



Education in HCI Outdoors: A Diary Study Approach

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ABSTRACT

To assist students and educators in more deeply grasping user technology needs in busy outdoor settings, we recommend using diary study assignments adapted from social science and human-computer interaction (HCI) research. This suggestion is based on insights that the field of HCI has expanded from computer use in controlled, indoor environments to technology application research in broader contexts, especially outdoor environments, where diary studies yield important insights. This can be seen in areas like social media, augmented reality, citizen science, and geolocation-based games, where it is difficult to understand the user experience for these areas through short-term, controlled exposure. Instead, educators must encourage students to step out of the classroom and into the real world to observe and experience interactions during multiple-use sessions over an extended time period, which offers students in-depth insights into real-world technology use, thereby setting the stage for them to design more human-focused technology applications and services that better meet user needs. This paper explores the utilization of the diary study methodology within the context of HCI education, examining its distinctive benefits and exposing tradeoffs in its challenges. Benefits discussed in the paper include adaptability to a wide array of user needs and circumstances, the capability to yield profound insights into the application of technology in real-world settings, and effectiveness in uncovering privacy concerns in daily life. Concurrently, we identify some practical challenges and introduce targeted strategies for addressing them, such as maintaining consistent student engagement, devising creative approaches for analyzing data, and encouraging deeper reflective practices among students. In so doing, this manuscript seeks to provide actionable guidance for crafting more impactful and immersive HCI educational initiatives through diary study assignments.

CCS CONCEPTS

• Human-centered computing → Field studies.

KEYWORDS

HCI Outdoors, HCI Education, Diary Study



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ACM Reference Format:

Jixiang Fan, Morva Saaty, and D. Scott McCrickard. 2024. Education in HCI Outdoors: A Diary Study Approach. In *EduCHI 2024: 6th Annual Symposium on HCI Education (EduCHI '24), June 05–07, 2024, New York, NY, USA*. ACM, New York, NY, USA, 10 pages. <https://doi.org/10.1145/3658619.3658621>

1 INTRODUCTION

Since its inception, human-computer interaction (HCI) has primarily focused on the interactions that occur when humans and technology converge. This interdisciplinary field blends computer science, psychology, ethnography, sociology, art, architecture, and more to understand and optimize the relationship between users and computers and create intuitive, efficient, and user-friendly interfaces [17, 32, 62]. Traditional learning and exploration in HCI predominantly centered in controlled indoor environments such as laboratories and office settings [27, 47, 52, 85]. This limitation can be ascribed to the initial lack of portability in the technology and devices involved in the early days of human-computer interaction when technology was often exclusively in specialized environments such as laboratories and offices [46]. This constraint necessitated that users be present in particular locations to engage with these devices, consequently hindering the spontaneity and adaptability of the interaction.

Real-world environments, particularly busy outdoor settings, are rife with unpredictable elements that profoundly affect user interactions and experiences. As noted by Bargas-Avila (2011), “Context of use and anticipated use, often named key factors of user experience, are rarely researched” [5]. Environmental factors such as weather and lighting significantly impact user interaction modes. These variables affect the user experience’s comfort and feasibility and alter interactions’ effectiveness and efficiency. Crucially, social scenarios and cultural factors play essential roles in shaping user interaction experiences. These elements, often missing in controlled environments, are vital considerations for design [35]. Furthermore, technological advancements, particularly in miniaturization and mobile computing, have progressively made devices more lightweight and portable. This shift has had a significant impact on the field of HCI. Mobile devices like smartphones and tablets allow users to interact with devices at almost any location. The continuous upgrade of these devices has not only altered traditional ways of interacting with technology. Still, it has further fostered the development of new interaction patterns (such as Augmented Reality [61]), greatly expanding the scope and possibilities of HCI.

Therefore, in the educational advancement of HCI, it is increasingly crucial to encourage students to transition from controlled spaces to the dynamic outdoors. This hands-on approach encourages students to engage directly with and observe usage in natural settings and foster comprehension of the varied and intricate nature

of user experiences. Through this immersive learning experience, students can more effectively interpret these observations into concrete design solutions. This also aligns with the third paradigm in HCI, the phenomenologically-situated paradigm, which shifts the focus from viewing users merely as information processors to acknowledging the depth and intricacy of human experiences [35]. It emphasizes the importance of thoroughly understanding human behavior and experiences and the significance of meticulously observing and describing complex phenomena through a combination of various theories and methodologies, such as ethnography, action research, and practice-based research. Based on these considerations, we advocate adapting the diary study method for HCI outdoors education. This paper first presents a practical case of applying a diary study assignment in HCI education, with the feedback from students. Then, the paper delves deeply into the advantages offered by this method while also clearly identifying the practical challenges it faces and our strategies to address these challenges. This paper seeks to offer practical guidance for designing more effective and engaging HCI educational programs through the use of diary study assignments.

2 BACKGROUND

This section provides an overview of related literature and background for the core aspects of this paper, including challenges in HCI outdoors and the usage of diary studies in the HCI field. First, we focus on introducing a feasible research methodology that can address challenges for HCI Outdoors, the *diary study* [10, 40, 73]. Then, We have elucidated the importance of field-based outdoor learning in HCI [47, 48].

2.1 Diary Study

The diary study is a research method commonly employed in fields such as psychology, sociology, and user experience (UX) design to gather qualitative data over a period of time [40, 45, 53, 64, 73]. In this method, participants are asked to record their activities, thoughts, feelings, or experiences in a diary format. These entries can be made either at regular intervals (e.g., daily or weekly) or in response to specific events or triggers [10]. Unlike traditional methods, which often rely on retrospective accounts, diary studies involve participants recording their experiences as they occur, providing a more immediate and authentic account of their interactions. This method has proven particularly effective in understanding users' nuanced and often fleeting interactions with technology in their daily lives [20]. It offers a deeper, longitudinal insight into real-world user behaviors and their engagement with technology outside traditional environments. The methodology of diary studies is versatile and effective for investigating usage patterns in various settings, encompassing both controlled laboratory environments and more unpredictable natural contexts [36]. Besides, diary studies can effectively prevent users from changing their behavior due to the presence of observers in laboratory experiments. Carter & Mankoff (2005) emphasize the value of diary study methods, where participants can capture their own experiences, even in distributed or remote settings [18].

Researchers in the field of HCI have frequently used diary study methods to conduct a wide range of investigations toward understanding user interaction patterns with targeted technologies [1, 13, 26, 82]. Only a very small number of HCI diary studies focused on outdoor natural settings and discussed the correlation between interaction mechanisms, the usage environment, and the changes in interaction patterns due to users' intrinsic factors. Our understanding of user-technology interactions in natural environments remains relatively limited [5, 6]. Educational experts have underscored the application advantages of the diary study method in higher education, particularly regarding LGBTQ identities, faith, caring responsibilities, international students, socioeconomically disadvantaged students, and employability [16]. Nonetheless, implementing the diary study method in HCI education benefits from explicit operational guidelines and explorations. Notably, Saaty et al. used a diary study approach and roundtable discussions to understand how exergames (video games that require physical activity) encourage undergraduates to engage more with nature [77]. This article provides a feasible sample reference for the HCI outdoors and diary study education combination. Therefore, we believe that integrating HCI outdoors education with diary-based learning constitutes an area and challenge worthy of in-depth exploration.

2.2 HCI Outdoors

The field of HCI originates from a profound understanding of the interactions, potential conflicts, and modes of communication that emerge when humans and computers are integrated. The advancement of technology, particularly in portable, wearable, and ambient technologies, has gradually extended human-computer interaction to outdoor environments, bringing unprecedented opportunities and challenges. The academic community has recognized that the domain of HCI has moved from traditional, controlled indoor settings to natural and urban outdoor environments to understand human-computer interaction more comprehensively [23, 47, 75]. HCI outdoors focuses on how people interact with digital technology in natural or urban settings, emphasizing the diversity and complexity of these interactions through field study [63]. Rogers et al. emphasize that traditional evaluation methods and metrics derived from controlled settings fail to capture the complexity and richness of the real-world context in which systems or technologies operate [75]. The changing nature of physical environments also considerably impacts user experience [47]. Many studies have found that field study identifies additional usability problems and can yield more accurate and authentic feedback data [27, 54, 80]. HCI study should not only focus on usability and usability assessment but also embrace wild and longitudinal field studies. Developers, researchers, and educators must anchor their efforts in the everyday reality of open environments. This involves delving into how people perceive and benefit from technology, examining their daily modes of interaction with it, and assessing its long-term effects on interaction patterns [60, 76].

Exploring HCI outdoors education is a field brimming with potential. The study of HCI outdoors poses unique challenges distinct from those encountered in more controlled indoor settings. One of the primary challenges is the variability and unpredictability of the environment. Unlike indoor settings, where conditions such as

lighting, noise, and temperature can be controlled or at least predicted, outdoor settings are subject to rapid and often unforeseeable changes. Factors such as weather conditions, time of day, and seasonal changes can drastically affect the usability and functionality of technological devices [2, 74]. Privacy concerns are particularly amplified in outdoor settings [63, 66, 70]. Using devices that capture or share location data, audio, or video can raise significant ethical issues. Users may be concerned about who has access to their data and how it is being used. Furthermore, data capture in public spaces can inadvertently involve non-participating individuals, raising ethical considerations about consent and data protection [38]. Additionally, social customs, culture, and religion all impact user behavior [29, 42, 57]. Consequently, an important area worthy of attention is the exploration of methods suitable for education and research in HCI outdoors [5, 23].

3 DIARY STUDIES IN CS COURSES

In this section, we demonstrate, through a pair of brief case descriptions, the application of diary study assignments in undergraduate Computer Science classrooms. While not a complete presentation or analysis of all aspects of these cases, this section seeks to provide practical references for future educators and to furnish a basis for the subsequent discussions in this paper.

3.1 Case 1: Peridot

In May 2023, the author of this paper initiated a two-week daily diary study assignment to investigate an outdoor mobile game named Peridot, developed by Niantic Labs. This game merges elements of traditional digital pet games, such as Tamagotchi, with geolocation features and augmented reality (AR) technology, encouraging players to explore the outdoors by caring for virtual pets. Released in March 2023, this classroom intervention was uniquely positioned to explore what game elements attracted users during the game's initial release period and how the game elements led to the formation of specific player communities. Additionally, we expected students to explore and understand the integration of outdoor elements with computer software and hardware technology through this diary study.

Eight CS undergraduates participated in this assignment, documenting experiences related to user interactions, feature preferences, social connections, and emotional and behavioral changes based on quantitative and qualitative prompts and templates. Each participant wrote ten diary entries totaling 13,496 words. Students agreed to allow the research team to analyze their diary entries. To process the content, we employed a combination of topic modeling to identify promising topics quickly and human coding to capture interesting and engaging interaction scenarios (See Section 5.4).

To present an exemplar diary finding, one student described being questioned by a passerby while using the Peridot AR feature in an outdoor location, prompting deep reflection on the appropriateness and privacy concerns of using camera-based AR technology in public spaces. Our diary prompts did not specifically address privacy issues; the students' spontaneous exploration exemplifies diary studies' tremendous support for fostering independent learning. During subsequent reflective group discussions, we highlighted

this case, which elicited enthusiastic responses and in-depth discussions from the students. As the discussions progressed, some students raised questions about improving the designs and led brainstorming sessions with their peers, suggesting potential improvements.

Students shared their personal experiences and reflections with each other and concluded that **users focus on different aspects when using the same software**. We believe this diary-based pedagogical method effectively realizes the “student-centered learning” objective in the classroom, allowing students to understand user experiences better and explore research topics or projects that align with their personal interests through deep reflection and feedback based on their diary experiences.

3.2 Case 2: Entry-level HCI Course

To explore the application of diary studies within large classroom settings and the challenges, we implemented identical diary study assignments in an entry-level HCI course in the spring semester of 2024. The semester project theme is to develop technology that supports the theme "Understanding Nature." Students need to select a location in mind where their theme is pursued (e.g., a park, forest, trail, museum, school, library). The developed technology should either supplement or replace current solutions or address an unmet technological need. Through diary studies, we aim to guide students in exploring and analyzing user interaction patterns and needs within the real world. This approach encourages students to uncover potential project ideas and design or enhance more user-centric and humanized products.

This diary study was conducted over three weeks and involved 73 students. Students were required to complete a minimum of three diary entries per week, with each interaction with the test software lasting at least 15 minutes. To cater to students' diverse interests and hobbies, we offered a selection of software spanning various fields, including geolocation games and social media sharing, among others. Students chose the software that aligned with their personal preferences. In this way, students could maintain their enthusiasm for learning and enhance their enjoyment of the diary recording process over the longer study duration.

We surveyed the students to assess the educational outcomes of the diary study after the reflective group discussions. 98% of students indicated that completing this learning assignment enhanced their understanding of HCI concepts to varying degrees (See Figure 1). It encouraged them to critically analyze interfaces and functionalities from a long-term perspective, thereby identifying potential research and project topics. Some students have indicated that compared to learning in a controlled laboratory setting, they feel more relaxed engaging in diary studies within real-life environments. This method aids in uncovering details that are easily overlooked. Furthermore, the longitudinal nature of diary studies enables them to observe and reflect on the changes in user interaction patterns and behaviors over time, thus facilitating more effective design functionalities (See Section 4). However, some students have mentioned that interacting with the designated testing software and repeatedly recording diary entries induces fatigue. We will provide a detailed analysis of this issue in the subsequent section titled “Unsolved Challenges” (See Section 5.1 to 5.3).

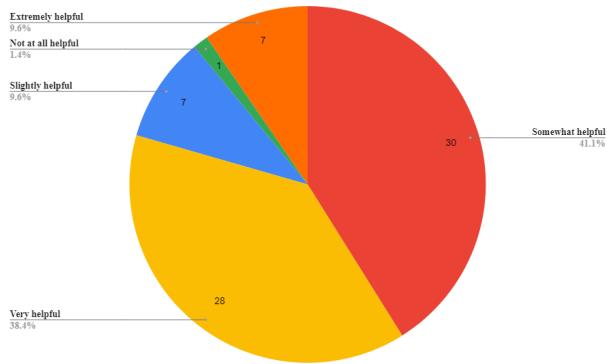


Figure 1: 98% students think diary study assignments help enhance HCI knowledge understanding.

4 BENEFITS FROM THE DIARY STUDY APPROACH

In this section, we delve into the advantages of diary studies as an educational method in HCI outdoors. Leveraging the lessons learned from prior research using diary studies [13, 37, 39, 67, 73, 79], our user studies [34, 77, 78, 81], and integrating the four elements of HCI Outdoors [62], we provide a detailed exposition and analysis of the benefits of the diary study method based on each element (See Table 1).

4.1 Outdoor

The variability and unpredictability of outdoor environments present challenges that cannot be overlooked in educational settings and must be carefully considered when designing outdoor learning activities. Diary study emerges as a pedagogical tool with unique advantages for outdoor settings, including remarkable environmental adaptability, temporal flexibility in capturing long-term experiences and changes [11], and cost-effectiveness. In this section we highlight how diary study approach can provide these benefits for education in HCI outdoors.

4.1.1 Excellent environmental adaptability. Diary studies exhibit excellent environmental adaptability, providing data conclusions with high ecological validity [3]. The environment is an indispensable factor in experimental design [15, 28], substantially affecting user interactions and feedback with technology in outdoor settings. Diary studies allow students to record interactions with technology under various outdoor conditions, offering an unrestricted method of documenting the real impact of environmental factors on technology use. Furthermore, diary studies can gather data across various outdoor environments, from urban centers to remote trails. This broad perspective is invaluable for understanding the environmental factors that influence human-computer interactions [24]. Such data feedback assists students in better understanding users' technological needs in outdoor settings and designing technology products adaptable to various outdoor conditions.

4.1.2 Temporal flexibility for longitudinal study. Diary studies possess a significant advantage in terms of temporal flexibility, making them an ideal tool for capturing long-term experiences and

changes [11]. Compared to traditional methods such as interviews and surveys, diary studies' extended duration and flexibility provide students with a unique opportunity to observe and understand how stakeholders' experiences evolve over time and how various events and environmental factors influence these experiences. Diary studies excel in the long-term tracking of individuals, capable of recording changes in life events and psychological states [43]. This is particularly important for understanding complex psychological and behavioral processes. Through continuous recording and analysis, students can build a more comprehensive and detailed dataset, offering a valuable resource for in-depth exploration of human behavior and experiences.

4.1.3 Cost-effective. Traditional field studies provide students with a valuable opportunity to gain a deep understanding of users' real experiences, allowing them to personally encounter the challenges and needs associated with interacting with technology. However, due to various factors such as time and space constraints, field studies often incur high costs in both time and other resources, and their outcomes are uncertain [23]. In contrast, as a more cost-effective method, diary studies significantly reduce reliance on expensive equipment and specialized personnel by having students collect data through diary entries. This approach offers flexibility in terms of time and space and is equally effective in capturing the subtle interactions during the technology usage process. Diary studies allow students to record and reflect on their experiences. Existing literature confirms a strong agreement between data self-recorded by users in diaries and data obtained from high-precision scientific instruments [25]. Therefore, diary studies provide deep insights into user experience and behavior and represent a more economical and feasible education method.

4.2 Human

The increasing diversity of student populations in higher education has drawn significant attention from scholars and educators alike, highlighting the importance of integrating diverse voices and perspectives into the educational framework [33]. Ensuring these varied voices are heard and valued within the educational process is complex and multifaceted. One approach to this challenge is the implementation of diary studies, which offers students a platform to document and reflect upon their authentic experiences and thoughts. Significantly, diary studies can uncover the intricate shifts in group dynamics and the depth and intricacy of individual viewpoints. By doing so, they can better comprehend the social and personal determinants that impact user needs.

4.2.1 Offer inclusive and diverse population. Diary studies can be an inclusive and diverse method, designed and implemented to consider the needs and conditions of various groups [55, 65, 83]. In the domain of HCI that focuses on specific devices, such as head-mounted Virtual Reality (VR) and autonomous driving technologies, significant physical demands are placed on the participants. These requirements encompass normal levels of vision and hearing and a lack of sensitivity to dizziness induced by three-dimensional visuals [19, 72]. This standard raises the barrier to entry, and many students interested in the field of HCI may find themselves unable to participate due to not meeting these conditions. In contrast, diary

Elements	Definition	Benefits from Diary Study Approach
Outdoors	An environment that is not indoors and lacks the controls and amenities of the indoors, for which factors like weather and lighting are of particular concern.	1. Excellent environmental adaptability. 2. Temporal flexibility for longitudinal study. 3. Cost-effective.
Human(s)	Individuals or groups for whom physical, mental, and interpersonal issues affect the situation and the technology use.	1. Offer inclusive and diverse population. 2. Uncover deep evolving group dynamics and users' nuanced views.
Computer(s)	Electronic system consisting of programmable hardware or Software.	1. Offer in-depth insights into real-world technology use.
Interaction	Ways that humans and technology connect and communicate.	1. Yield genuine, rich user experience insights. 2. Authentically reveal real-life privacy issues 3. Foster active learning and collaborative engagement.

Table 1: Four elements of human-computer interaction outdoors [62] along with the advantages of utilizing Diary Study Methodology in HCI Outdoors Education

studies, as a more open and flexible approach to education, offer an alternate path to a broader student population. Physical limitations (mobility issues) or sensory challenges (limited vision or hearing) generally do not impede participation in diary studies as much. The diversity of diary recording methods [18, 31, 53], including text, audio, and video, ensures that a broader population can participate in ways that suit them best. Diary studies emphasize the subjectivity of human experience, treating each participant as a unique and important individual. Each participant has the opportunity to authentically express their thoughts and needs throughout the process, providing them with a platform to explore how physiological, psychological, and interpersonal factors influence technology usage and user experience, thus facilitating a deep understanding of these interactions. By acknowledging and accommodating the diversity of human conditions, diary studies provide a rich and nuanced perspective on human-computer interaction.

4.2.2 Uncover deep evolving group dynamics and users' nuanced views. As time progresses, users may gain new insights into their experiences or be able to identify and articulate their emotions and thoughts more clearly. Diary studies, as a longitudinal pedagogical approach, enable students to more profoundly comprehend how users' feelings and perspectives change over time or whether there are persistent patterns and trends. Furthermore, diary studies demonstrate unique advantages in revealing group dynamics, particularly in understanding individuals' roles and interaction patterns within a group over time [12, 49]. When individuals record their interactions with other group members in their diaries, these records capture not only surface-level interactions but also delve into the underlying emotions, attitudes, and cognitive processes. This allows participants to observe communication patterns, power structures, mutual support, and conflicts among group members. By analyzing these diaries, participants can better understand how individuals find their place within a group and how they are influenced by and, in turn, influence the group culture. Moreover, diary studies can reveal the temporal dimension of group dynamics. Individuals' entries at different time points reflect the evolution and changes in internal relationships and roles within the group over

time. This aspect of diary studies adds a dynamic and longitudinal perspective to understand human interactions in group settings considering users' nuanced views.

4.3 Computer

Diary studies in the context of education in HCI outdoors provide a unique lens through which educators and researchers can observe and analyze the spontaneous interactions of users with technology in natural settings. This approach enables the collection of longitudinal data on how environmental factors influence the usability and effectiveness of technological tools. By encouraging participants to document their experiences and thoughts, diary studies facilitate a richer understanding of the complexities and nuances of HCI in outdoor environments, shedding light on user behaviors, challenges, and evolving needs over time.

4.3.1 Offer in-depth insights into real-world technology use. The core value of diary studies lies in providing a method to observe and analyze real-world interactions, enabling students to profoundly understand the application of computers and other technologies in diverse and uncertain outdoor environments. This approach matches with the goals of project-based learning (PBL), a teaching strategy to enhance knowledge comprehension through discovering, defining, and resolving real-world problems [9]. However, as Piccolo et al. pointed out, a primary challenge faced by PBL is that students may engage only superficially due to a lack of experience, often overly focusing on the final product while neglecting the decision-making process during design [69]. This highlights the importance of educators encouraging students to deepen their understanding of users' actual experiences through prolonged practice to identify the challenges and needs that arise during technology interactions. Diary studies, as a method for deepening understanding through the recording and reflection on daily experiences, can help students gain detailed insights into how individuals use technology in their daily lives, including usage patterns (such as frequency and duration) and contexts, as well as the challenges and frustrations faced during technology interactions. This promotes innovation and improvement in technology design and aids in creating products

more aligned with real-world usage scenarios [56]. The data collected through diary studies provide a theoretical basis for students to reproduce real interaction scenarios in simulated or controlled environments [51, 61], emphasizing the importance of testing in real settings to ensure that technological solutions are not only theoretically effective but also efficient and reliable in practical applications.

4.4 Interaction

By capturing in-situ data [4, 18, 44, 79], diary studies reveal how users interact with technology in their natural environments, offering authentic, rich insights into user experiences and guiding students in designing products that better meet real-world needs. Furthermore, this method authentically unveils privacy issues in real life [71], enabling students to understand and navigate the complex dynamics of privacy outside of controlled environments. Lastly, diary research promotes active learning and collaborative participation among students, breaking away from traditional passive learning methods and encouraging a deeper, more interactive exploration of human-computer interaction principles. These three advantages—deep user insights, genuine privacy considerations, and enhanced learning collaboration—demonstrate the comprehensive value that diary research brings to HCI outdoors education.

4.4.1 Yield genuine, rich user experience insights. A significant advantage of diary studies is the ability to generate a large amount of in-situ data [4, 18, 44, 79], which is crucial for understanding how users interact with technology in natural environments. Diary studies capture a richer and more authentic range of user experiences than studies conducted solely in controlled environments. This means that students can gain deeper insights and understand users' daily challenges and needs. These insights are invaluable for designing technologies that are genuinely responsive to real-world conditions and user requirements.

4.4.2 Authentically reveal real-life privacy issues. Privacy concerns are an inevitable and crucial consideration in user-technology interactions in outdoor environments [58]. Users are concerned not only about their own privacy but also about the privacy of bystanders [38]. Cultivating a collective sense of civic responsibility among students while guiding them from moral, ethical, and social perspectives to critically examine programs, software, and data represents a crucial direction in which all computer science educators must collaboratively endeavor [50]. Despite attempts to simulate real environments in traditional learning methods, effectively guiding students to consider different perspectives is often challenging. In these experiments, students and observers are usually informed that they are part of an academic research project, which may lead to a cognitive bias - the belief that privacy concerns are less critical due to the controlled nature of the experiment. This mindset can reduce vigilance against privacy breaches and affect the genuine perception and response to privacy issues [22, 41]. In contrast, the diary study method offers a more in-depth way to explore and reflect on privacy issues [71]. By recording and reflecting on their technology usage experiences in daily life, students can experience and understand privacy concerns more authentically. This self-reflection process helps to reveal users' views and behaviors towards privacy

in real environments. Diary studies also assist students in better understanding how users balance privacy with functionality in real life. Users may encounter privacy issues while using technology in everyday settings that might not arise under controlled indoor environments. Through the analysis of diary entries, students can gain insights into users' actual attitudes and behaviors when dealing with privacy issues, guiding the design of technology that better aligns with user privacy needs.

4.4.3 Foster active learning and collaborative engagement. Upon collecting diary entries, educators must guide students in deeply analyzing these materials. Through this opportunity, students can gain valuable moments of communication and learning. This approach transcends the isolation felt in traditional learning methods, emphasizing active participation by students, who are seen as proactive information processors rather than passive recipients [35]. Educators should inspire students to share their experiences, perspectives, and reflections in this process, further promoting an in-depth learning process through dialogue. Such interaction facilitates mutual learning, feedback, and suggestions among students and deepens their understanding of HCI theory and its practical applications. Diary study methodology breaks the constraints of traditional teaching methods, transforming students from passive absorbers of information into active creators of knowledge. This participatory teaching method improves the quality and satisfaction of learning and provides students with profound learning experiences, creating a more collaborative and engaged learning atmosphere.

5 UNSOLVED CHALLENGES

Existing literature on diary studies includes many variations on frameworks for conducting a diary study. In HCI education, educators and researchers universally confront a significant challenge: the lack of a unified framework to guide the design and implementation of diary studies. Carter and Mankoff (2005) revealed the profound impact of media selection on the quality of diary data by comparing different recording mediums, including photographs, audio recordings, location information, and physical artifacts [18]. This research underscores that even minor design differences can substantially affect the outcomes of diary studies, particularly in the field of HCI research outdoors, which is fraught with uncontrollable and unpredictable factors. Therefore, the development of a comprehensive implementation framework becomes especially crucial. Such a framework ensures the effectiveness of diary studies in HCI education, safeguarding the reliability, comparability, and repeatability of research findings, thereby maximizing their potential value. This section delves into the challenges of diary studies in applying HCI outdoors education. These include choosing the right testing technology, arranging the frequency and duration of diary entries, designing effective diary prompts, and analyzing large diary data. We propose a series of specific and feasible countermeasures in response to these challenges (See Table 2). Through these strategies, we aim to optimize the diary study process in HCI outdoors education, enhancing its effectiveness and efficiency.

Challenges	Potential Threats	Possible high-level solutions
Appropriate diary study testing techniques	Due to a lack of functionality, students engaged in repetitive, mechanical tasks of no substantive value during the diary recording phase, making it challenging to comprehend user needs and the established knowledge topics truly.	Educators or researchers ought to conduct pilot studies to ensure that the selected testing software is suitable for long-term application and possesses sufficient functionalities to assist students in composing and reflecting on reports.
Frequency and duration of diary entries	Excessive frequency or overly lengthy intervals between required diary entries may result in students losing interest or forgetting to complete the task.	Select an appropriate diary form for the subject and guide students to make meaningful entries at critical moments rather than merely compiling routine, descriptive reports.
Effective diary prompts	The absence of appropriate prompts results in students becoming entangled in limited and one-sided functionalities or user scenarios, thereby preventing the initiation of more extensive and profound contemplation.	Advocate for interdisciplinary and cross-disciplinary collaboration to develop a comprehensive and diverse prompt repository. Aiming to provide students with broader learning perspectives and enriched angles for contemplation.
Analyze large diary data	Due to limited resources and class sizes, instructors facing challenges to analyze, interact with, and summarize students' diaries through traditional human coding methods. This impedes the educational outcomes of diary studies.	Establish a collaborative learning environment based on diary studies by integrating topic modeling with human coding methodologies and employing group discussion strategies.

Table 2: Challenges remain for diary study as an educational tool and possible high-level solutions

5.1 How to select appropriate diary study testing techniques?

Selecting appropriate testing technologies is crucial for study in outdoor environments due to the unpredictability and variability that these settings introduce. Ideal testing technologies should possess flexibility and robustness to ensure accurate and reliable data collection under unstable and extreme conditions. Additionally, user experience is a key factor. In selecting technology, educators must meticulously evaluate whether its functionalities and modes of interaction are sufficiently comprehensive and appropriate, ensuring that students have ample opportunities for in-depth observation, documentation, and reflection throughout prolonged use rather than merely engaging in repetitive, meaningless tasks. Furthermore, the choice of technology should be closely aligned with educational objectives. For instance, if instruction aims to facilitate students' understanding of concepts related to outdoor privacy, then camera-based augmented reality technology would be an apt selection. Simultaneously, for technology still in development and may contain flaws, educators must consider whether potential issues (such as system crashes or errors) could negatively impact students' comprehension of the course subject, thereby deviating from learning goals.

Based on these considerations, we propose the following comprehensive suggestions in contrast to traditional diary learning approaches. Before selecting emerging technologies for diary studies, educators should personally use candidate technologies and conduct thorough evaluations (or choose trusted others to use them), with a focus on real-environment settings. This process must not be a cursory understanding of technology functions but an in-depth, practical exploration, enabling educators to comprehend the core functions and features of the technology fully. Through firsthand

experience, educators can better grasp the technology's user interface and user experience, which is crucial for the success of diary studies.

5.2 How to arrange the frequency and duration of diary entries?

In conducting an outdoor diary study, educators must meticulously consider the frequency and timing of diary entries to ensure alignment with the study's objectives. Interval-based, signal-based, and event-based are the three main types of diary study designs [10]. Interval-based design is a traditional approach requiring entries at fixed intervals (e.g., every hour or daily). It is straightforward and suitable for continuous monitoring and recording, especially outdoors, but may miss significant spontaneous events or subtle changes. Signal-based design utilizes random or predetermined signals (such as reminders or alarms) to prompt diary entries, which is particularly effective in outdoor experiments as it can capture irregular or unplanned environmental changes, providing a richer data sample. Event-based design mandates immediate recording by participants when specific events occur. It is well-suited for capturing rare or specific events, like sudden weather changes or particular environmental interactions. This design is particularly valuable for studying immediate responses and decision-making in outdoor activities. The protocol choice depends on the study's specific objectives and the participants' lifestyle in outdoor environments. For instance, for studies requiring the capture of immediate interactions in user-technology device interactions, an event-based design might be more appropriate, whereas for studying the long-term impact of outdoor environmental changes on user experience, an interval-based design might be more effective. Inappropriate design choices may lead to critical data loss, resulting in students drawing biased conclusions when composing user feedback reports.

5.3 How to design effective diary prompts?

Diary studies do not necessitate that students report their actions in meticulous detail like a ledger. Instead, educators ought to devise efficient diary prompts to direct students' focus toward a profound comprehension and reflection on predetermined subjects. In light of the diversity and unpredictability of outdoor environments, we propose adopting a mixed-prompt design in lieu of the traditional fixed template used in diary-style learning. This design amalgamates fixed questions with a selectable question pool, aimed at enhancing the relevance and quality of data while avoiding the accumulation of irrelevant information and simultaneously improving the efficiency of data analysis. The fixed-question segment should concentrate on the core subject of the education topic, encompassing typical diary entries such as event details, modes of interaction, etc. On the other hand, the selectable question pool should allow and guide students to choose and document those rare but potentially significant experiences and situations, such as emotional responses, privacy considerations, and more. The flexibility of this method not only maintains students' enthusiasm for engagement but also reduces the fatigue associated with repetitive tasks. Furthermore, educators can provide students with validated rating scales to gather quantitative data. By integrating quantitative and qualitative data, educators can guide students in understanding the distinct values and roles of qualitative and quantitative data in uncovering user needs.

5.4 How to analyze large diary data?

The content of outdoor diaries typically encompasses entries covering various topics and fields. The diversity of this content suggests that the traditional approach of relying solely on manual reading and analysis may no longer be applicable. Amidst the typical pedagogical challenges such as large class sizes [59], diverse student backgrounds [14], and limited teaching resources [84], finding a method to analyze data to enable educators to swiftly grasp the themes and concerns expressed by students in their diary entries becomes particularly crucial. Through such analysis, educators can gain deep insights into students' thoughts and needs, thereby adjusting their teaching strategies and subsequent assignments more accurately to significantly enhance teaching effectiveness and the learning experience.

We suggest combining human and computer-assisted coding approaches when analyzing diary entries. Human coding, also known as manual coding [30], refers to the process of reading diary entries and categorizing the content based on predetermined themes or newly emerging patterns. During this process, participants should thoroughly familiarize themselves with the data, repeatedly read the diary entries, and mark unique interaction scenes and patterns. This approach is particularly effective for identifying subtle details and complex patterns that automated methods might overlook. Topic modeling [7] is a computational technique used to identify and cluster recurring themes or topics within large sets of textual data. It is particularly useful when dealing with a large volume of diary data, as it can quickly and efficiently process and categorize information, providing a high-level overview of the main topics discussed by participants. Topic modeling can complement human coding by uncovering latent patterns and themes that may

not be immediately apparent. Techniques such as Latent Dirichlet Allocation (LDA) are commonly used for this purpose [8]. Topic modeling is best used with human coding, as it cannot understand context and nuances critical in qualitative research. However, the results obtained from the same dataset through human coding and computer-assisted coding are not exactly the same [21]. Therefore, it is imperative to integrate and contrast these two outcomes to ensure the accuracy and comprehensiveness of the analysis.

6 CONCLUSION

This paper underscores the significance of encouraging students to step beyond the traditional controlled environment to engage firsthand with real-world outdoor environments, thereby experiencing, observing, and reflecting upon user needs. We suggest incorporating diary study methods into course assignment designs to enhance students' abilities to comprehend and summarize user experiences and needs in complex outdoor settings. This practice aids students in gaining a deeper understanding of the complexities of HCI and fosters their sensitivity and insight into environmental and user behavior. We explicitly highlight the nine unique advantages of the diary study in HCI outdoors education.

Oleson et al. synthesized students' challenges in studying HCI, dividing them into four primary domains [68]. Our paper demonstrates a significant advantage of diary studies in assisting students with the challenges of *"how to do design work"*. Diary studies enable students to unearth valuable insights and data from primary sources, capturing user needs more accurately and designing more appealing, user-centric products and services. This approach significantly sharpens their understanding of user needs. It enhances their ability to address questions such as *"WHY - Why do we do this design activity in this way?"* and *"SYNTH - How do I interpret this feedback?"*

Finally, we explored the challenges of implementing diary study within the educational process and proposed feasible strategies. Future research should delve deeply into these and compare and integrate the diary study methodology with traditional HCI pedagogical approaches. Through such an approach, the potential value of diary studies in HCI education can be more comprehensively unearthed, providing a well-rounded instructional framework for pedagogical design.

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