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Crowdsourcing Remote Co-design Towards Improving the Validity and Reliability of mHealth Application Development – A Case Study on Sleep Solved: A mHealth App Designed Virtually with Teens

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Abstract

INTRODUCTION: Co-design has become a fundamental pillar of formative digital health research. Typically, this approach involves in–person workshops that involve a rich but limited amount of data. Virtually crowdsourcing co-design, however, provides the promise of rapid and vastly increased data. This is a novel, exploratory approach in mHealth design that may appease common health research concerns surrounding reliability and validity, whilst providing swifter feedback to meet product development timelines.
OBJECTIVES: The objective of this exploratory single case study was to explore the virtual, crowdsourced, co-design of Sleep Solved, an educational mHealth sleep app designed with teens. In doing so, we wished to learn which virtual methods were used to engage teens in the co-design and to explore how these virtual co-design methods can be adapted for large-scale ideation and testing.
METHODS: We conducted an enquiry-based iterative case study utilising the Bayazit 3-stage model. 85 teens participated over 11 months. Data was thematically analysed over several design iterations.
RESULTS: Rapid virtual feedback allowed for quick pivots in a short time frame. Four stages of feedback from teens led to iterative changes to scientific information contextualisation and user experience, from lo-fidelity mock-ups through to a coded app beta.
CONCLUSION: The co-design of Sleep Solved exemplified the potential of virtually crowdsourcing teens in mHealth. Key to this evolution will be the ability to leverage big data utilising AI and machine learning approaches to data collation and synthesization, such that meaningful and contextual findings can be applied in line with software development timelines.

Keywords: mHealth, digital health citizens, co-design, crowdsourcing, user experience, person-based design, sleep, teens

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1. Introduction

1.1 Leveraging Mobile Health to Improve Sleep Hygiene in Teens

A worldwide epidemic of sleeplessness is rapidly emerging amongst teens. [1] With one in four young people reporting sleep problems and 4% of all adolescents reporting patterns of sleep disturbance [2], there is great concern that poor sleep habits are fuelling a rise in neurodevelopmental disorders [3] and a variety of mental health challenges[4] in young adults. More specifically, long-

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term adverse effects include metabolic issues, chemical imbalances, obesity, and chronic disease. [4] It is estimated that this phenomenon is costing the healthcare systems worldwide US $16B annually, with loss in work productivity costs exceeding US $50B annually. [5] These socioeconomic challenges are driving sleep research towards more rapid, instantaneous mobile health (mHealth) solutions that can help teens solve sleep problems into adulthood.

The emergence of mHealth is positively disrupting traditional health approaches on a scale not seen since the emergence of antibiotics. [6] mHealth apps provide ubiquitous, instantaneous access to support digital health diagnostics, self-help, preventive behaviour change and various other intervention types. [7] With investments reaching US $410 billion in 2022, [8] mHealth investment is expected to grow beyond half a billion by 2027 [9]. Key to the development of mHealth into the mid 21st century is the contextual design [10] with young people. [11] Teens are digital natives who hold the potential to harness the far-reaching impacts of digitally ubiquitous, instantaneous health technologies throughout life. This is especially important seeing that up to 15% of adolescents today have been diagnosed with a chronic illness or disability, [12] and the downstream impact on an already overwhelmed health care system is concerning. Developing strategies that help transition young people from paediatric to adult health care in the mode of personalised mHealth self-care is therefore paramount. [10]

1.2 Teenage Years: A Transition in Sleep and Digital Activity

Considering that the period of adolescence is a period of biological shift in circadian rhythms, [13] this is an important time to connect with teens on developing good sleep hygiene for life. From the age of 13 through to the age of 18, teens see a typical decrease in total sleep time of almost 1.5 hrs.[14, 15] This, coupled with an increased academic workload and greater independence to utilise digital technologies, provides the opportunity for insomnia and other sleep problems to emerge [16, 17]. Insomnia, which can be defined as “a difficulty in falling asleep, difficulty staying asleep, and non-restorative sleep,” leads to symptoms of fatigue, impaired concentration and mood disturbance.[18] Recent research has even found that sleep disorders impair the secretion of the human Growth Hormone (GH).[19] Insomnia and other forms of sleep disturbance interfere with many important human functions such as memory consolidation, attention, thinking and reasoning abilities, emotional processing, physical restoration and energy conservation.[13] Additionally, research over the past three decades has shown a correlation between sleep challenges, poor academic performance and increased abuse of nicotine and alcohol. [20]

Poor sleep habits and their resulting comorbidities can often persist and increase into adulthood,[15] contributing to a flow of downstream health and social problems. Alarmingly, research has shown that adolescent sleep problems persisting into adulthood in approximately 50% of teens,[15] additionally, global estimates in youth mental health problems have risen to between 10% to 20%.[21] These trends call for new and innovative approaches to mediate teen sleep problems. In seeking to address these challenges, the opportunity to curate a mHealth app for sleep awareness is a prospective approach, considering today’s teens are digital natives living on the cutting edge of tech culture. In support of this, encouraging research has found that 81% of adolescents have used the internet to seek health related guidance [13]. As digital natives, today’s teens are the first generation to grow up with the technological ubiquity of smartphones and other internet of things (IoTs). Co-designing an mHealth based sleep intervention with teens, one that is embedded into their digital ecosystem is a forward-thinking approach to healthcare intervention design.

1.3 Virtual Crowdsourcing with Teens: The Digital Health Citizens of Tomorrow

Co-designing a mHealth-based sleep intervention with young people is an integral part of the strategic transformational change of health systems. [6] As healthcare shifts towards more accessible, tailored solutions that prioritise individual needs and preferences, the drive to find better ways to co-design with young health users is heightened. [10] As noted in a recent (2024) study [22] on sleep app co-design, research that engages young people in sleep app development is lacking. An emerging method to improve this is virtual crowdsourcing the co-design ideas of teens. This method leverages the collective brain of participants, promising a wealth of rapidly collected data touchpoints, towards better understanding how to tailor needs to young mHealth users. [23]

As digital natives, today’s teens are the first generation to grow up with the technological ubiquity of smartphones and other Internet of Things (IoTs). They are intrinsically techno-social and entirely comfortable with the reciprocity of communal interactions [24] during in-app experiences. This positions teens as a generation of health “prosumers”: consumers of health services and users of social health technologies. In support of this, encouraging research has found that 81% of adolescents have used the internet to seek health related guidance. [25] This evolution resonates with the NHS goals to create a new social contract with its users, positioning them as activate participants in health care, rather than passive recipients of ‘sick care’. Through this vision, today’s teens can become tomorrow’s sophisticated health users. This emerging goal is centred around providing the tools and opportunities for digital health citizens to empower their own health care experience. [25]

More robust, data-rich methods to co-design are foundational towards improving scientific discovery, breakthrough treatments and more personalised care.

Crowdsourcing virtually bridges time, distance, and affordability in healthcare in ways traditional co-design methods cannot. [26] In this regard, crowdsourcing teen co-design presents a window to the future of mHealth. More broadly, this aligns with the World Health Organization's (WHO) systematic and cultural transformation of health care ecosystems, led by disruptive technologies that position people as digital health citizens; active engaged participants in the process of curating digital health solutions. [24] Digital health citizens are positioned at the intersection of 'bio and techno-sociality'. They are defined as active, responsible partners in the discourse, technologies, and social practices of health care. [25] This shift in strategy is intended to reduce the downstream cost of sickness services, instead promoting better health services throughout life. [27] As an overarching philosophy, the digital health citizen approach can seek to impact the three core mobile health (mHealth) design challenges of: reduced costs (budget), increased data points (validity) and rapid digital product delivery (time constraints). [28] This all-digital co-design approach resonates well with the technocentric ecosphere of today's teens.

1.4 Related Work

In consideration of these findings, the University of Bristol in association with the Prudence Trust set upon the aim to create and evaluate an online support programme entitled Sleep Well. The programme aims to use young people's smartphones to detect and treat early onset sleep and mental health problems. The three-step project aims to:

1. work with young people and creative teams to co-produce digital interventions to help teens (age 14-18) understand how to improve their sleep
2. adapt an online adult insomnia treatment (SHUTi) that has 6 modules refocused for teens in the United Kingdom (UK)
3. work with teens to identify best treatments for anxiety and depression in those with mental health symptoms

This approach culminates in a series of stepped sleep apps for teens:

1. **Step 1: Sleep Solved:** An interactive, educational sleep hygiene app designed with and for teens.
2. **Step 1: Phone Downtime:** An interactive app that tracks phone usage, providing insight and tips on how to manage usage during ideal sleep down times. [16]
3. **Step 2: Teen SHUTi:** A modified teen version of the adult SHUTi app that provides cognitive behavioural therapy for insomnia (CBT-i) based solutions tailored to the teen audience.
4. **Step 2: Bite Back:** A self-guided online wellbeing and resilience program for teens.
5. **Step 2: Project YES (Youth Empowerment and Support):** A website offering a series of short sessions that have been proven to improve teen's mental health, run by scientists at the Lab for Scalable Mental Health.

Sleep Solved was the focus of our case study. Before approaching the study, we first investigated existing sleep solutions in the mHealth community in order to gain insights into previous efforts.

1.5 Sleep and mHealth App Design

There have been a number of efforts utilising mHealth to improve sleep deficit and to increase sleep hygiene. To summarise some of the main contributors analysed in the research community (Table 1):

Table 1. Summary of prominent mHealth sleep interventions

mHealth app	Focus	Description
Doze	CBT-i	A free transdiagnostic, self-management, cognitive behavioural web app that provides personalised feedback on sleep disturbance. The app was designed using an interactive, experience-based co-design process with end users. [29]
Calm	Mindfulness meditation	A commercially successful mindfulness meditation mobile app that includes 'sleep disturbance' as part of a group of health behaviour (change) objectives. [20]
Sleep Scheduler	CBT-i	A digital sleep diary that can suggest (or intervene) in sleep scheduling using a CBT-i approach. [5]
iREST (interactive Resilience Enhancing Sleep Tactics)	Mindfulness meditation	An mHealth platform designed to provide a just-in-time adaptive intervention (JITAI) in the assessment, monitoring, and delivery of evidence-based sleep recommendations in a scalable and personalised manner. The platform includes a mobile phone–based patient app linked to a clinician portal. [18]

Sleepio	CBT-i	A multimedia rich iOS and web app that combines the functionality of a sleep diary, CBT-i coach and virtual sleep expert providing components of CBT, as well as other non-drug treatments for insomnia such as Imagery Relief Therapy. [5]
Sleep Ninja	CBT-i	A CBT-i that focuses on psychoeducation, stimulus control, sleep hygiene and sleep-related cognitive therapy. This is delivered via training lessons, recommendations and sleep tips; a six-week program that concludes with a black belt in sleep. [2]
Better Nights, Better Days – Youth	CBT-i	A CBT-i with strategies that target adolescents (age 14-18) with neurodevelopmental disorders (NDD) and sleep problems. [30] The app aims to educate on healthy sleep behaviours towards effective sleep practices. It does this by providing recommendations and a daily sleep diary for sleep tracking. [15]
SHUTi (Sleep Healthy Using the Internet™)	CBT-i	A personalised, interactive web app built on predetermined "if-then" algorithms [18], SHUTi is designed to improve the sleep of adults with insomnia. In the form of an online course, users have daily and weekly tasks to monitor and record the subjectivity of their sleep data.[5] As part of the broader Sleep Well project, SHUTi is currently being adapted for teens in the UK.

To summarise, where apps like Doze and Calm are focused on self-management, and apps like Sleep Scheduler and Sleepio combine sleep scheduling and CBT-i, and apps like iREST and SHUTi centred on behaviour change, there was a need for a teen-centric educational sleep app that serves to 'on-board' with sleep hygiene education, building towards diary, tracking and CBT-i approaches. In essence, a gap was identified that segues teens towards sleep management and CBT-i; one that is educational, informative, and in the vein of today's teen tech culture [31]. This is where Sleep Solved enters the picture as a teen sleep app centred on engagement and education, a bridge towards larger sister projects: Phone Downtime (tracking), Teen SHUT-i (CBT-i), Bite Back (mental health and resilience) and Project YES (Youth Empowerment and Support, mental health and wellbeing) as part of the broader Sleep Well multi-year initiative.

1.6 Understanding the Motivation Behind Sleep Solved: A Teen Sleep Awareness App

The need for a teen-centric educational sleep app is strongly supported by the fact that only 36% [20] of the teenage demographic actively seeks mental health support through traditional methods. With adolescent sleep problems frequently persisting into adulthood, it is essential to address this issue, as it is adding stress to an already strained health system in the UK. A recent study by Toguas et al. [15] cited inaccessibility, cost, time and stigmas as key factors dissuading teens from seeking traditional help. Contrastingly, mHealth offers the potential to increase accessibility, reduce costs, and provide private, instantaneous interventions. mHealth is uniquely positioned as a medium that lives in the "digisphere" of today's teens: the app space.

However, despite there being more than 2000 mHealth apps targeting sleep[32], there is little in the way of evidence-based support for their development. A systematic review [33] noted that only 13% of sleep apps provided links to evidence-based scientific literature. Addressing vast variance in sleep disorders such as insomnia, dyssomnia, and sleep insufficiency [29], often collectively described as "sleep debt" [13], in a manner that is both educational and engaging to the very specific teen demographic, is challenging. A review by Aji et al. [34] (2021) noted that various attempts to incorporate a user-centred design (UCD) in sleep apps was bridging the gap between patients and health professionals. Nonetheless, approximately half of the sleep apps reviewed did not utilise a person-centred design (PCD) approach. In this regard, there is a unique and important opportunity for the co-design of Sleep Solved to culminate in the three design objectives of: person-based, science-focused and intelligent design.

With these objectives in mind, Sleep Solved aims to support teens with their sleep and mental health. This, in response to the lack of uptake in traditional sleep and mental health intervention amongst teens, especially in economically challenged demographics. An interactive educational app design with and for teens, it is designed to harness the ubiquity and instantaneousness of mHealth technologies in order to impact teen smartphone users at-scale. A multi-year project that is part of a broad UK public health intervention that seeks to improve mHealth sleep support in young people, it is intended to be used in partnership with Phone Downtime, a sleep tracking activity app that provides metrics on sleep behaviour [35]. After 6 weeks of Sleep Solved, users were then offered an educational stepping stone to Teen SHUTi, a course-based CBT-i behaviour change app to support insomnia, Bite Back, and online mental health, wellbeing and resilience

programme produced by the Black Dog institute in Sydney, Australia. Lastly, Project YES (Youth Empowerment and Support) is a website offering short, optional sessions that have been shown to improve teens mental health, run by scientists at the Lab for Scalable Mental Health. The onboarding with Sleep Solved is aimed to provide the right sleep information in a teen-centric interactive user interface (UI) that lays the foundational education for good sleep hygiene. It is hoped that findings from this teen co-design may impact positive behaviour change, helping teens who struggle with sleep and mental health challenges. Simultaneously, it is hoped that lessons are learned on how to crowdsource teen mHealth users remotely.

The need for positive behaviour change is well-established in the literature as evidence linking downstream mental health challenges in poor teen sleep hygiene is well-documented. However, considering that a recent systematic review on interactive cognitive behavioural therapy (iCBT) found limited to no impact on improving sickness absence (SA) in people struggling with mental disorders, [36] there is a pressing need to specifically learn more about how the ideation and testing of mHealth sleep apps with young people can become more effective and reliable. Stemming from this is the need to understand how virtual co-design methods can be implemented at-scale, in order to increase the number of data points, improving validity and reliability in mHealth studies. Subsequently, our research questions were:

[RQ1]: How were virtual methods used to engage teens in the co-design of a sleep self-help app?

[RQ2]: How can these virtual co-design methods be adapted for large-scale ideation and testing in the emerging digital health citizen ecosystem?

1.7 The Challenge and Promise of Crowdsourcing Ideation and User Testing Data Virtually

Given the important potential of virtual crowdsourcing in mHealth research, we endeavoured to case study this online, iterative process to create Sleep Solved. The app was designed by a team of health experts (sleep, psychology), digital designers (artists and developers) and importantly, the person-based approach (PBA) [37] to engage in a co-design with teens. The stages of ideating and testing with end users (teens) was conducted entirely by virtual crowdsourcing. Crowdsourcing is positioned as a catalyst that can provide a quantum leap in health and medical research. It is considered a pathway towards a new era of "citizen science", providing the ability to pool the imagination of health care users [38]. Virtual crowdsourcing, which can be defined as an "online, distributed problem-solving and production model that leverages the collective intelligence of online communities for specific purposes" [39] is not a new concept. [40] However, it remains nascent in the digital health design space, providing the potential for a larger crop of data-points in the rapid collection of mixed-method approaches to data collection of ideation and testing. [41] Studies have lauded the ability for crowdsourcing to garner feedback from thousands of participants in a matter of hours. [23] As Swan et. al have noted, crowdsourced health research is an emerging contemporary trend that accentuates the emerging "citizen science" approach to Health 2.0, [41] wherein patients become active participants—practitioners of their own good health—utilising the best of web 2.0 technologies that incorporate big data techniques and artificial intelligence (AI), towards providing intuitive, information analytics for "health citizens". The virtual crowdsourcing approach in digital health co-design may represent an important bridge between the challenge to rapidly create digital solutions within a constricted timeline and traditionally slower, safer large data needs in health care research. In essence, virtual crowdsourcing may bridge top-down (health care) and bottom-up (digital design) approaches around faster, richer, user data points. [39] Gaining more data points in a shorter time frame is of mutual interest to digital and health stakeholders alike.

More specifically, it is hoped that through this virtual crowdsourced project, broad feedback may be collected towards better understanding how to effectively co-design virtually with young mHealth end users at-scale. Considering that 95% of adolescents (aged 13-17) use a smartphone, [4] [21] and with behavioural strategies being considered the frontline in healthcare prevention [3], an educational mHealth sleep app provides a way to engage teens before negative habits form. It is expected that this novel approach to designing a sleep app for teens will uncover more challenges and opportunities, something that should be embraced in the digital health community. However, any positive steps that contribute to positive behaviour change [32] in teen sleep habits opens up a new window of opportunity towards better leveraging mHealth to improve the self-empowerment of healthcare in young people. An approach that is very much in-tune with the National Health Service's (NHS) new "social care" [42] objectives to create digital "health citizens" [43] who are "prosumers" (both consumers and producers of health data) in the emerging Health 2.0 ecosphere.

With this perspective in mind, we present empirical evidence from the experience of virtually co-designing with teen co-designers through various phases of ideation and testing. Secondly, we provide insight and suggestions on how to scale-up virtual co-design methods for the digital health citizen era, understanding how human-computer interaction (HCI) research in mHealth may contribute to increased data points and therefore increased empowerment of digital health end user involvement in co-design.

2. Methods

Seeing that our research questions are exploratory in nature, we have modelled this enquiry-based iterative case study after Bayazit's 3-stage model: [44] [45]

Model 1: Find out about current design practices (e.g., pursue a design project to help uncover decision-making processes and social responsibilities).
Model 2: Devise improvements in design methods (e.g., help conceive and develop new design procedures, information, priorities, and tools).
Model 3: Make improvements to designed artefacts (e.g., help contribute to how a type of product can or ought to be designed, how it can be improved, and to demonstrate benefits).

The Bayazit methodology culminates in three key outcomes of which we provide our contextual output:

1. **Knowledge elicitation:** This involved the documentation of co-designers' thinking, archived in an unstructured, unanalysed form, inclusive of all internal project team meetings, online Young Person's Advisory Group (YPAG) workshops (n=1), think-aloud interviews (n=20), online surveys, online user testing and feedback focus groups (n=7). In essence, the raw data from the co-design journey.
2. **Data analysis and interpretation:** This involved the thematic analysis of the aforementioned data, resulting in themes and subthemes reflective of the plus points, pain points and gaps and opportunities derived from the co-design process.
3. **Knowledge synthesis:** This involved the data synthesis of findings relative to the virtual co-design journey with teen collaborators, and the wider validity and implications relative to scaling up methods for larger virtual data collection into the digital health citizen era.

2.1 Settings

The Sleep Solved co-design took place over the course of 15 months (June 2022 - August 2023). All participants, including health researchers, designers and developers co-designed virtually, with some internal work and meetings taking place on-site at the University of Bristol. A virtual codesign was selected in order to increase ease of participation amongst teens across the UK. Participants aged 14-18 were recruited from colleges and schools across England through partnership with two organisations: E-ACT [46] and the Association of Colleges [47]. Wider PPI consultation was achieved in partnership with UK based charities for sleep and mental health: The Sleep Charity, [48] the McPin Foundation, [49] and a Young Person's Advisory Group (YPAG) [50] from Bristol.

2.2 Participants

Over the course of 11 months, 85 Participants aged 14–18 were recruited from colleges and schools across England through partnership with two organisations: E-ACT [46] and the Association of Colleges [47]. Wider PPI consultation was achieved in partnership with UK based charities for sleep and mental health: The Sleep Charity, [38] the McPin Foundation [49], and a Young Person's Advisory Group (YPAG) [50] from Bristol. Sleep Solved co-designers were recruited from college and secondary school students from some of the most deprived regions in the UK. In order to recruit young people to PPIE activities within the target age range (14-18), a video and QR poster describing the study was shared with partner schools and colleges (Appendix A). Teen participants were engaged in the form of virtual surveys, focus groups and think-aloud interviews (Table 2).

Table 2. Summary of co-design events

Event	Method	Participants and Objectives
Young People's Advisory Group (YPAG) (2022/09/08)	Focus group	Ideation. 6 young people, 3 young women, 3 young men, aged 14-17
PPIE feedback (2022/11/22)	Qualtrics survey	App names, colour palette, logo, themes, poster, information sheet. 5 respondents: 4 young women, 1 'prefer not to say', age range 14-17, half from 10% most deprived areas of the UK.
PPIE feedback (2022/12/02)	Qualtrics survey	App themes, ranking Theme 1 vs Theme 2. 7 respondents: 5 young women, 2 young men, 6 of White British ethnicity, 1 Sri-Lankan/Sinhalese. All aged 16. From the 30-40% least deprived areas of the UK.
Virtual Meetings (2023/01/19 - 2023/07/14)	Think-aloud interviews	20 participants: 8 young men, 10 young women, 1 non-binary, 1 genderfluid. 13 White British, 1 Arab, 1 African 1 White and Black Caribbean, 1 Pakistani, 1 South Asian, 1 Middle Eastern. Age range 16-18 (average age: 17 years). 10 of the 20 from the 10-50% most deprived areas of the UK.

PPIE feedback (2023/14/02)	Qualtrics survey	4 logo options. 9 respondents: all young women, 7 of White British ethnicity, 1 White and Black African. Aged 16-17. 6 of the 9 from the 20-50% most deprived areas of the UK.
Sleep Solved app trial Feedback (2023/04/12)	Focus group	Recruited from McPin. 7 users tested the prototype app; six young women and one non-binary person, aged between 16 and 18 years old (average age: 17.12 years). Six were of White British ethnicity, and one user was of Middle Eastern ethnicity. Levels of deprivation ranged from the 40% most deprived, to the 20% least deprived.39 The majority had self-identified sleep problems ranging from difficulty sleeping 2-3 times per week, to more than 4 times per week.
PPIE feedback (2023/05/16)	Qualtrics survey	Recruited from McPin. 7 users tested the prototype app; six young women and one non-binary person, aged between 16 and 18 years old (average age: 17.12 years). Six were of White British ethnicity, and one user was of Middle Eastern ethnicity. Levels of deprivation ranged from the 40% most deprived, to the 20% least deprived.39 The majority had self-identified sleep problems ranging from difficulty sleeping 2-3 times per week, to more than 4 times per week.

2.3 Ethics

Ethics was sought and approved by Ethics and Research Governance, University of Bristol. The main feasibility study was approved by the North West – Greater Manchester Central Research Ethics Committee (Reference: 23/NW/0129). For PPIE activities, consent was not required from contributors, in line with National Institute for Health and Care Research (NIHR) Centre for Engagement and Dissemination guidance on patient and public involvement in research [51].

2.4 Data Collection and Analysis

Teen participants were engaged in the form of virtual surveys, focus groups and think aloud interviews (Appendix B). Fieldnotes were taken throughout the project reflective of internal meetings, discussions, meeting recordings, interviews, think-aloud interviews and surveys. Data was then collectively organised, and coded and themed in a thematic analysis. Following the Braun and Clarke analysis protocol [52], data was carefully scrutinised, line-by-line, resulting in the organic arrival at codes, themes and sub-themes.

3. Results

3.1 Overview

3.1.1 Project Strategy

The conceptualisation of the Sleep Solved app combined the collaborative elements of: clinical management approaches, PBA and UCD. Initial team meetings culminated in a three-fold hoped outcome:

1. To explain the core principles of key sleep hygiene behaviours,
2. by providing credible trustworthy scientific information,
3. created in a positive user experience that is engaging and informative.

The guiding design objectives to achieve this outcome were to understand:

1. user characteristics,
2. design objectives to suit these characteristics,
3. and the subsequent user experience (UX) and app features for intelligent design.

The collective goal was succinctly described as: *how science can help you sleep better*.

3.2 Overview of Patient and Public Involvement and Engagement (PPIE)

3.2.1 Preliminary Research

Preliminary investigation was made into arousal factors that would prevent sleep. Using a problem/solution format, factors such as caffeine, alcohol, sugar, nicotine, technology use and exercise were explored in the literature by expert researchers, relative to the release of cortisol and adrenaline (alertness hormones) versus melatonin and adenosine (restful hormones). Additionally, brand analysis within popular culture in the teen demographic was explored to better understand how young minds are mediated digitally today.

3.2.2 Protocol

A participant information sheet was created for all suitable participants explaining the aims of the study, the essence of the Sleep Solved app, how participants can participate, as well as how information will be collected and used.

3.2.3 Outreach and Recruitment

With the help of UK sleep and mental health charities, young persons aged 14-18 were recruited to participate in the co-design process to test and improve Sleep Solved (Figure 1, Appendix A, C). Posters were distributed in schools and colleges physically and a video was disseminated digitally. Participants received between £10 and £40 depending on the level of their participation in the study. Participation was entirely online (virtual) and required participants to have an Android smartphone.

Figure 1. Sleep Solved outreach recruitment video

3.3 Virtual Co-Design

3.3.1 Young Person Advisory Group Brainstorming Session

To kick-off the PPIE sessions, the Bristol YPAG group [50] [53] was consulted to understand the message, medium(s) and design approach. Teen participants agreed with the core message proposal (i.e. how science can help you sleep better), and noted that an app that was simple, soothing and informative about sleep hygiene would be beneficial, particularly one that provides a format that answers key questions and clears up common misconceptions. They also noted that most of their teen friends may be unaware of the science surrounding sleep.

3.3.2 Branding and Theming

Before venturing into the app design and features, the first design step was to develop an app name, colour palette (theme) and branding approach (Figure 2, Table 3). Six names were proposed by the research team to teen co-designers with Sleep Solved being the most popular choice. Three colour palettes were mocked up by a design agency with the most popular responses being the playful and approachable stylised neon pastel iconography and night blue sky backgrounds (resonating with sleep time). In terms of brand resonance, interestingly, TikTok and Nintendo Switch were less popular in comparison with brands that were nonprofit organisations (NPOs) or government-led charities denoting the professionalism of self-help.

Figure 2. Sleep Solved mood board

Table 3. Branding and theming co-design resolutions

Problem	Resolution
App name	Sleep Solved
App theme	stylised neon pastel with night sky
Design themes	simple, visible, relative, relaxing, informative, intelligent design

"Style is clear…colours are visible…easy to find" (PPIE feedback from teen co-designer)

3.3.3 First Iteration: Discovery (low-fidelity PowerPoint)

With conceptual ideas for branding and theming in place, the research team began to refine an approach to bridge pertinent scientific information on sleep hygiene with intelligent design approaches (Table 4). As a first step in the app development process, the research team (comprising health psychologists, designers and developers) utilised a blue-sky approach by iterating information and design layout concepts in low fidelity PowerPoint mock-ups (Figure 3). This would allow for rapid testing of both interpretation of scientific information and the UX, with easy on-the-fly adjustments.

Table 4. App interactions and engagement objectives

Interaction Type	Objective
Micro (learning) moment	quick bites of scientific information
Pop-ups	optional supplementary information
Enlightenments	pivotal questions that are often misunderstood

Information was kept concise, led by snippets of information called "micro learning moments", that presented quick engaging copy mediated by soft imagery and icons. This approach was built upon preliminary research pointing to challenges in language comprehension, engagement, and reducing the intimidation surrounding scientific information. The design was refined several times internally before being scaled up in fidelity for presentation to teen co-designers.

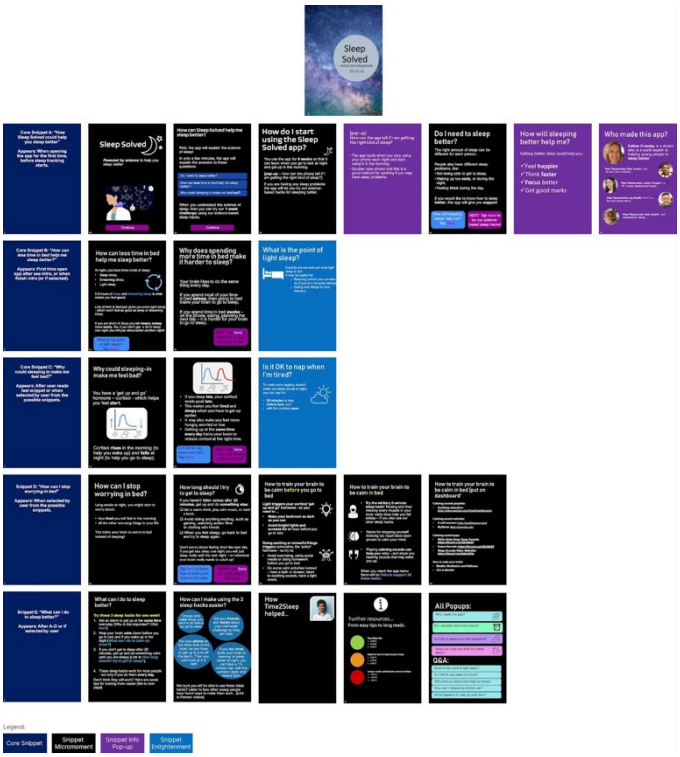


Figure 3. Sleep Solved low fidelity mock-up mapping with micro-moment snippets

3.3.4 Second Iteration: Visualising the app design concept (medium-fidelity Figma prototype)

Through a process of internal co-designing, the challenge to strike a balance between presenting scientific information whilst making it visually simple was explored repeatedly. Since the first iteration mock-up was focused on deciding on scientific information and how to present it, it was not formulated considering the constraints and affordances of mHealth design. The second iteration then focused on co-designing app screen mock-ups that would provide a viable design concept to integrate the scientific information into an intelligent app design. Successful apps like Duolingo and Mercedes-Benz were explored for design approaches to app onboarding, scrolling and swiping etc., in order to evaluate intuitive gestures and interactions with end users. A UX designer reconceptualised the first iteration mock-ups within an app design framework in Figma considering mobile app gestures and calls to action (Figure 4).

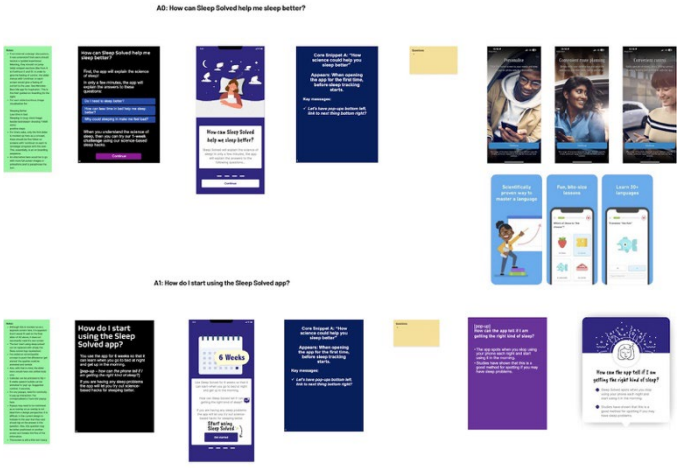


Figure 4. Sleep Solved app concept ideation mock-ups

The initial PPIE feedback pointed to simplicity through visible, relaxing but relative and informative, intelligent design. This began to take form in the second iteration, through app screen mock-ups that utilised soft but bright pastel images and fun, playful iconography that was semiotic. In this vein, two theme concepts were polished and tested with teens. One theme was darker in tone with text on coloured background panels, whereas the other utilised sharper imagery and white panel background sliders. The latter of the two was more popular with teen testers with preference given to good contrast (background/foreground), and bright neon colours to draw attention to imagery with less text (Figure 5).

Key teen co-designer PPIE feedback: *"[It's] simple, doesn't have too much writing and gets to the point, not overwhelming to look at."*

Key themes from PPIE: concision, visualising meaning, soft icons (imagery)

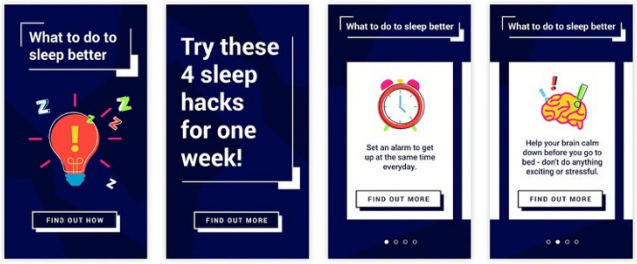


Figure 5. Most popular Sleep Solved medium fidelity mock-up as chosen by teens

Additionally, the research team understood from the preliminary brand research that the app name and logo design would be an important mediator with teens. To this end, four versions of the Sleep Solved logo were tested with teens (Figure 6). The most popular selection being the fourth variation (far right, below).

"The logos are better being colourful I think as they are aimed at younger audiences." (PPI feedback from teen co-designer, 16, F)

Key themes from PPIE: colourfulness, legibility, demographically contextual

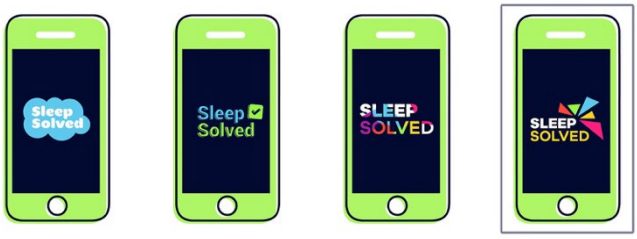


Figure 6. Sleep Solved Medium Fidelity App Icon Mock-ups

3.3.5 Third Iteration: Coded App for Testing (high-fidelity)

With feedback on both app and branding mock-ups reviewed by teens, a web developer from the research team began to code the app for user testing. A focus group was formed to use and test the beta version of Sleep Solved for one week. Seven teens with existing sleep challenges gave their feedback. They enjoyed the visual nature of the app experience and found the information relevant and relatable. Teen co-designers identified numerous bugs and design improvements ranging from menu navigation buttons to continuity errors. Of key importance was the desire for more interactive multimedia and retention concerns (i.e. one-and-done experiences). Overall, users found the tips in the app (sleep hacks) useful when put into practice but were curious about related apps in the project that would provide metrics from sleep tracking. Key themes that emerged were: navigability, informativeness, relevance, relatability (Table 5).

Table 5. App interactions and engagement objectives

Interaction Type	**Objective**
Text	keep it informative, minimal, but do not oversimplify it
Menu	need for a visible menu with progress bar (or task completion checkboxes)
Points/Rewards	addition of a points system to make the experience more rewarding
Related sleep apps	need for more relatability to Phone Downtime and Teen SHUTi (sister apps) for tracking, metrics and notifications

These findings from teen co-designers led to a final beta-launch version that incorporated layers of UX feedback on the scientific information, usability and retention (Figure 7).

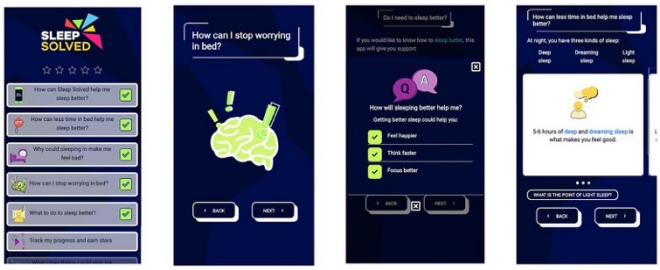


Figure 7. Sleep Solved coded beta app (high fidelity)

This concluded the co-design phases of the project and the case study. A video walk-through of the project is available in Appendix D.

4. Discussion

This exploratory case study sought to investigate the methods to rapidly iterate a virtual co-design with teen participants facing sleep challenges, and to understand how these methods could be scaled up to increase validity and reliability of data in the emerging Health 2.0 era. Our findings illustrate the advancements and challenges to co-design outside of traditional workshop environments. As with any instrument of measurement, there are pros and cons to its utilisation. Whilst virtual crowdsourcing brings the promise of more data, challenges exist in how to recruit

and vet participants, and how to analyse emotional UX data acquired remotely. The virtual co-design of Sleep Solved garnered two key themes (Table 6).

Table 6. Summary of themes and subthemes

Theme	Subtheme
Information Contextualisation	simplicity, informativeness, demographically relative
User Interface and User Experience	visibility, navigability, visualisation

These two themes dominated user feedback such that teen users felt the information presented in the app needed to be scientific yet simple to understand, informative yet not boring, and demographically relative (i.e. interesting and easy for the teen audience to absorb. Additionally, much of the feedback on the UI and UX was focused on imagery and text being visible yet concise, easy to navigate, and a true visualisation of the scientific message. It was interesting to note that teen users understood the seriousness of a sleep hygiene app and the mental health challenges that surround it. A brand affinity survey showed that many of the brands in teen popular culture and their forms of mediation (like TikTok) were deemed unsuitable by teen co-designers as design references for a sleep self-help app. This illustrates the astuteness of teen mHealth app users, that they are not in need of mere entertainment for engagement.

A key positive of the design process was the rapid data collection from a wide pool of participants, something that speaks to the need for larger population studies in mHealth co-design (i.e. to improve validity, reliability) [41]. However, one of the key challenges was the lack of digitisation of traditional UX workshop exercises (e.g. sketching, dot-voting etc.) and the rich emotional feedback they garner, data that often speaks beyond statistical feedback. Additionally, some of the design concepts that were popular amongst expert research team members were less popular amongst teen co-designers and quickly dismissed (despite the small participant pool). To improve the reliability and validity of findings, this gulf of evaluation demonstrates the need for the further involvement of teens alongside designers in the co-design space at-scale, into the Health 2.0 era. Although the themes discovered during this virtual co-design process satisfied the goals of an iterative design process, to envision Créquit et al.'s "citizen science" approach, much larger, richer mixed-method data collection is needed to improve the validity and reliability of data, improving the contextuality of the co-design process [43]. With these general observations in mind, we turn our attention specifically to the research questions.

4.1 The Utilisation of Virtual Methods to Engage Teens in the Co-Design of a Sleep App

4.1.1 Data Collection Approaches

The four PPIE events with teen co-designers ranged from 23-40 recruitments with an average participation rate of 32.7%, and a median (n = 7). Participation rates were similar in size to typical in-person workshops. By incorporating national charities (The Sleep Charity, The Association of Colleges and the McPin Foundation), the research team was able to recruit from a larger pool (nationally), making the core demographic more rapidly attainable for this study. The first three PPIE events were surveys which provided the benefit of rapid and blunt assessment of digital assets and copy. The research team was very attentive to teen co-designer feedback and made changes accordingly. However, as with many co-design studies, the number of subjects was limited, such that strong design determinations were built upon limited end-user feedback. This is consistent with recent findings in a 2025 systematic review of Challenges to Co-Design Digital Health Interventions with End Users [54] that found 78.3% of studies included less than 20 subjects, with only 7.8% including more than 50 subjects. Although survey feedback is rapid and statistical, it is often brought into question for margin of error (deviation) in small sample sizes. To this end, richer approaches to crowdsource more data could be helpful.

4.1.2 Co-Design Approaches

The prototypical on-site co-design workshop which garners mainly emotional, qualitative feedback in a fail-fast agile environment, was not conducted virtually. Instead, traditional research approaches such as surveys and think-aloud interviews were conducted to gain rapid insights. Where co-design may more broadly refer to the involvement of stakeholders in the design process, *how* this takes place is much more subjective. In app design, the process of defining the questions, examining assumptions, exploring personas and mapping user journeys are typically in-person workshop collaborations. During this blue-sky phase, the (research) question may pivot, misconceptions may arise, and challenges often surface. Solutions, be they information or design oriented are often prioritised and voted on. Sketching exercises wherein the design team (including end-users) flesh together a vision of the solution is common. These approaches would have been beneficial to Sleep Solved but would have added scope and strained delivery timelines. Additionally, these emotionally rich

methods are also tagged with the same challenges of reliability and validity due to a similarly limited sample size. Moving forward, the challenge with co-design workshops lies in how they can be utilised remotely, in a cost-effective, timely manner. Traditional workshops are data-rich but not asynchronous, requiring much analysis after the fact. A core challenge exists in mHealth on how to utilise proven industry co-design methods: at-scale, with scientific validation, all within the constraints of an mHealth app timeline.

4.1.3 Testing Approaches

The testing phase was conducted with a group of seven teens who used Sleep Solved over the period of one week. Teens were asked open-ended questions like "How did you find using Sleep Solved over the past week?" and about their routines and methods to calm their minds or spend less time lounging in bed. This think-aloud group format allowed teens to scaffold their design feedback as well as stating their misunderstandings or misconceptions about the science of sleep. They were also able to compare and contrast the 'sleep hacks' learned from Sleep Solved micro-moments to the practical impact (or not) on their sleep related behaviour. There was a desire for more personalisation in the form of more enriching engagement (rewards) and progress markers (checkboxes). Overall teen co-designers found the app helpful and were intrigued to learn even more about the science of sleep. Nonetheless, virtual ideation and testing approaches that produce larger, organised datasets representing user preferences and tracked usage of the prototype would provide richer more contextual feedback. Attaining this will require novel database-driven co-design interfaces, as we will propose.

To this end, the three iterative design phases built around three surveys, a one-week beta trial, and subsequent focus group, provided rounds of changes that improved Sleep Solved. However, just how effective this co-design process could be with virtual approaches that garner much more data is a question of much intrigue. Concerns regarding reliability and validity may be soothed by methods that generate a larger data pool with a more diverse array of digitised UX workshops. In that regard, our attention shifts to our second research question on the potential methods to scale-up virtual co-design.

4.2 Methods to Scale Up Virtual Co-Design for Large-Scale Ideation and Testing in the Health 2.0 Era

The rounds of virtual co-design in Sleep Solved illustrated the promise and broader reach of expanding the data pool in mHealth design. Considering that healthcare will account for more than 36% of the world's data volume by 2025, mHealth is paramount in the delivery of improved personalised care. [26] The emerging Health 2.0 era positions patients as partners, "prosumers" of their own healthcare, [25] much akin to how YouTubers both consumer and produce content. This interdependent relationship between clinician and patient, mediated by countless other stakeholders (designers, developers, psychologists etc.) marks a quantum leap in healthcare delivery. It is reciprocal and empowering rather than hierarchical and systematic.[55] This shift underscores the need for tighter alignment between healthcare professionals, digital designers and end users in the co-design of mHealth apps. However, a clear challenge lies in how solutions are arrived at from the perspective of industry (agile, mixed method), health care (clinical, largely quantitative) and psychology (social, largely qualitative). App design is rapid and iterative, clinical trials are slow and statistical with large datasets, while social science studies are emotional and analytical with smaller data sets usually. All of these perspectives are valid and necessary in the formulation of an mHealth solution but often the research silos into one of these approaches individually. In exemplification of this, a recent systematic review [54] found that in a review of 171 studies involving co-designing with end-users, only 1 in 4 studies utilised a mixed methods approach and none of them leveraged the data goldmine of virtual co-design. While Sleep Solved showed that virtual crowdsourcing can be effective, it utilised methods (surveys and think-aloud interviews) that only scratch the surface of co-design data points. To mediate broader challenges in digital health, new approaches are needed that produce larger datasets rapidly, without losing the richness of emotional feedback or falling into siloed perspectives that can limit the potential of the co-design. Reflecting on the co-design approach in this study, we developed the following five recommendations on how to scale up virtual co-design for large-scale ideation and testing in mHealth:

4.2.1 Recruitment

This study revealed a 32.7% participation rate amongst recruited teens. Researchers can use this marker to consider the scope of outreach needed. Scaled-up, gaining 327 participants from 1000 recruitments would be a much-improved dataset. This underscores—in spite of any challenges—the potential for virtual crowdsourcing. With the assistance of The Association of Colleges (and other charities), demographically relevant recruitment took place across the country. This process could be further enhanced by utilising teen-centric social media such as TikTok, Snapchat and Instagram for demographically driven recruitment ad campaigns. This opens the potential for 1000s of responses that form the cornerstone of improved validity and reliability (more data, less margin of error) in digital health co-design studies. [56] This of course would require meaningful data that can be filtered and organised

in an automated fashion. This is where expanded virtual approaches become very prospective.

4.2.2 Big Data Virtual Co-Design

As alluded to previously, traditional workshops are largely qualitative, synchronous and time consuming, with small but rich data pools (typically 5-8 people). Sleep Solved utilised remote surveys and think-aloud interviews for rapidity and reach. However, by digitising workshop UX exercises asynchronously, as our concept exemplifies (Figure 8), with a co-design interface that presents moodboards that can be annotated with memes or stickers, by providing lo-fidelity sketches that can be drawn over or highlighted, and logos that can be annotated or doodled over—visual and interactive forms of asynchronous feedback can be obtained en masse. Much like some online surveys, each section of the co-design could be timeboxed for usage tracking. This approach would allow for some of the best industry practises to be digitised, producing larger datasets, utilising a website or Google Jamboards, resonating with teens by utilising the social cues they enjoy. In the Sleep Solved study, financial incentive was provided to teen survey subjects, this approach could also be utilised for a synchronous online design jam, that seeks to utilise industry-styled zero-to-hero design approaches in developing an initial prototype (with teens) in a half-day virtual workshop.

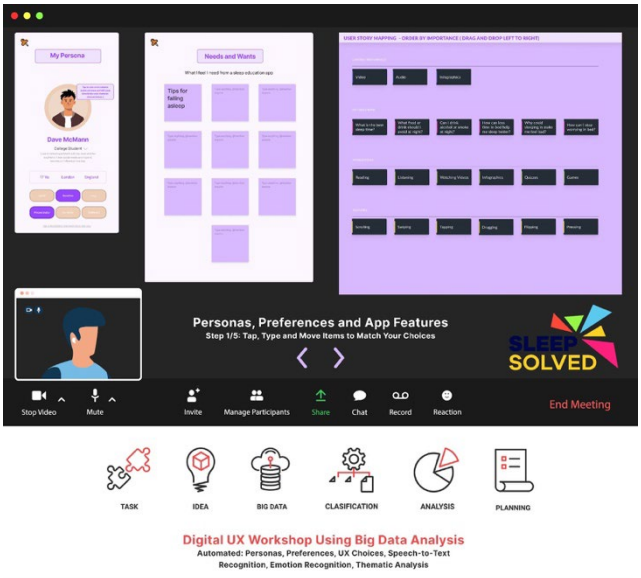


Figure 8. Prototype for an asynchronous co-design experience jamboard

4.2.3 AI and Machine Learning in Co-Design

The aforementioned concepts for digital recruitment and co-design are in need of automated processes that reduce the inundation of uncollated data. It would be an exhaustive process for researchers to comb through extensive data, one that would negate the gains of digitising feedback. In this regard, there is a need to automate user responses in the forms of stickers, ratings, heat-mapping areas of mock-ups that gain the most activity, pitch recognition of voice feedback and speech-to-text processing that can generate keyword themes and subthemes automatically (automated thematic analysis)— all of this to better understand usage metrics and preferences in co-design. This is a mixed-method approach where qualitative and quantitative approaches can meet, where statistical and emotional feedback can complement one another, a silo-free approach that leverages the best of various sciences in the coproduction of an mHealth app. It also allows for drill-down data that maps preferences to personas. This is difficult to envision without the smart metrics derived from the automation of workshop data that is collated smartly and instantly.

4.2.4 Observational User Testing

Asynchronous testing that captures both emotional feedback (vibes) and user actions (metrics) can be obtained by observational user testing. This emotional feedback may include speech (pitch and tone, text-to-speech) and body language (reaction to media or calls to action) which can be linked to the given app screen in view. This data can be automated and mapped to the actionable metrics of the end user. This combination may address the longstanding variance in qualitative and quantitative analysis of an mHealth app that often juxtaposes user feedback with user activity. In this, there is the opportunity to ‘draw a line’ through trends in the data that better combines the actions and opinions of end users, seeking to vastly improve the challenges of validity and reliability; iterating design based on richer data.

4.2.5 Co-Design Vlogging

In addition to leveraging teen social media platforms for recruitment, publishing the digital co-design experiences of participants may garner mass feedback in the form of ideation through social commentary. It is also an additional way of gauging broader feedback to design concepts. A popular activity amongst teens nowadays is the publishing of multiplayer online role-playing games (MMORPG) experiences to be viewed online, or for young people to publish lived experiences, or their own tutorials (vlogging). The observation of co-design experiences itself may be of intrigue to young people, garnering important secondary feedback at-scale. This data can be mined using machine learning algorithm software such as AirOps,[57] to collect social media keyword filtering towards thematic trends in social responses.

These experimental concepts resonate with findings in our background literature review that are founded on the three

core values of: person-based, science-focused, and intelligent design. An approach that is hoped to create richer, more personalised data points for improved co-design in the mHealth domain. Consequently, it is hoped that these potentially broader metrics provide both micro-level improvements (co-design environment) and macro-level strategic policy development (digital health citizens, social care agenda) into the Health 2.0 era.

4.3 Key Challenges

These concepts, though promising in principle, are untested and would face key challenges. Amongst them is the danger of obtaining inappropriate data (outside of the target demographic), and falsified tests or designs (junk data), especially when participation may be financially incentivised. This is a longstanding challenge in research [58] that would be multiplied in larger virtual recruitments. Without the value of face-to-face validation, greater challenges exist regarding data integrity [59]. AI and machine learning is an emerging field that can be manipulated [60] to 'lie with statistics'. Ethics and integrity loom large in the scientific discussion of automated metrics.

4.4 Big Data and Digital Health Co-Design into the Health 2.0 Era

Whilst tempering the promise of large-scale virtual co-design with the challenges of a domain still very much in its adolescent years, there is an inevitability that digital health co-design must trend in the direction of increasing the scope and uniqueness of data points for mHealth evaluation [41]. It is well-established in the literature that smaller qualitative studies jeopardise validity and reliability and that clinical trials are long and cumbersome, often outliving the life of an mHealth project [61]. Emerging research such as Liang et al.'s sleep app co-design study (2024) lauded the ability to engage young people asynchronously for better engagement. [22] Additionally, Cormier et al.'s SMILE sleep app (2024) points to a *precision medicine* paradigm shift [31], improving engagement through closer partnerships between end users and health design teams. Finally, Shriane et al. (2025) echo the sentiments of this case study in taking a reflexive iterative approach to co-designing with young end users, showing higher retention rates due to engaging exercises and a sense of authorship [17]. We argue that this process must begin in the formative ideation stages and further improvement is dependent on larger, richer, more contextual datasets to provide better validity and reliability, something remote, asynchronous crowdsourcing can help facilitate in mHealth co-design.

The Health 2.0 approach that envision digital health citizens as active participants in their own healthcare necessitates the need for deeper involvement of end users in co-design, an approach that has richer, more plentiful data points that better justify design decisions, reducing the gulf in evaluation amongst stakeholders spread across government, research, industry and consumers. The Sleep Solved study exhibited the potential to rapidly crowdsource with teen co-designers through digital outreach and asynchronous online data collection. However, a mixed methods approach that scales up these data points utilising AI and machine learning to digitise UX workshop data represents a potential step forward, such that from both digital and health perspectives, enough confidence in the data can occur in a reasonable amount of time, in line with project deliverables. This novel idea combines a number of core digital health challenges under one proposed umbrella solution as cited in our introduction: reducing costs (budget), increasing data points (validity) and rapid digital product delivery (time constraints).

5. Conclusion

This paper presented the virtual co-design process of creating an educational sleep hygiene app with teens. Our findings illustrate some of the benefits and challenges encountered in virtual co-designing. This study has led us to several promising suggestions for future experimental research that may increase data points, improve reliability and validity and further involve co-designers. We encourage fellow researchers to experiment in these approaches towards leveraging virtual co-designing into the Health 2.0 era.

Appendix A. Recruitment Poster

The Sleep Solved study recruitment poster which was shared with schools and colleges.

Appendix B. Participant Information Sheet

What is the Sleep Well study?

- We want to see if new phone apps can help young people with sleep problems.
- Not sleeping well can make you feel worried or low, so we're going to check if these apps can help with these problems too.

Who can take part in the Sleep Well study?

- You can join if you're aged 14 to 18 years old and have a smartphone.
- Unfortunately, you can't join if you're getting help from a doctor for sleep or mental health problems (e.g. depression or anxiety). This is because you should stick to the advice you're getting from your doctor.

If you'd like to take part, please read the information below and fill in the forms at the end:

- If you are you are 14 or 15, please read this with your parent, carer or guardian.
- If you turn 16 while taking part in the study, you'll be asked to update one of the study forms to show you're happy to continue.

About the apps

1. Sleep Solved

Sleep Solved was co-created with young people and will give you science-based tips called "sleep hacks" to help you sleep better. These sleep hacks have helped other young people with their sleep.

Alongside this, you may also use an app called Phone Downtime. You tell it when you plan to sleep and wake up. This is only available for Android users.

2. Teen SHUTi (Sleep Healthy Using the Internet)

The SHUTi app has helped adults sleep better. We want to see if it can do the same for younger people.

3. Bite Back

Bite Back is a website with short sessions that has been shown to improve wellbeing in young people.

4. Project YES

Project YES is a website offering a choice of short sessions that have been shown to improve young people's mental health.

What do I need to do?

- Start by answering questions: You'll first answer some questions to tell us if you agree to taking part. Then you'll fill out a short survey about your sleep and wellbeing.
- Use Sleep Solved whenever you want to.
- After 6 weeks you may also be able to use SHUTI, Bite Back or Project YES. Which app (or apps) you are offered will depend on your needs.
- More quick surveys later: We'll ask you to do the short surveys again after 6 weeks, 6 months, and

1 year. This helps us see if anything has changed with your sleep or wellbeing.

Optional stuff:

- Chat with us: You can choose to talk one-on-one with someone from our team about how you sleep and what you think about the study. This chat would be online and could take up to an hour.

How we keep your information safe

For our study, we need to know a few things like your:

- name,
- contact details,
- date of birth,
- gender,
- ethnicity,
- postcode.

Who uses your information

- People in the research team will look at your information to make sure our study is done right.
- No one else will be able to see your name or how to contact you. We'll use a code number instead of your name.
- We will keep all information about you safe and secure.
- We would only need to speak to your school or college if you tell us something that makes us think your safety may be at risk, or that you may harm yourself or someone else.

After the study

When we're all done, we'll keep some of the data so we can double-check the results. But we'll write our reports in a way that no one will know that you were part of the study.

Your choices about how your information is used

You can leave the study any time you want, and there is no need to say why. We have to keep your records a certain way to make sure the study works. This means you can't see or change your information once we have it.

Want to know more about how we use your information?

- Ask someone from our research team
- Visit this website: www.hra.nhs.uk/information-about-patients/
- Email the University of Bristol Information team on research-governance@bristol.ac.uk
- To see how the University of Bristol handles your personal data, visit this website: http://www.bristol.ac.uk/secretary/data-protection/policy/research-participant-fair-processing-notice/

What happens if I change my mind about taking part?

It is your choice whether you take part or not. You can send us an email to say you want to leave the study at any time.

Are there any benefits if I join?

You'll get tips to sleep better. You might get to try SHUTi, Bite Back or Project YES to help with your sleep and wellbeing.

Are there any downsides if I join?

The only downside is the time it takes to complete the surveys, which takes about 5-10 minutes. Most people will be asked to complete the survey 4 times.

What do I do now?

If you are happy to join this study, please click ‘continue’ at the bottom of the page.

Who is funding this research?

The Prudence Trust: They fund studies about helping young people feel better.

Questions?

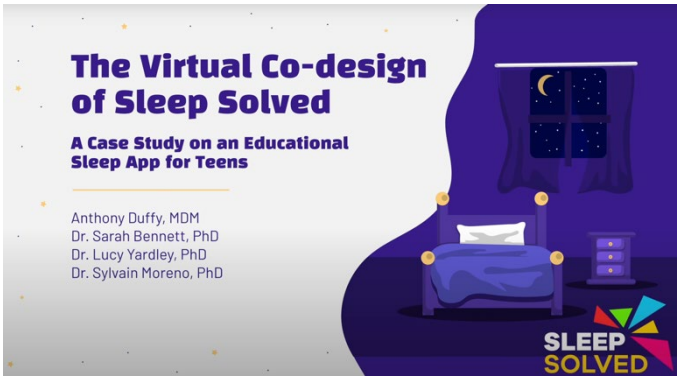
Talk to us via email: sttamp-study@bristol.ac.uk. We’ll get back to you as quickly as possible.

Appendix C. Teen Outreach Videos

Sleep Well Student Outreach Video: https://youtu.be/Jm3BtUo1Fo4?si=at4jutUxmyAJTC5L

Sleep Well Staff Walkthrough Video: https://youtu.be/Jm3BtUo1Fo4?si=KTBUJhcequTkwMzr

Appendix D. Video Walkthrough of Co-Design Process



Walkthrough video: https://youtu.be/DTLhyuhwQTQ?si=-iHZYFlUh5SjgIND

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