualized data.

It is essential that emerging methods are critically examined by the HCI community, applied across diverse contexts, and assessed for their limitations. Research methods often evolve incrementally through reflection on results and adaptation to different settings. This paper presents a case study evaluating the use of CUXC for capturing long-term UX within a hospice. Further research is needed to determine whether CUXC can be effectively applied in other sectors, such as education, healthcare, or finance, where processes rely on multiple technologies to deliver services. In this study, all participants successfully completed the different phases within the tool with minimal assistance. However, assessing the practical efficacy of the tool requires further analysis and comparison with alternative approaches. More reflective case studies are necessary to evaluate both the results and the operationalization of the CUXC.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

Conflicts of interest

None declared.

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