Designing Technology-Mediated Peer Support for Postgraduate Research Students at Risk of Loneliness and Isolation

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ABSTRACT

Student mental health and wellbeing have come under increased scrutiny in recent years. Postgraduate research (PGR) students are at risk of experiencing mental health concerns and this, with the often isolated

and competitive nature of their work, can impact their sense of community and social connectedness. In response to these concerns, we designed Pears, a system to connect PGR students for regular “pearings” (in-person meetings) and provides activities to promote reflection and conversation. A four-week evaluation of Pears with 15 students highlighted its potential to sometimes, but not always, facilitate peer support. Some participants would instead meet formally and according to their needs, others instead used the system to make new social connections. Additionally, some participants who faced work-related difficulties during the study found using the system contributed to their stress levels. We conclude by noting how technologies that encourage peer support can help build social relationships, providing an avenue to share similar PhD experiences and guidance for those new to the experience, while importantly raising awareness and an understanding for the need to take time for self-care. However, these technologies must be utilised carefully, and are not a replacement for other sources of student support in universities.

CCS CONCEPTS

•Human-centered computing~Human computer interaction (HCI)~Empirical studies in HCI

KEYWORDS

Peer Support, Loneliness, Postgraduate, Student, Isolation.

1 Introduction

Loneliness, while often transitory, can have serious effects on mental health. There is often an assumption that loneliness is a problem that mostly affects older adults, but there are a multitude of situations where people experience loneliness during the course of their lives. One population that is at risk of loneliness and social isolation are university students. Students can be affected by loneliness after moving to new cities or countries, which necessarily changes interactions with members of their social network [5], because of the anxieties brought on by social comparison with other students, particularly around popularity [102], and from the pressures of their university work [81,70,79]. One group of students that are affected by loneliness and social isolation, but are less attended to by research, are PhD (often referred to as postgraduate research, PGR) students. PGR students may face particular challenges and struggles which have been shown to have a significant impact on their mental health and wellbeing (e.g. [49,101]). For example, PGR students are sometimes seen as neither students nor professionals, making it hard for them to access specific resources; they are often expected to work alone, and often in competition with their peers; and they can struggle to balance work and personal life [26]. However, while there are over 100,000 PGR students just in the UK [35], recent reports have highlighted how poorly supported they are as a student and occupational group [56].

Prior HCI research has explored the ways technology may be designed to increase social connections and interactions, with a view to ameliorating feelings of loneliness and social isolation (e.g., [50]). However, much of this work focuses on other groups of individuals, in particular older adults, and leads to the development of support strategies that may not translate to other groups. Students going through a life transition, potentially moving away from their homes and existing support networks, present specific challenges that differ from those of other populations [97]. Previous work [76] has suggested that social and psychological interventions to reduce loneliness in university settings may improve mental health. In a netnography of strategies used for dealing with loneliness, Janta et al. [41] found that PGR students developed a range of coping mechanisms, such as face-to-face and online social interaction, professional development, and temporary escape from the doctorate, all of which universities could implement to decrease feelings of isolation in PGR students. However, while existing work such as this shows that students and PGRs specifically could benefit from targeted interventions and support, there is still very little work done in this space.

To address these issues, we present the design and evaluation of Pears, a physical-digital system that aims to facilitate peer support and social connectivity among PGR students. Pears comprises of a smartphone application and a physical paper-based journal, which links students together for regular "pearings" (in-person meetings between two students) and provides a set of activities to promote conversation and reflection on their studies, social activities, and PhD progress. We conducted an in the wild evaluation [78] of the system over 4 weeks with a group of 15 postgraduate students (who did not previously know each other), through which we gathered analytics from the Pears app, conducted pre- and post-study interviews, and completed a 6-month follow up with participants. Our analysis of gathered data highlights how Pears facilitated peer support, although this was not consistent throughout the study. We observe how PGR students adopted different styles of use of the systems depending on whether they were motivated to learn from the experiences of other participants, or seeking new social connections or emotional support. Our findings highlight the value of designing interventions that support PGR students in taking time out of their studies to meet and connect with their peers, while also problematising our assumptions that promoting peer support will necessarily ameliorate feelings of social isolation.

Through the design and evaluation of Pears we offer the following contributions to the field of human-computer interaction: (i) we build on prior work on the role of technology in addressing issues of loneliness and social isolation through highlighting the opportunities and challenges associated with deploying technology-mediated peer support systems to address issues of social connectivity; and (ii) from this we highlight recommendations for the design of systems seeking to address experiences of isolation, loneliness and associated mental health concerns in PGR students.

2 Background

2.1 Loneliness, social isolation, and university students

The literature on loneliness and social isolation is heterogeneous, and very often the two terms get used interchangeably. However, there are important differences between the two concepts. Loneliness can be defined as *"the unpleasant experience that occurs when a person's network of social relations is deficient in some important way, either quantitatively or qualitatively"* ([68] p.31). Social isolation, on the other hand, refers to an individual's lack of social contacts [99]. As such, loneliness necessitates a subjective and negative evaluation of the existing status of one's social network [103]. In England, an Office for National Statistics survey found that 5% of adults reported feeling lonely "often" or "always" [75]. While research into loneliness has existed for half a century, over the last decade there has been a growing body of work highlighting the links between experiencing loneliness and health outcomes. Feeling lonely can have significant impacts on an individual's mental health, with it being associated with depression [9], deliberate self-harm [80], and suicidal ideation [86]. But it is also increasingly related to poor physical health outcomes, such as high blood pressure [34], increased risk of stroke and heart disease [94], and increased mortality [39]. Indeed, perhaps unsurprisingly, people reporting loneliness also report poorer levels of sleep [54] and engage in unhealthy behaviours that may impact on their physical health further (like smoking cigarettes, and drinking large quantities of alcohol [45]).

Much of the research on loneliness and social isolation has, historically, being tied to the fields of gerontology and it has thus often been considered an issue primarily as people grow older. However, there is a growing recognition that loneliness occurs across the life-course and even relatively short spells of loneliness can have significant effects on people's mental and physical health. Indeed, it has been noted that between 3% [96] and 22% [72] of children and adolescents experience prolonged periods of loneliness. The period of time when young people move to university is one where there are specific risks of experiencing feelings of loneliness and an objective reduction in social contact [66,70]. It is a period of time that involves changes in many young peoples' responsibilities and roles [51,75], and significant changes in the nature of relationships with family and friends [36,79]. Starting at university often involves

moving to a new city, and the need to form new social bonds and connections. Recent reports have indicated up to 1-in-4 students report feeling lonely (22%) or always (4%) lonely [92]. Research on the impact of loneliness on students has noted how it impacts on both social adjustment and academic performance when arriving at university [100], and is an important factor in students dropping out of their courses [42]. There are also strong associations between reported loneliness and mental health problems among university students [55,76], which some believe is one of the factors in the increased demand on student support and wellbeing services at Universities [89].

Although many of these studies relate to undergraduate students, postgraduate students also go through a major life transition when starting their studies, often still moving to a new city or country, living in a different culture, and away from their existing support networks. However, PGR students face specific challenges compared to students at other levels. PGR students are generally older and this often goes with greater role-related demands that involve financial concerns (such as cost of living and lack of state-backed student loans [57]), family and caring commitments, pressures related to cultural differences (particularly for international students), balancing workload, and career uncertainty [56]. PGR students may struggle to adapt to a style of working where they must work more independently on their own project, typically in a more solitary manner [26]. The intensity of PGR study and the *"effortful mental work"* ([91] p.9) associated with studying towards a thesis could place PGRs at higher-risk of depression and of further isolating themselves from their peers and other forms of social support. Furthermore, student wellbeing and support services offered by universities are in high-demand and increasingly over-stretched [85], and many PGRs consider these primarily geared towards the needs of other student groups [101]. As a consequence, students who are struggling in their PGR experience may find it difficult to find support. Indeed, PGRs often fall into an ambiguous zone between students and staff in university systems, feeling that support for undergraduate students is not suited to them, but that they are ineligible for the support provided to university staff. As such, while there are growing numbers of PGR students [35], they have received very little attention in terms of the specific types of support that might benefit their mental health and successful completion of their studies. Some universities do offer peer support or mentoring programmes for PGR students, but the majority of studies of these programmes appear to focus on mentoring new PGR students within individual disciplines or departments, and most commonly focus on group-learning of academic-skills [46].

2.2 Loneliness and social technologies

An ongoing topic of enquiry is how social media and social networking platforms can provide ways for people to form new social connections and, potentially, ameliorate feelings of loneliness and isolation. For instance, studies of Facebook have highlighted how users reporting higher levels of loneliness are more likely to share personal information and overly emotional messages on the platform in order to engender support from others [6]. Studies of young adult users of Instagram highlight how they have a reduced tendency to report experiences of loneliness compared to users of other, predominantly text-based, platforms; something that Pittman and Reich [69] argue is due to the increased social presence and intimacy afforded by image-based social technologies. However, this literature confounds the notion that social technologies can make people feel more connected with the idea that they *de facto* increase social support. Significantly, in their study of Twitter, Kivran-Swaine et al. [43] highlighted how users utilised the platform to express and share feelings of loneliness, and that those who shared the most enduring experiences of loneliness were less likely to be responded to by other users; findings that were also echoed by Mahoney et al. [53]. As such, the literature on loneliness and technology use highlights how they pose a complicated relationship.

Nowland et al. [63] observe that there are two dominant perspectives on the role of technologies in relation to loneliness and social isolation. There are those that argue that technology use has the potential to lead to the displacement of "offline" relationships with new ones online, and with this technology places people at increased risk of loneliness [44,61]. The alternative view is that technology use, and specifically social

networking and social media platforms, can enhance existing relationships and stimulate new ones [33,93]. Going further into this body of literature, however, highlights how there are a multitude of factors that may influence whether technology use may increase or decrease feelings of loneliness. Nowland et al. [63], in their review of empirical studies on loneliness and social technology use, highlight how people that report high loneliness tend to approach the use of technologies in different ways, where they are more likely to use technologies to further displace offline relationships. Other studies report similar findings where pre-existing feelings of loneliness can lead to Internet over-use and addiction [7], and that people experiencing loneliness have a tendency to adopt platforms such as Facebook, rather than that use of the platform causes them to feel lonely [83]. Indeed, these arguments make sense when examined in relation to other studies that have highlighted how students reporting higher numbers of Facebook friends also reported higher levels of loneliness [82]; or that students who try to present inauthentic versions of themselves to attract new social ties on social media report higher levels of loneliness [88]; and studies amongst older adults that suggest that the use of social media to keep in contact with family and existing friends reduces social loneliness, but when used primarily to find new friends it can increase emotional loneliness [87].

2.3 Peer support, mental health and loneliness

Peer support, where individuals use their lived experiences to help one another, has risen to attention in recent years as an important means to help individuals living with mental health conditions, partly in response to the large gap between demand and supply for mental health care services [17]. This gap can be acutely witnessed in universities, in part resulting from the rise in student numbers without a corresponding increase in mental health support, leading many students to turn towards other means of support such as mental health apps [85,28,84]. Subsequently, there has been a big push on involvement of peers in mental health service design and delivery.

Several projects have explored the potential for peer support to support mental health. O'Leary et al. [64] highlight the potential for peer support systems to reduce the burden on professional services, but ruminate the importance of appropriately matching peers, not only by their diagnosis or condition, but also their feelings, beliefs, needs, and of providing support at the correct moment. They also highlighted the potential risks and ethical concerns when professionals are less involved in support, and the importance of mitigating these with strategies such as with tools to detect potentially harmful activities, or providing training to peers to allow them to better support others. By turning towards online interventions, there is the added benefit of anonymity when sharing personal information concerning mental health or loneliness. Park's study on mental health management practice on college campus [67] noted that those who use online services, in part, chose to do so as they are able to be anonymous, and therefore feel less judged about their mental health issues. This is supported by Choudhury and De [12], who report that the anonymity afforded by sites such as Reddit leads to significant amounts of self-disclosure concerning mental health issues, in comparison to Facebook where users are required to provide more personal details. This highlights the importance of peer support groups being a safe space for people to share, especially when they may be discussing sensitive topics such as loneliness or mental health. Moving beyond virtual platforms alone, Ma et al. [52] presented 5 ideas created by designers to support graduate student mental health, including hybrid physical-digital systems, bringing together a digital space for students to share issues and a tangible item box for providing feedback to the user. This paper explores further uses of hybrid physical-digital systems.

While it is rare that addressing loneliness is the explicit motivator for the involvement of peer support, it is very often an important factor driving people to seek the support of peers, and can be significantly reduced through participating in peer support processes. Both strong-tie relationships, such as family or close friendships; and weak-tie relationships, such as colleagues; can be useful in addressing these challenges, in many cases weak-tie relationships a can have a significant positive impact and may provide a different perspective to stronger connections [32]. In the context of student mental health, peer support might offer an important route to connecting students together and potentially providing optimally matched [16] social

support for the challenges faced during their PGR journey. Peer pairing initiatives such as “buddying” schemes are relatively commonplace and have demonstrated to benefit integration of new students and staff from different backgrounds into schools [10], universities [73], and workplaces [62]. These initiatives have potential, especially when focused on the formation of in-person, rather than just online, support [40,3]. This does not mean, however, that online support does not have benefits. By introducing online peer support there can be an increase in accessibility for those who have poor mental health [65].

While designing for technology-mediated peer support is an important issue in mental health service design, it is arguably still significantly understudied, particularly when considering certain groups. Moreover, there is scope to further explore how systems that promote both peer support and help reduce loneliness, while supporting good mental health, can be designed.

3 Research design

Building on the above work, in our research we were interested in the ways digital technology might be utilised to address loneliness and social isolation amongst PGR students, considering the specific factors and needs of this diverse group. The resulting system we designed - Pears (a play on the word “pairs”) - comprises of a mobile application and paper-based journal, which links participants together for regular “pearings” (in-person meetings between two participants) and provides a set of activities for participants to share with one another through the app, to promote student conversation and reflection on their studies, social activities, and PhD progress. In the following sections, we provide an overview of our initial research activities, including the design workshops which inspired the design of Pears. We then provide an overview of participant recruitment and the procedure of the study through which Pears was evaluated over a 4-week period with 15 PGRs in a university in North East England. The study received ethical approval from the Ministry of Defense Research Ethics Committee (MoDREC) and we received informed consent from all participants. At the end of the study participants were provided with a debriefing sheet which provided contact details for a range of mental health support services.

3.1 Designing Pears

The Pears system was created as part of a large multidisciplinary project exploring loneliness and social connectivity for various communities and populations, one of which was university students. Our specific work on Pears builds on prior qualitative work (reported already in [97]) where interviews were conducted with students at different levels of study and with diverse circumstances (i.e., undergraduate, postgraduate, international, home, local). These interviews explored their transitions to university and their subjective experiences of feeling socially isolated and (dis)connected from family, friends, peers, and more. A key finding from this initial work was that there are specific factors related to the PGR student experience that might make them especially at risk of feeling isolated from others. This included working independently for extended periods of time, often being based in hot-desking spaces on campuses and not having a clear workplace identity or coherent community of other students to bond with, working at times of the year when campuses would be quieter with no undergraduate students and fewer faculty members and a multitude of other life commitments such as caring responsibilities. Furthermore, this initial work started to highlight how PGR students often had unclear identities within their institutions, sitting between undergraduate and other postgraduate students, and research and other academic staff. This often-meant support services available to staff or other students may not be perceived to be appropriate for them.

Building on this, we ran a series of design workshops with PGR students to explore some of these issues in more detail, and to identify ways digital interventions might respond to these in appropriate ways. While in this paper we focus on the findings of the Pears system that was created after these workshops, in the following sections we provide an overview of the workshops themselves. These workshops provided us with further insights into PGR student experiences and while findings from them were not intended to

provide specific design requirements, they did help to inspire and inform key decisions in the design of Pears.

3.1.1 Design workshops with PGR students

We recruited 24 PGR students from a university based in central England. While all of the students came from the same institution, they represented great diversity in terms of their disciplinary background and the subjects they studied (8 from science and engineering subjects, 3 from arts and creative disciplines, 7 from social science, 2 from life sciences and 4 from humanities). Most of the participants had entered their PhD studies directly from a Master's or other degree – however, we did have 2 participants who classed themselves as mature students and were conducting their PhDs after working in industry for several decades. 13 participants identified as female, and 11 as male. For the workshops participants were split into three groups (based primarily on availability) and invited to participate in a set of two workshops per group.

The overall design of the workshops was guided by those used successfully in work exploring issues of social isolation with other populations (e.g. [50]), and balanced activities that supported participants in considering and sharing their personal experiences with activities that promoted group creativity and reflection on insights coming from the discussions in the workshops.

In the first set of workshops, we focused on activities that enabled the students to start talking to each other about their experiences of isolation, belonging and connectivity with others. The workshops started with a "year in the life of" activity where participants were paired together and interviewed each other about their journey thus far as a PGR student, discussing highlights, lowlights and events related to their studies over the prior 12 months. After completing a visual timeline that represented the last year, we asked the participants to reflect further on this timeline by drawing line graphs over the top of them to represent feelings of (dis)connection, isolation, belonging, enjoyment and frustration in relation to key events. After working in pairs for this activity, each pair then quickly shared their timelines with other participants in the workshop. While a simple activity, this prompted participants to start reflecting together on commonalities in their experiences despite the great diversity in the subject of their studies. It also helped them to identify temporal rhythms in relation to isolation – such as during holiday periods when the campus is much quieter, around key deadlines when interaction with others reduces, and when first starting their studies when it is hard to meet other PGR students. After sharing their timelines, the participants worked in pairs again and were asked to identify a lowlight from their timelines to act as a starting point for a design activity. In this activity we asked participants to create a 'magic machine' [2]. Following [2], this activity asked participants to imagine they had been transported from the future and had brought with them a device that enabled a present-day PGR student to navigate the lowlight. As in [2], we stressed to participants that in this activity technology is a "magical unknown" and to focus on the material making and the experience rather than technical feasibility. Participants were given a range of materials to assemble their machines (e.g., cardboard, wire, stickers, various paper and card shapes). After developing their magic machines in pairs, participants were asked to create a short storyboard to capture how the machine might be used and experienced in practice. This was followed by a short role-play demonstration of the machine to the rest of the group in the workshop.

Between the two workshops, students were asked to complete a cultural probe [29] activity, for which we provided them with cameras to take photographs in response to approximately 20 pre-defined prompts. The prompts for the probes were intended to promote further reflection on the students' home and work lives, and to explore issues of solitude and isolation from others, as well as experiences of belonging and connectivity. The cameras were returned to the research team prior to the second workshop for processing. The second workshops started with participants working in different pairs to review the cultural probe returns, and to then identify overlaps between the images captured in relation to specific prompts. This

involved participants clustering photographs together based on their content, and producing simple affinity diagrams to explore relationships across the probe returns and the discussions from the first workshops. These activities enabled the students to reflect further on their experiences, and to articulate explicit links between ideas they had generated and the places, people, and activities they conduct in their home and work lives as PGR students. The second workshop ended with the project team presenting a university brochure that comprised of a series of 'questionable concepts' [98]. Questionable concepts are visual illustrations and short textual description of fictional designs that respond to themes and issues identified in prior fieldwork and data collection. As noted in [96], they can be valuable in stimulating feedback from participants about design concepts, and to provoke critical discussions of the ways digital interventions may (and may not) address issues identified through the course of the research. Based on insights across the first workshops and the magic machines participants had created, we developed four concepts. These concepts looked at ways of buddying students together, to help them find similar PGR students at the university, to provide automated advice and support to lonely students, and to promote empathy between students. These concepts were then collated in a 'welcome' brochure for new PGR students for a fictional university, which was printed and handed out at the workshop. In the workshop, participants took time to read and review the brochure, and then discussed the merits and problems of each concept in turn.

3.1.2 Findings from design workshops

The workshops generated a large amount of material for the research team to analyse. Each workshop was audio recorded (approx. 700 minutes in total) which were transcribed. However, the workshops also had additional data in the form of the visual timelines, photos of magic machines and storyboards, probe photographs, and affinity diagrams. To analyse this data, the multidisciplinary team on the project came together for a series of further synthesis and design meetings, where excerpts of the data gathered from the workshops were iteratively grouped together around themes.

We observed four key themes across all the data. First, there was a concern with social connectivity *between* PGRs, especially to discuss PGR matters. Many of the PGR students taking part in our workshops did not belong to large research groups or PhD training programmes, and thus had limited opportunity to meet other PhD students with whom to talk about their studies. This was compounded by many of the participants feeling great pressure to make progress with their studies, meaning finding opportunities to connect with other students was rarely prioritised over, for example, completing a report, meeting with supervisors, collecting or analysing data, drafting thesis content, etc.

Second, and related to the latter point, it was clear that meeting with a peer could offer many points of connection around the challenges, emotional dimensions and practical requirements of completing a PhD. However, the students also expressed concerns about their own knowledge and skills. They often felt uncomfortable in helping other students, feeling they were not experienced enough, or that they were studying in a very different domain with different expectations around what a PhD is. Perhaps as a result of this they were also reluctant to reach out to others for support, feeling they needed to find answers to problems they were facing for themselves. Yet the activities used in our workshops (especially the initial activities where students worked in pairs) demonstrated how PGR students from a very different disciplinary background have knowledge and insight that are useful to each other, and also showed the students how many problems experienced during the PhD are common regardless of subject area. This was surprising to some of the participating students themselves, some of whom were surprised at the start of the workshops that we had brought such a diverse group together, remarking that we'd need disciplinary specific groups to be useful to PhD students.

Third, many of the PGRs expressed concerns around technology contributing feelings of isolation from others. Some lamented how technology had increased opportunities for them to work remotely and from home, yet this had meant they could go days or even weeks without seeing another person (note this work was conducted prior to the Covid-19 pandemic, since when this is even more commonplace). However, the

incentives for coming into campus were often limited. Many of the students worked in hot-desking spaces, which left them feeling like they lacked a "place" of their own on campus. This also meant, perhaps ironically, that fewer PGR students came onto campus in the first place. As such, those that did come on campus to socialise would often find there would be very few others to interact with.

Finally, the data demonstrated the value of many of the activities used in the workshops in supporting reflection from participants on their PhD experiences, and in expressing these to other students. This was especially true for timeline, line graph and probe activities, where participants remarked how such "simple tasks" (as one participant referred to them) required careful consideration and also enabled them to compare their own experiences, assumptions and perceptions to other students. At the end of the workshops, several of the participants reported how they were surprised with how playful or creative the activities were for what they thought may be a very serious and potentially dry subject matter. Because of this, we considered it important to ensure the design work for the next stage of the project built on this learning by scaffolding reflection through simple reflective activities that could be shared with others.

3.2 Pears

The design of Pears was inspired by the core issues raised in the design workshops. Pears comprises of a smartphone *application (app)* and a paper-based *workbook*, the latter containing a user guide, blank agenda pages, and 16 guided activities for participants to complete throughout a 4-week deployment. Primarily, Pears encouraged participants to do two things: (i) to meet with other participants in meetings that were automatically scheduled by the app three times each week; and (ii) to complete guided activities in the workbook, which they would then document and share with other participants via the app. We explain the system in more detail in the following sections.

3.2.1 The Pears App

The Pears app is the central part of the system. The app provides participants with: details of their scheduled meetings (such as time and place), along with push notifications reminders (Figure 1a); a visualisation of their network of social connections (Figure 1b); functionality allowing them to message those they have already met or have a meeting scheduled with (Figure 1c); tools allowing them to photograph and share their paper-based activities from the workbook (Figure 1d).

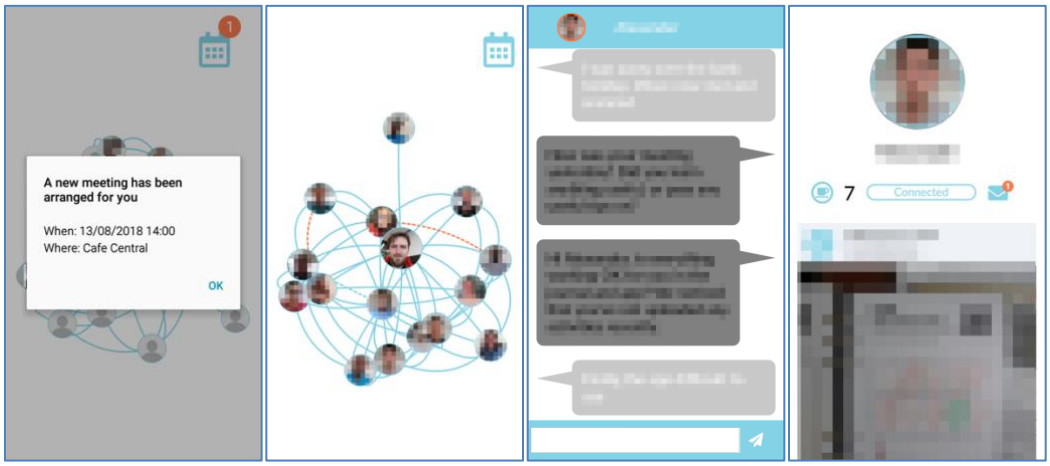

Fig. 1. From left to right: (a) the notification that participants receive for a scheduled meeting; (b) the "social network" display, showing the signed-in user and those they have connected to; (c) the application's built-in messaging system; and, (d) a participant's profile, as seen by another participant.

As noted, one of the purposes of the system was to encourage face to face meetings between pairs (or "pears") of participants, which were automatically scheduled by the app 3 times each week: on Mondays,

Wednesdays, and Fridays. Our initial research highlighted how many PGR students lacked social connections with other students and prioritised their university studies above meeting others. However, those who took part in the design workshops found that sharing the challenges of completing a PhD while working in pairs to complete reflective activities and discuss their experiences provided numerous benefits – something we hoped to replicate by facilitating students meeting in pairs within the Pears system. Many students in the design workshops also highlighted how technology had enabled them to work away from campus, compounding their relative isolation – an ongoing challenge made more difficult by many students not having a fixed working space on campus. By scheduling frequent face-to-face meetings each week, and thus encouraging participants to come onto campus more regularly, we hoped that Pears would create opportunities for students to be more socially connected.

Whereas some peer support systems (e.g., O'Leary et al. [65]) directly facilitate multiple meetings between pairs of participants, presumably in attempts to foster closer relationships, Pears was instead designed to facilitate weak-tie relationships and scheduled each pair of participants to meet only once. This approach was adopted after we observed students in the design workshops, who were previously reluctant to request help, engage in peer-support soon after interacting with others with whom they had not formed strong bonds. Furthermore, by facilitating a broader network of social connections through weak-tie relationships, we also maximise the number of unique meetings and opportunities to generate new relationships within the 4-week study period. Following their initial meeting, participants were able to use the built-in messaging system (or otherwise exchange contact details) to arrange further meetings, if they wished.

The app provides no guidance for discussions in the meetings, but all participants were scheduled to meet in pairs so they could more easily meet and discuss their completed workbook activities (see next section), which we suggested participants might wish to use as discussion prompts. This was similar to Fleck et al. (2020), where pairs of PGR students were brought together to jointly make sense of, and learn from, their individual tracked productivity data [26]. Motivated by findings from the design workshops where PGR students from diverse backgrounds and disciplines were pleasantly surprised to find they had more knowledge and insights in common than they had expected, scheduled meetings between participants were randomly assigned, without any additional matching taking place. Furthermore this approach seemed appropriate as our sample was already from a fairly specific population, all being self-selected full-time PGR students, working on the main campus of a single University.

Prior to each scheduled meeting the participant would receive a notification informing them of who to meet (or "pear" with) and where (in 1 of 4 predefined public locations on the university campus). This was intended to limit the burden on participants and relieve them from having to exchange messages to decide a time and date for each meeting. Participants would then attend the meeting in person, confirming to the system they had met each other by using the Pears app to scan a near-field communication (NFC) tag in the other participant's workbook.

When participants open the app for the first time, they are asked to complete a simple profile, with their name and a profile picture. After this, the app home screen presents participants with a network diagram. Upon first use, this diagram is empty, with just that individual participant's icon in the centre. Through use of Pears, this diagram develops with links to other participants appearing, with the different coloured lines denoting different statuses of the connections between participants (Figure 1a). A *solid blue line* represents a connection where both parties have scanned each other's NFC tags, denoting that they had an in-person meeting together. A *blue dotted line* instead represents a connection between two people where only one has scanned the NFC tag. An *orange dotted line* indicates a connection where a meeting has been scheduled but has not yet occurred. It was important to ensure that upcoming scheduled meetings would stand out in the network (using orange) as a way of emphasising to participants who they would be meeting next, and what common connections the two potentially had. Moreover, the blue lines served as a visual cue for participants to remember to scan each other's tags when meeting, in order to change from an orange

line to a blue dotted line when the first participant scanned in, and then a solid blue line when the second participant also scanned in. In order for a participant to appear permanently in someone's network diagram, they would have to scan each other's NFC tags to have confirmed an in-person meeting had taken place. If participants failed to meet (and scan each-other's NFC tag) by midnight the day following their scheduled meeting, they would disappear from each-others' network diagram and would no longer be able to view each other's content or message each other. Otherwise, if participants did meet, they were free to message each other for the remainder of the study, to allow them to continue contact or meet one another if they chose to. This was an intentional design decision to ensure that participants kept regularly meeting face to face, as this was the focus of our system. The visualisation of their growing network was intended to serve as an encouragement to continue to engage with the app over time and provide evidence of links participants made with other peers.

Through their network diagram, participants were also able to click on each connection and view others' profiles (Figure 1c). As well as the basic information (photo and name), profiles were populated over time with a feed of the activities that participants had shared, and a summary of how many 'pearings' in total they had attended. Each profile also gave the option to message that particular participant. Beyond facilitating messaging, the core role of the individual profile pages was to allow other participants to view any completed and shared reflective activities (explained below), which gave participants an opportunity to familiarise themselves with new connections before a meeting, offer discussion points, as well as allow comparisons of similarities and differences in experiences and stages of their PhD studies.

3.2.2 The Pears Workbook

Along with the smartphone, each participant was also given a workbook – an A5 folder containing a user guide for the Pears system, contact details for the research team, and a weekly journal with guided activities to cover the 4-week study period. The guided activities were designed to promote reflection and provide participants with experiences to share and topics to discuss, both through the app and during meetings. The NFC tag that allowed participants to connect with one another in-person when they met was attached into the inside cover of the folder, which also meant that participants always had their completed activities close to hand for face-to-face meetings. We also included a plastic wallet in the back of each folder, which contained 10 coloured felt-tip pens for completing the activities, and where participants were also able to safely store the study smartphone (see Figure 2).

Fig. 2. Two images showing the contents of the Pears "study pack", including: The Pears Workbook (with NFC tag visible in top-left corner), a zipped wallet containing coloured pens for participants to complete the workbook activities, the Samsung J3 smartphone and charger.

The workbook is organised by week. Each week section started with a double-page spread which invited participants to make a note of their plans for the week (Figure 3). This was followed by pages providing 4 guided activities for participants to complete between Tuesday and Friday each week. For the purposes of our study, which was conducted over a 4-week period, this resulted in a total of 16 activities that could be completed and shared with others through the app (see Table 1). The workbook and activities were guided

by the initial design workshops, where we found that PGR students not only sought support around practical issues of completing their PhDs, but also the emotional challenges that came alongside. The design workshops themselves included reflective activities that were intended to elicit responses from participants to aid us in better understanding their experiences, but alongside we found that participants strongly valued these activities – particularly where they supported reflection and sensemaking of their PhD experiences. Inspired by this, we designed Pears to include a similar set of activities for participants to complete, and then share and compare with others. The activities themselves were designed to encourage participants to reflect on their PhD experience, their working practices, their progress, and their research. In turn, participants were encouraged to digitize and share these activities through the app, allowing other participants to view their completed activities. In creating the activities, we were heavily inspired by the activities in the initial design workshops that participants reported valuing, along with wellbeing journaling tools developed by mental health charities and support organisations (e.g., [58]) that aim to promote a combination of personal reflection, relaxation, and future planning. Activities were intentionally kept ambiguous and flexible, to allow participants at different stages of their PGR journey to creatively appropriate them to their own needs. Our hope was to replicate the success that participants experienced during the workshop, into a hybrid online-offline experience through the Pears app and meetings. The activities were piloted with a small number of PGR students who were not part of the study and their feedback was integrated into their design to make them more valuable for participants, and the instructions easier to understand.

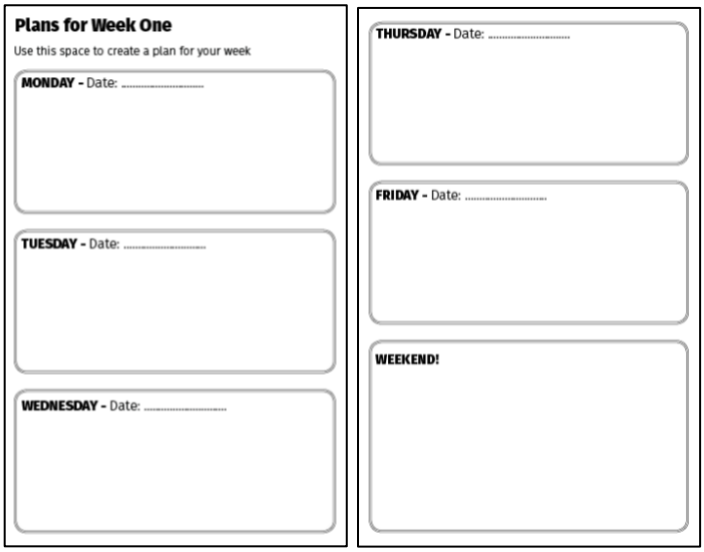

Fig. 3 Example of the double-spread journal provided for participants in the workbook each week

The activities in the workbook were divided into four broad types: *"for sharing"*, a set of activities designed so that when uploaded would give insight into the current status of their PGR studies; *"for you"*, a set of activities to facilitate reflection on a more personal and individual level; *"to participate in"*, a set of more playful activities designed to share habits or advice with other participants; and finally, *"for reflecting on"*, which encouraged participants to take some time to reflect on their previous week's emotions and activities. We present an overview of these activities in Table 1, a selection of completed activities in Figure 4, and have included a copy of the participant workbook in the supplementary materials.

		Journal	Activity Type	Guided activity
Week 1	Monday	Plans for week 1		
	Tuesday		For sharing	Thesis progress so far
	Wednesday		For you	PhD libs
	Thursday		To participate	Map your campus
	Friday		For reflecting	How are you doing?
Week 2	Monday	Plans for week 2		
	Tuesday		For sharing	Annotate your day
	Wednesday		For you	What's been exciting?
	Thursday		To participate	Help a fellow out
	Friday		For reflecting	How are you feeling?
Week 3	Monday	Plans for week 3		
	Tuesday		For sharing	What's the scoop?
	Wednesday		For you	How's your day going?
	Thursday		To participate	Doodle your research
	Friday		For reflecting	Task colour grid
Week 4	Monday	Plans for week 4		
	Tuesday		For sharing	What's been noted?
	Wednesday		For you	Who have you seen?
	Thursday		To participate	Top 10 research playlist
	Friday		For reflecting	Productivity bar chart

Table 1 Overview of the journal and guided activities included in the workbook

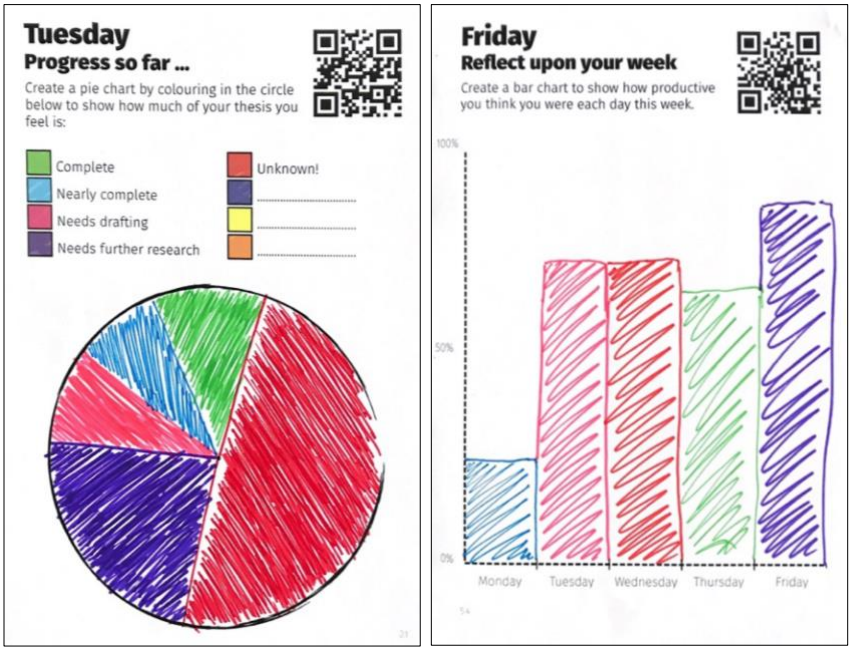

Fig. 4. Figure showing examples of the guided activities included in the Pears workbook, as completed by participants.

While we intended the activities themselves to present a valuable opportunity for participants to reflect on their own studies, we also saw the completed activities as being a potentially useful resource for peer support and discussion with other participants through messaging and during face-to-face meetings,

replicating the fruitful conversations participants in our design workshops had with one another. We also hoped that through sharing, participants would learn from each other and normalise some of the challenges and working practices that they may have been unaware they were sharing with others, similarly to Fleck et al. (2020) who brought pairs of PGR students together to make sense of their tracked data [26]. To facilitate this, the documentation and sharing of completed activities was completed through the app: after scanning the NFC tag in their own workbook, the app would prompt the participant to scan the unique QR code located at the top of each activity page, which in turn opened the camera to allow participants to photograph the completed activity. Once saved on the device, this would appear on their Pears profile for themselves and their connected network to view (as a means of support, helpful comparison, and insight into the activities of other PGRs).

3.3 Participants

In total, we recruited 15 participants to take part in the evaluation of Pears. Participants were recruited through emails sent to departmental mailing lists and the PGR society, posters displayed on notice boards around the host university, and through word of mouth. These recruitment materials called for PGR students to take part in *"a four-week study looking into the experience of social isolation while completing studies"*; and invited potential participants to view an online information sheet and complete a recruitment survey which collected demographic data; and allowed us to ascertain their eligibility to take part. To be eligible, we required that participants were regularly situated on the main university campus (rather than on remote campus locations), and could commit to attending meetings three times each week during the study period. Additionally, we asked potential participants two sensitising and contextual questions about their student experience, which were not used for participant selection, but helped us better understand the challenges that individual participants may have experienced: *"During your PGR experience, have you found it difficult to find connections with other students and peers in the university?";* and *"On a scale of 1-5 How well do you feel you have integrated with other PGR students in your cohort?".* Participants were compensated with up to £60 (approx. $75USD) in shopping vouchers for taking part in the study: £20 for attending the opening interview; £20 for participating in the trial itself; and finally, £20 for attending the closing interview and returning the study materials.

In total, 49 unique potential participants completed the recruitment survey, 12 of whom were not eligible to take part because of their availability over the study period. Aiming for a diverse sample of students, our eventual sample included 15 participants (9 female and 6 male), aged between 24-70 (average: 31), from various departments and faculties in the university, and at different stages of their PhD (from those in their first month of study, to those in an extension-period). Our sample also included both domestic (n=3) and international (n=12) students, and those who had lived or studied in the university city before (n=6) and had not (n=9). Participants had various living arrangements, though the majority lived alone or with a partner, and not with other students. All participants in our sample were studying full-time, which was not a prerequisite for taking part, but likely due to the commitment required for the study.

3.4 Procedure

We conducted our evaluation of Pears over 4-weeks in the summer of 2018 – a quieter period for the university where fewer social events were offered and some facilities were unavailable. All participants took part in the study over the same timeframe and were first asked to take part in an on-boarding interview. We scheduled onboarding interviews at our participant's convenience, during the week before the start of the trial. First, we asked participants to read the information sheet and complete the consent form, giving them an opportunity to ask any questions they might have. We then asked participants general questions to help us better understand their PGR experience, such as: *"What motivated you to do a PhD?"; "Tell us about your research"*; and, *"Tell us about your working space"*. Along with this, we asked participants what motivated them to sign-up to the study and what, if anything, they hoped to gain from taking part. We then introduced the Pears system to participants. So that participants did not need to use

their own phone and data connection, we supplied them with a Samsung J3 Android smartphone, complete with a SIM card and the app installed. We demonstrated the app by asking them to upload an example activity to their own profile and connect with the lead-researchers account, which also allowed us to send participants ESM (experience sampling method) messages through the app after each scheduled meeting. Finally, we provided participants with their study pack and a £20 shopping voucher for taking part in the first interview. These interviews were audio recorded for later transcription and lasted on average 38 minutes.

The evaluation of the system began the following Monday, once the participants had received their study pack (three participants started later than this, because of scheduling difficulties, thus resulting in fewer scheduled meetings). During the study, the procedure for meetings facilitated via Pears was as follows: each participant had up to 3 meetings scheduled each week, on Monday, Wednesday and Friday (except for one Monday which fell on a public holiday and most of the campus was closed, where meetings were instead scheduled for the Tuesday); meetings were scheduled for either 11am, or 1pm; meetings were suggested to take place in university-owned cafés, or eateries, across the campus to help ensure that participants were meeting in a safe public space; each meeting was scheduled between two unique participants (i.e. those who had not previously met with one another through the system), so that each participant would have the opportunity to meet as many other participants as possible; finally, participants received notifications for these meetings between 3 and 12 hours before they were scheduled to take place. Some participants told us in advance that they would be unable to attend certain meetings; for example, because they had teaching responsibilities on particular days or had annual leave booked. In these cases, we ensured these participants were not scheduled to meet. This resulted in a total of 78 scheduled meetings.

Throughout the course of the trial, following each scheduled meeting, the Pears app was used to push messages to participants and ask questions based on their actions in the study. For example, after a completed meeting we might have asked a participant *"what did you discuss in the meeting?"*, or if a meeting did not happen, we might have instead asked *"we noticed today's meeting didn't take place, what happened?"*. The decision to follow-up each meeting with a message was intended to be akin to an ESM approach [15,14], which aimed to provide a better understanding of our participants' experience of the study over time, and allowed us to use these responses as prompts in the final interview.

Finally, once the study was complete, we scheduled closing interviews with each participant. Before each of these interviews, we compiled and analysed each participant's responses to our messages and the activities they had uploaded to their profiles. This allowed us to have a better understanding of their experience in the study, as well as clarify any particular points or experiences. Beyond contextualising and clarifying the data we had already collected, our questioning in these meetings focused on understanding their use and experience of the various components of the study: the workbook and activities; the meetings and conversations; and the app itself. We also asked participants about any suggestions they had to improve the system; and any difficulties or challenges they had faced during the study, and the role that Pears had played in these. As before, these interviews were audio recorded for transcription and lasted an average of 46 minutes. At the end of the interview, we provided all participants with a list of resources should they have wished to seek support for any difficulties the study had raised. These included pointers towards student support offered by the institute, as well as more general mental health resources including Nightline, Samaritans, and Supportline. Finally, we provided participants with their end of study £40 shopping vouchers (approx. $50 USD).

Finally, to better understand longer-term outcomes of using the system, 6-months after their completion of the study we emailed participants with follow-up questions. In particular, we asked questions including: *Have you kept in touch with any of the other participants who you met through the study?*; *As a result of your participation in the study have you continued journaling in a different format, or replicated any of the*

activities from the journal?; *Is there anything else you would like to add?*. Seven participants responded to this email, for which no further incentive was provided.

3.5 Analysis

We collected various qualitative and quantitative data throughout the study, all of which was collated for analysis and allowed us to build an understanding of each participant's background, working environment, engagement with Pears, and other outcomes from use. These data included: responses to the recruitment survey; fully transcribed pre- and post-interviews; participant responses to our ESM messages; messages sent between participants in the study; telemetry and usage data, such as the number of meetings and the time of these meetings (if they were delayed or not); completed workbook activities; and follow-up responses.

All qualitative data were entered in Atlas.ti and analysed thematically, following Braun and Clarke's [8] iterative process. To this end, after the first interview and during the trial period, a single document was prepared for each participant, which included the first interview transcript, activities uploaded, ESM messages, and usage data. This was done by two researchers to uncover expectations, experiences, and challenges that could inform the final interview questions and analysis. Once the final interviews had been completed and transcribed, these were open coded and an affinity diagram was produced to construct and iterate higher level themes, also in relation to the initial data collected. Quantitative usage data was used to further contextualise participants' responses and aid our analysis throughout. This ultimately led us to uncover main challenges PGR students face in relation to loneliness and social isolation, styles of interaction with the app, and the benefits and hindrances that come as a result of taking part in activities and meetings.

In the following sections, we present usage data, case studies, and themes from our analysis. Due to concerns around the identifiability of our participants, some quotes have been edited for anonymity. Where this was not practical, quotes have been substituted with a *rich data description* [30] of the participant's response, which are a way of presenting the multifaceted complexities of participants' situated experiences in order to engage the reader.

4 Findings

Before using Pears, our participants reported experiencing challenges making connections with others in both their working and personal lives since starting their PGR studies. Many felt poorly integrated within their research groups and distant from their supervision team, and had few friends and social connections in their university city. This was true both for those new to the city and those who had previously lived or studied there. Beyond social isolation, our participants also experienced challenges in their working lives, particularly around their work-life balance and reported feeling guilty when they engaged in non-work-related activities. Generally, participants responded positively to use of Pears, appreciating meeting other participants and expressing benefits from reflecting and sharing their working practices. In the following sections we examine these in depth. We begin by providing an overview of participant engagement with Pears over the course of the study. We then go into more detail, drawing out two distinct styles of using Pears adopted by participants during the study, followed by discussing the themes developed from our analysis related to the value of the guided workbook activities and challenges associated with in-person meetings with peers.

4.1 Engagement with Pears over the Study Period

Participant engagement with Pears during the study was overall positive. Each participant was provided with 16 workbook activities (4 per week) they could complete and share using the app during the study, resulting in a potential total of 240 activities from our 15 participants over the 4-week study. Participants

completed a total of 198 of these activities (participant average 13, SD 3.4, overall 83%), 5 participants completed all 16 activities and 4 completed fewer than 10. Participants' engagement with these activities decreased over time: participants completed 97% (58 of 60 possible activities) of the guided activities in week 1 (activities 1-4), decreasing to just 63% (38 of 60 possible activities) of those in week 4 (activities 13-16 - see Figure 5). We further explore participants engagement with these activities in section 4.3.

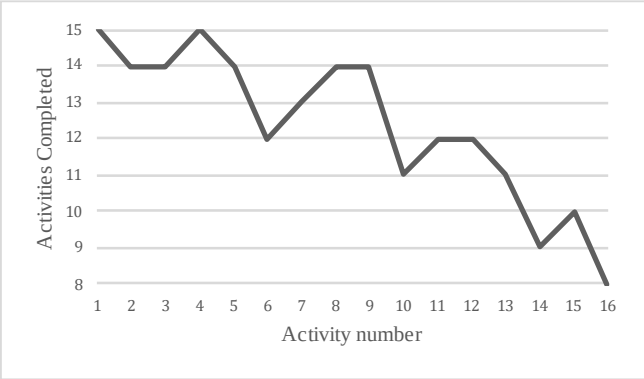

Fig. 5 Total number of guided activities completed over time

Meetings between participants were normally scheduled on Mondays, Wednesdays and Fridays over the 4-week study, which resulted in a total of 78 scheduled meetings, 44 (56%) of which were attended by both participants. In contrast to the completion of journal activities, the number of these scheduled meetings that were attended by both participants increased over time: just 50% of the meetings were attended by both participants in week 1, raising to 62% in week 4 with 100% of scheduled meetings completed on the final day of the study. Participants were not offered any additional encouragement to attend the scheduled meetings throughout the study, instead this rise in engagement was because many participants reported appreciating these meetings more as the study progressed, as we further discuss in section 4.4. Meetings scheduled on Mondays were generally least well-attended, with an average of just 25% of these meetings taking place, compared to an overall average of 56%. Our participants indicated that this was due to scheduling difficulties, often because most did not work at weekends and had decided their plans for Mondays either the previous week, or further in advance. On average, each participant met with 5.9 other participants (MIN: 0, MAX: 10, SD: 2.2). One participant did not meet any other participants during the study, although she was engaged with other aspects of the system and attempted to take part in 2 meetings where the other participant did not attend. Participants reported that most meetings lasted 40-50 minutes, though some were reported as being shorter (as little as 5-minutes) and some were much longer (up to 2-hours). Participants' conversations in these meetings were varied and are discussed at length throughout the remainder of the paper.

4.2 Student challenges and Pears use styles

From our analysis of participant's engagements with the Pears system, we identified two distinct styles of use of Pears: 1) most participants used Pears as a way of gaining peer support and assisting with academic-life related challenges; 2) others, who already had support-networks amongst their colleagues, instead saw Pears as a tool to gain social connections, particularly for non-academic activities. Understandably these use styles reflected the challenges that participants faced in their day-to-day lives, but because these two uses were not always congruous with one another this sometimes resulted in clashes between participants with different motivations. We present these styles of use below, using examples from across our study and two in-depth case studies, to illustrate the breadth of use of the Pears system and the range of PGR experiences and challenges faced during the study. Following this, we will more closely examine our participants' use of specific functionalities in the system.

4.2.1 Style 1 – seeking peer support

One challenge participants commonly faced was related to solitary working, without any kind of support network beyond their academic supervisors. Many of those who had faced these challenges attempted to use Pears to connect with their peers, reflect on their research and working practices, seek practical advice, and make new professional connections across the university.

Before using the system, these participants felt they were poorly integrated with their cohort, or could not identify as being part of a cohort at all. Almost every participant who faced this issue reported that they did not have a fixed working space, but instead worked flexibly between shared "hot desking" departmental or faculty-level working spaces, in the library, or from home. Participants explained these working environments were not conducive to making connections and realising peer support. For example, P15 who had recently moved from working at a large departmental hotdesking room, to a fixed desk in his own office explained: *"it kinda feels like a factory floor* [in the hotdesking room] *... I didn't really make any friends while I was there"*. Similarly, P13, who was in her second year and usually worked from the library explained that she only knew a handful of other students: *"I don't really know anyone, there's a couple of girls in the library that occasionally if I bump into then we'll have a chat for a few minutes, but basically I am on my own"*. Further exacerbating these problems, many of our participants who did not have fixed desks felt there was little point in coming to campus, so often worked from home.

These participants also struggled with distant academic relationships with their PhD supervisors: both physically, in terms of location and the contact they had; as well as academically and pastorally, in terms of the extent to which they felt able to be open and honest with their supervisors. For example, P5 explained how she struggled to have *"one-to-one meeting*[s]*"*, as her supervisor instead held monthly meetings in *"a big group, loads of students... during my time when I was there it was around 40 or 10 more* [different students taking part]*. Masters were there, undergraduates were there"*, where she did not feel able or comfortable to freely speak or express her concerns. Similarly, when talking about her relationship with her supervisor P13 explained how she wanted to maintain a positive impression: *"you don't want to appear to be needy either do you?"*. These supervisory challenges, combined with distant working practices and a lack of peer support sometimes resulted in our participants feeling disconnected from other academics, and from academia itself. This also meant that some participants struggled finding support when they faced difficulties.

Use of Pears aided these participants in coming together to discuss their research, their working situations, their relationships with their supervisors, and to support each other. Almost all our participants reported discussing their research with others to some extent, and some even talked about collaboration possibilities: *"there are possibilities of collaborations in the future* […] *there will be an opportunity in the future to look at possibility of maybe writing a paper for* [anon]*, we can write a paper for that"* (P8). Many participants also discussed their annual progression report – a requirement for all PGR students at the host university to submit at the end of each academic year. Although almost all the PGR students in the university needed to submit this, most of our participants had only discussed this with their supervisors and never other students. There was sometimes tension in conversations between participants at different stages of their PhD: those at the beginning were much more concerned with this report compared to those who were further through. P1 explains: "*It's another perspective because they're already done with that stage. So, they see it as something that's really simple and easy* […] *I mean, to them it sounds like, 'Oh, what are you worrying about? It's just the annual progression. It's not a big deal' You know?"*. Although this report had a fixed deadline for all students, P15 was aware that it was possible to extend this deadline – information that he passed on to others in our sample. P2, who was experiencing some significant PhD-related challenges during the study (*"I was at the point of giving up my PhD. I didn't give up. I was like, 'let's see what happens'"*) acted upon this information and delayed her submission, relieving some of the pressure she was feeling. However, overall, P2 found meeting others to contribute to her anxiety, rather than provide relief: *"I was actually excited to meet more people but I think it turned out to be the other way. It just became*

more of an added anxiety". Bringing PGR students together had a double-edged sword effect on stress and anxiety, providing relief for some and contributing to others, as we further discuss in section 4.4.2.

To further illustrate participants' use of Pears to gain peer support we present a case study of P7: a PhD student in his second year, who had a distant relationship with other students and academic staff. He explained that his PhD had been going fairly well, but he had struggled with distant supervisory relationships (*"I don't know my supervisor's office"*) and little peer support (*"peers in my faculty with whom I have some sort of informal relationship with, I could just say like three persons or so"*). By using Pears he hoped he would meet other PGRs with whom he could discuss these challenges and get a different perspective.

After an uncertain start to the study (*"I had a very bad experience the first time, the first meeting wasn't held"*) 6 of his 11 scheduled meetings were successful, although he remained anxious that other participants might not attend meetings. When meeting others he was *"a little concerned about the topics of discussion, what do we talk about?"*, and suggested that some discussion prompts would have helped: *"when you have a guide of what to talk about, it's always better"*. The completed workbook activities were designed to fulfil this need and provide participants with topics to discuss, but in practice few participants engaged with discussions around others' shared activities, as we discuss in the next section. However, despite his concerns he gained a lot from these meetings, where he mostly discussed his work and research with other participants. For example, in his first meeting he met someone who shared resources to help him learn SPSS, and in another he *"got someone else who, she said she's going to use NVivo but she's just starting to struggle with it and said we will learn together".* He also discussed his concerns around his supervisors in the meetings, which reassured him that he was learning to become an independent researcher, *"we were trying to compare the advantages and disadvantages of each one* [supervisory approach]. *I said I like the sense of independence I see myself growing into now, but it was a lot of struggle for me at the beginning".* He completed all 16 activities in his workbook, which he found were particularly useful in making him reflect and *"think about things I ordinarily wouldn't think about"*, but he did not discuss these activities with other participants. Overall, he found participating in the study to be a positive experience - he made new connections with other students in the university and through this realised peer support. The scheduling system and participants who skipped meetings were a source of considerable frustration and stress for him; but the discussions he had and the connections he made were valuable, as were the insights he made as a result of reflecting on his own PhD journey through the activities in his journal.

4.2.2 Style 2 – seeking social connections

Beyond a lack of peer support and professional relationships, a smaller number of participants faced challenges related to social isolation in their personal lives and used the Pears to attempt to make new friends, rather than discuss work. Some of these participants felt they already had good working connections and relationships, and were less interested in peer-support related to work, but did want more social connections outside of their working lives. More in line with our expectations resulting from the initial design workshops, others struggled with both personal and professional isolation. Highlighting their benefits, those PGRs who had permanent work spaces alongside their peers and colleagues tended to have better working relationships and thus were more interested in using Pears to meet new people for friendship and social relationships. Accordingly, they tended to put less effort into the journal activities that required them to think about work and avoided talking about their work or research during meetings.

In many cases, the social struggles our participants experienced mirrored those that existing literature has found in undergraduate students (e.g. [70,79,66]): meeting new people, studying away from home, moving to a new city, and making friends. Many of our participants were indeed living away from home, or living in the university city, and country for the first time (or had studied in the city before, but been away for some time). But even those who knew the city well sometimes struggled with social isolation. For example,

P6, who had completed her undergraduate and taught-postgraduate studies in the same university, articulated the difficulties she faced as PGR student compared to her prior experiences:

"when you're an undergrad, like, you know hundreds of people like there's loads of people and stuff in your class […] *then Masters is it a little bit like less* […] *and then you go to like a PhD and then you see the same faces and stuff every day* […] *you go in the office and sometimes you don't even say hello to people, you just literally sit down on your desk and get on with things* [… I] *don't feel like there's that kind of - it sounds horrible - but friendliness".*

Although P6 grew up in the area, had attended the university since undergraduate level and had a permanent desk, she struggled to connect with her peers and knew few other people in the city. In our opening interview, she questioned if her patients (participants) were friends: *"a lot of my socialisation is with patients, and then you're, kind of, umming and ahhing, and you're like, 'Are they your friends? No, they're not. They're your patients'"*. Initially she hoped that Pears would help her find more social connections, but this was not the case: she *"added two people on Instagram, as you do"*, but did not intend to *"interact with them much later on"* and in the follow-up confirmed *"I've not met up with or kept in contact with any other participants I met over the study"*.

Generally, Pears was less successful for those attempting to make social, rather than work, connections. Many participants commented that meetings felt formal and compared them to networking meetings, rather than a coming together of friends. This largely appeared to be because of the differences between our participants outside of their working lives – they shared few common interests and were generally not a good match. Reflecting on this, P13 explained that she initially *"rather thought there might have been some kind of continuing connections coming out of these meetings"*, but that she then realised *"that's not the way friendships work really, is it?"*. The cross-purpose of the meetings between participants was often an issue for those with good working relationships who did not want to discuss work, particularly as the majority participants were more interested in work-oriented peer support. Reflecting on her participation in the study, P3, who was primarily interested in making new friends, discussed how a system with a broader focus beyond PGR students might be a better fit for her requirements:

"Lately, my life is all about PhD and people who have a PhD, or people who are doing a PhD so… It's not about PhD, it's about the people, if that makes sense. Like, if the point is getting a group which is struggling with loneliness, if the point is to make these people socialise… So, it's not really about, keep dipping in the topic of the research, but maybe it's just to connect people, and so it doesn't really matter if they're students or not" (P3).

To further illustrate our participants' social use of Pears, we present an in-depth view of P10: a second-year student who had a good work network and a permanent-desk in a room shared with 16 other PGR students. She also had a good relationship with her supervisors, who made time for her despite being busy (*"I do just pop in if I need anything")* and a strong working relationship with her fellow PhD students (*"I can talk to people in my department* […] *it's just like a communal thing we're all going through").* However, after moving to the university from a different country she struggled to find personal connections, and hoped Pears would help her meet new people across the university: *"I know most people from my faculty already, but I think it'll be interesting to meet people outside of it, and just to meet people I wouldn't ordinarily meet".*

During the Pears trial she attended 5 of the 11 scheduled meetings, and completed 15 of the 16 activities. After some technical problems in the first week were resolved (*"for the first week and a half, I think, I didn't actually meet anyone, because I had been getting the notifications after the meeting")* she only missed two further meetings: "*once I actually got into it, it was really good"*. She was most interested in talking to people about non-work-related topics during these meetings, *"*[the PhD is] *what we do all the*

time. It's all what we're thinking about. You don't want to talk about that", whereas many of those she met wanted to discuss work: *"I wasn't really that interested because, you know, I don't want to talk about my PhD; because if they talk about theirs, I have to talk about mine"*. She reflected on the fact that at university she has *"a lot of opportunities to talk about our research already, but there's not really that much of a focus on the researcher as a complete human who does other stuff"*. Because of this, she also thought that most of the workbook activities were too work-related *"it felt too close to my PhD, if that makes sense? Like, 'I'm already working on it, I don't want to do more work'"*. However, despite the focus on work, she felt she did benefit from taking part, explaining: *"I like the idea of it, and I liked meeting people that I hadn't met before, and just liked talking to them, as well* […] *The people I got on with really well, I added* [on Facebook]*, but most of the people, I was just like, 'Yes, you're nice, but we don't really have anything in common*"". As she explained in the follow-up, the system was successful in making new weak-tie relationships, but did not facilitate making any new close social connections: *"when we see each other at events we'd usually chat but haven't really met up* […] *I wouldn't say it led to lasting relationships"*.

Some participants, particularly those earlier on in their PGR journey did not have a clear preference for either use-type and instead wanted to learn from other students at the same time as making new social connections. For example, P4 started his PhD less than 6-weeks before taking part in the study, was highly engaged with the study (attending 10/11 meetings and completing all 16 activities) and excited to meet and learn from new people. He explained, *"one of the main reasons I went, I made the time. Because you could actually meet some people and, like I said, that was one of the main things that I was missing"*. This contrasts with other, perhaps more jaded, participants who were further along their journey and had more struggles with attending the meetings and completing the activities because they were balancing other commitments on their time: running research, teaching, and even having job interviews. This suggests that the system might be best suited towards those who are earlier on in their PGR journey, but this oversimplification does not account for the support that more senior PGR students can provide to those earlier on, which can be useful for both the younger and more senior student. For example, P9 who submitted his thesis a number of weeks after completing the study explained that he was still happy to have taken part, despite not "needing" it himself: "*I think it's good. I'm glad I've done it, in terms of meeting other people, but I don't desperately need it, particularly where I am and how lucky I am to have a support network around me anyway"* (P9).

4.3 Guided workbook activities

Completing and sharing the guided workbook activities represents a significant component of the Pears system, and proved to be divisive amongst our participants. Pears was designed to encourage participants to reflect on their own practice through these activities – not only by completing the activities, but also by exploring other participants completed and shared activities through the app, and discussing these completed activities during face-to-face meetings. Many responded positively to the activities and found them useful for aiding reflection on their PGR experiences, considering their research differently, and sometimes even helped them better managing their time and work-life balance. However, participants did not tend to engage with other's activities, or discuss them, to the extent that we had intended, instead suggesting doing so felt voyeuristic. Furthermore, the reflective activities also triggered anxiety or stress in some cases, particularly when they felt they had not achieved enough, or compared negatively with their peers. The workbook also included more creative activities which encouraged some participants to engage with each-other's shared activities, but others found these activities tedious and complained that they were too "simplistic" or childish, which alienated them from engaging with them.

4.3.1 Engagement with reflective activities

Many of the activities were designed to encourage participants to reflect on aspects of their personal and professional lives, such as the time they spent doing different activities, the progress they had made towards completing their PGR studies, or their moods and emotions (an overview of activities is provided

in 3.2.2). Most participants appreciated these activities and reported gaining insights about themselves as a result of engaging with them. Some suggested that the activities helped them feel more accepting of areas of their lives they had previously felt guilty about, whereas others realised that they needed to make changes to their working lives. This often arose when participants compared their activities with those shared by others, which, for example, helped them recognise changes they should make to more efficiently progress towards completing their PGR studies:

"I just found it really enjoyable, and it did, kind of, make you think, 'Where am I at with my PhD?' It, kind of, makes you think, 'Oh God, I haven't done enough in some parts', like the pie chart completion and everything. I was like, 'Oh my goodness. Everyone's is so green, like completed, and mine's all drafty.' So, it made [me] *think, 'Okay, maybe you need to adapt a little bit to dedicating more time to do writing'"* (P6).

Such transformative reflections were not only related to our participants' work lives, for example, some reflected on how many social connections they had made (*"It was a bit depressing because I was like, 'Okay, I've not actually spoken to anyone for the past week'"* - P10), or about the boundaries between their work and personal lives (*"having a bad afternoon or feeling sad in the afternoon didn't necessarily mean that you had to feel sad in the evening. It was all the things surrounding work-life balance"* - P5). However, the realisations that participants made as a result of engaging with these activities was not always associated with a positive outcome, and a small number felt negatively about themselves, or their progress, when competing some of these activities: *"I didn't like those, like, how was your week, or plan your week, because it would just, yes, I would just feel as if I didn't do enough"* (P2). This led participants to have a more complex relationship with the completion of these tasks which often resulted in additional stress and anxiety, particularly when they felt they had not progressed well, or compared negatively to other participants.

4.3.2 Constrained sharing and viewing of others' activities

When participants were concerned about implications arising from a particular activity, they would often either choose to not share it, or complete it less honestly. This was particularly true when a participant felt the activity revealed something "too personal", or if they were concerned that the activity might portray them negatively. Most participants suggested that they still completed the activities when they felt uncomfortable with their potential self-portrayal, but that they would "censor" themselves to present a more ideal scenario. For example, presenting a more "productive" version of themselves when reflecting on their progress. Participants indicated that they were most likely to stretch the truth in more personal aspects of their lives, such as their emotions or how they were feeling:

"I'm just not really comfortable with answering them. Definitely posting things, because some of them sometimes can be a personal like, 'Oh, I'm feeling fat', it was just a bit like, 'Oh, do I want to be… Strangers are seeing what I'm posting'. That's, I think something to be careful about […] *because obviously this can be personal"* (P15).

Others felt uneasy sharing activities they felt were very personal. Some chose to either not complete these, or complete and then not share a subset of the activities. P2, who faced some difficulties during the study completed 7/16 activities, but chose to not share any of these activities with others. They explained: *"I was just going through a very rough patch on my own* […] *it just felt as if this is personal stuff* […] *it just becomes a reflection of me, and that's why, somehow, I didn't feel okay to upload it"* (P2).

Within the context of a peer support system, these acts of self-preservation have the potential to be particularly problematic, as the platform could end up with a set of shared activities that only portray positive content: happy and satisfied PGR students who are always productive and are progressing well with their studies, even when we know this is not the case. This could then further stigmatise users of the

system who are facing challenges and are seeking support, exacerbating a so-called imposter syndrome. However, although the sharing functionality in the app was designed to facilitate reflection and conversation between peers, few participants reported actually looking at the activities that others had uploaded. Participants instead suggested that it somehow felt "stalkerish" or voyeuristic to look at other participants activities, even though this was limited to those who they had already met in person, or who they had a scheduled meeting:

"I don't know. Culturally, I don't like to stalk people […] *that might be stupid on my side. It's not that I'm a prude, of course, but I don't know. I just feel like it is kind of like stalking someone, looking through their profile"* (P11).

"I even did something that felt a bit awkward, which was after the study, I went through the people that I had met, already met, wasn't going to be meeting them again but I went through their notes, oh, yes, this has been happening since I met them, oh, it's interesting and seeing… it's probably a bit stalkerish" (P12).

We suggest that the tensions raised in this section were in some part because of the highly personal nature of some of the guided activities and the relative unfamiliarity between participants, who met each other only once during the study. The topic of participants "opening up" and discussing more sensitive or personal subjects is further expanded upon when we discuss the meetings between participants.

4.3.3 Enjoyment and frustration when engaging with activities

Alongside the reflective activities that some participants deemed too personal to share, the workbook also included a number of more creative activities (see examples in Figure 6), which also received a mixed reception, but were more successful in encouraging participants to engage with one another's shared content in some cases. Most participants enjoyed these activities and some reported that completing them was therapeutic, helping them "destress" and disconnect from their working day, particularly when they included colouring: *"I found the activities really interesting. It was, kind of, like, a destress thing. You came in from doing uni, and then I could literally sit there and colour in. It was great"* (P6).

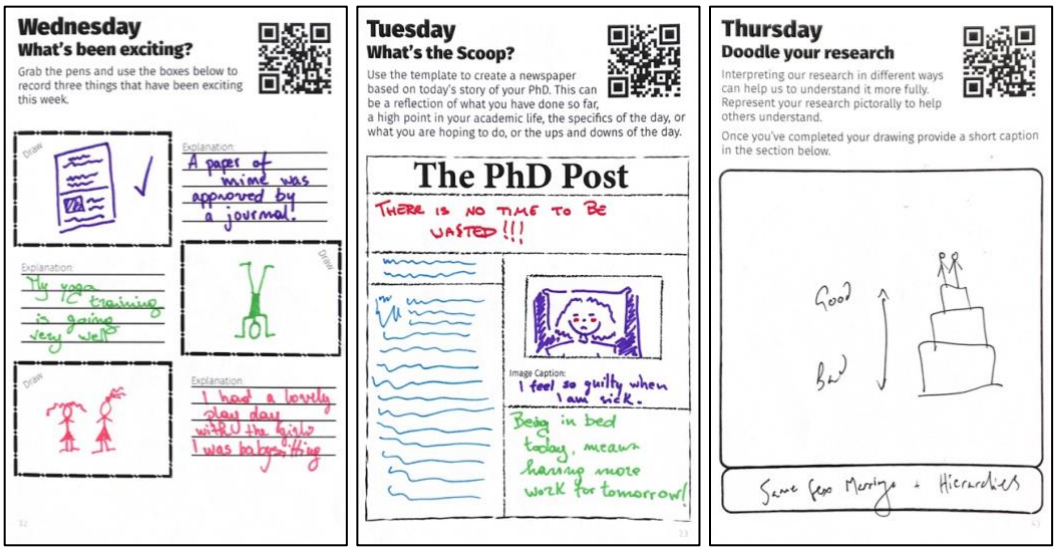

Fig. 6 Examples of some of the creative completed activities

Although most participants appreciated the opportunity to reflect and be creative that these activities encouraged, praise was not universal and tended to decrease over time. Some participants considered these activities to be "childish", too simplistic, or otherwise not useful. For example, P13 who completed 8/14

activities explained that she completed them somewhat begrudgingly: *"I did kind of fill them in, but it was more a case of because I had to, rather than because I thought I was personally getting anything out of it"*. Others complained that they found drawing or being creative challenging and thus found the activities to be frustrating: *"anything that pertains to drawing was very, very difficult for me"* (P7). Furthermore, some participants who started off more positively found their enthusiasm about the activities waned towards the end of the four-week trial, particularly owing to the continued effort needed, and perhaps as a result of the novelty wearing off – this caused a drop-off in participants overall engagement with these activities, as presented in section 4.1.

An unexpected positive outcome resulting from the "burden" of completing these creative activities was that some participants drew inspiration from the activities that others shared on the app: *"Sometimes when I was like, oh, what do I do on this one? What should I write? I would just sometimes have a look at some examples"* (P4); resulting in them engaging with other shared activities as per Pears' design. *"I was stuck and I didn't know what to do with one of the journal entries. Sometimes I'd go and see if they'd posted one. I'd go, "Okay, that's how it's supposed to be done"* (P1). However, from the interviews it was unclear if looking at other participants' shared activities increased their value – if this inspired participants to reflect on their own practices, or encouraged them to consider alternate approaches. Participants instead suggested that they would look at others' activities to help them determine how reliable the other participant might be, and determine if they were likely to attend their scheduled meeting.

4.4 Meetings between participants

As noted in section 4.1, 44 of the 78 scheduled meetings took place over the 4-week study, resulting in 44 pairs of participants physically meeting one another and having conversations on a range of topics. Although meetings were between strangers, other participants were easy to spot: *"these booklets were particularly good to have on the table as a kind of, it was almost like wearing a red carnation, you know - when people saw that, they knew who you were"* (P13). Participants' experiences of these meetings were generally positive and most came to appreciate chatting to other PGR students, even when they had not previously been interested in meeting others, so in this respect the system could be considered a success. However, participants also reported that some conversations were experienced as overly awkward or "professional", that other participants were unsupportive and that the protocol around attending meetings contributed to their stress and anxiety, largely because of the regularity of meetings and uncertainties around other participants attendance.

4.4.1 Conversation and peer support

Almost all of our participants reported that simply "meeting new people" was the overall most positive outcome of taking part in the study. Participants were generally pleased to meet new faces, enjoyed conversations with those from different academic fields, discussed differences and similarities in PGR experiences across different areas of study, and began to understand the experiences of students with different backgrounds:

"it's good to meet different students from different departments. I know a lot about the students from my own department and we're lucky that we have […] *a good social community. But still that doesn't mean that I knew people from other departments, it was quite interesting to hear about their research and also about their experience as PhD students"* (P12).

Before taking part in the study many of our participants were considerably less excited about discussing their work with others, and were perhaps more sceptical of the value of peer support. This was particularly true of those who were more isolated in their PGR studies: those who did not have a fixed workspace with other students and instead often worked solitarily, either from home or from the library. However, over time as they came together to discuss their research and help one another, many came to understand similarities and shared experiences that they had with others and the potential benefits of peer support.

Participants reported topics of conversation to be broad and varied, ranging from personal discussions about their background and hobbies, to work-related topics such as sharing practical knowledge about processes within the university such as the annual progression report that all students in the university needed to write: *"there was one girl who was kind of freaking out about her annual progression. She was* [preparing] *her first one, and I had just done my second one* […] *I think I helped her a bit"* (P10). Over time, this resulted in many participants making more of an effort to attend the scheduled meetings and engage in conversation with other participants. For example, P11 started the study with few expectations, but then realised that talking to other PGR students was a useful way to get support: *"you can feel that other people, from other departments and in other fields, also share some of my worries about the PhD. Then I said, 'Okay. Perhaps this is useful'. Then on the third meeting, that is when I realised, 'Yes, it's super useful to have these sorts of things'"*.

Although these meetings were successful in bringing PGR students together and encouraging them to talk, most of our participants were largely uninterested in having ongoing close friendships with those who they met during the study. In the follow-up survey, none of our participants reported having kept in touch with one another. However, the study was much more successful in creating weak-tie relationships where participants would speak to one another again if the occasion arose, for example P15 explained *"I'm sure if I saw her again we'd sure to have a conversation and it would be great"*, and fittingly it changed participants perspective on the benefits of peer support and talking to other PGR students. This appeared to have an effect beyond the study period, as participants told us that they were more actively participating in social activities. For example, P5 explained that she was embracing talking to others in her research group instead of focusing on her own research. Some participants who started the study in relative isolation, such as P1 who "*was hoping to meet with more people*", gained a more subjective feeling of this after meeting others, encouraging them to make changes and become more social, *"because my bubble feels a little bit too small"* (P1).

4.4.2 Unsupportive and overly formal meetings

Although as we saw in the section above many participants realised the benefits of speaking to others, participants reported the majority of meetings feeling more "formal". This was in part because participants were reluctant to open up with each other about more personal issues and the struggles that they faced in their PGR journey, and were unsure about what to talk about during the encounters. This was especially true for some participants who felt nervous, worrying particularly about other participants who might be quiet(er), or who were less confident about how to handle silences in conversations: *"There are some personalities where you have to extract, literally extract, the information. That makes you kind of like the interviewer instead of having a chat"* (P11).

Conversational prompts, as suggested by P7, might be a way to overcome the initial awkwardness and help break the ice: *"if you find two people who are very reserved, it is difficult for each other to break each other. But when you have a guide of what to talk about, it's always better"* (P7). We did not provide conversational prompts as the workbook activities were intended to provide inspiration and topics for conversation during the meetings. However, because many participants did not regularly look at each other's completed activities through the app, this did not work as intended at the outset of the study. However, over time (and once there were a larger history of completed activities in the physical workbooks) participants did begin to discuss the guided workbook activities in meetings.

Unfortunately, debilitating stress and anxiety had been a big part of the student experience for many of our participants. A small number of other participants preferred shorter meetings because they found they contributed to their stress levels, particularly when they were already struggling with their mental health, and found it difficult to open up. For example, P2 explained she was "*excited to meet more people"*, but that doing so "*just became more of an added anxiety",* further explaining, *"I would have wanted to have a*

much more relaxed conversation when I'm not too stressed in my head". Some of our participants had previously received support for stress and anxiety, or had time away from their PhD, whereas others had attempted to self-manage these problems. P2 experienced some significant challenges during the study. One might have imagined that providing participants with opportunities for peer support would result in positive outcomes but this was not always the case, and some participants found that rather than helping, the Pears system actually contributed to their levels of stress and anxiety.

During the meetings we found that participants often feared the other person not being empathetic or supportive around particular feelings, emotions, or experiences, which made them reluctant to share. While participants were not afraid to offer practical help (such as in the case of annual progression tips), finding ways to open up about emotional and mental wellbeing struggles was a lot harder. For example, P14 had moved away from her family to pursue her PhD, which she found challenging to cope with, but felt she could not share this with her peers: *"If I met more people who have a similar situation I would like to meet this person more. Because we understand each other, people who maybe have a family, we understand what we are talking about"*. However, when she did share with a fellow participant with whom she felt might be able to relate, she did not receive the emotional support she had hoped for. The other participant explained: "*I don't particularly want to be a prop - you know, if I meet somebody again, it's got to be on a mutual level"* (participant not identified for anonymity). In every case these meetings were the first time that pairs of participants had met each other, which likely had a significant impact on how comfortable participants were to open up with one another – if participants had known each other better, they would perhaps have been more likely to share more during the meetings. While Pears itself only facilitated the initial meeting, our intention was that participants could then go on to arrange future meetings, either through the in-built messaging system or by otherwise sharing contact details during meetings. However, perhaps because of the regularity, which gave little down-time between scheduled meetings, no participants arranged to meet one another again during the study period.

4.4.3 The labour of meetings

Although most participants enjoyed taking part in the meetings and found them to be useful, many also told us that arranging and attending such frequent meetings was a *"big commitment"* (P2). Participants agreed that they would be available to take part in all meetings (one meeting each Monday, Wednesday and Friday over the 4-week study) at the outset of the study, but they sometimes struggled to fit the scheduled meetings into their routine and sometimes cancelled ahead of time, or otherwise failed to attend. The majority of participants thought that the frequency of meetings *"was a bit intense"* and that *"perhaps two a week would be a bit more manageable"* (P15). The meetings became *"like another thing on my 'to do' list, rather than something I wanted to do"* (P10), and some participants suggested the regularity of meetings contributed to their already heightened stress and anxiety. However, other participants appreciated the compacted nature of the study which gave them the opportunity to potentially meet 12 other PGR students over a short 4-week time period: *"I think it was fine in the time period that the study was on for. I think if it was, like, six months, then that might've been too much, but I think the four weeks was a good, kind of, start to finish"* (P6).

Thirty-four of the 78 scheduled meetings were not attended by both participants. While meeting with other PGR students was the highlight of Pears for most participants, the most frustrating part of the experience was attending meetings where the other person failed to turn up. When they were unable to attend a meeting, few participants notified us or the participant with whom they were scheduled to meet, meaning that many meetings were attended by just one participant, resulting in a wasted journey and opportunity: *"that was a little bit disappointing… I mean, you agreed to participate. If you're not showing up, and you know that somebody else is waiting for you, just tell the people. It's just nice"* (P3).

In order to avoid wasted journeys, many participants took to using the built-in messaging service to communicate with one another and convene on a convenient time and venue for their meeting, resulting in

each meeting having a significant additional labour associated with it, which some participants found to be particularly stressful, and sometimes even caused them to disengage:

"I wouldn't mind the process if I didn't have this kind of mental pressure on me […] *getting this phone on and then tracking what is happening and then you're messaging the other person, 'Oh, I missed this thing. Can we re-schedule? Can we meet tomorrow?' That's an extra effort that you put in, and I think it should have been much more easy-going because it shouldn't be so much work, connecting with people"* (P2).

Some participants suggested that the meetings could be more flexibly driven by the participants themselves, rather than being scheduled by the system: *"I think it would be better if people could then, kind of, pick and choose as and when they could attend. So, maybe have like, I don't know, a database where people say, 'I'm available this date, this time', and then if anyone picks it up, then you've got a meeting"* (P6). However, most participants felt that some level of structure was good, as if they had complete autonomy the meetings would become a lower priority and might never happen. Ultimately, a trade-off between these extremes might be the most successful option: a system which can bring students together and suggest meeting times and places, but provides students with the agency to choose who they meet with, and allows them to suggest particular dates and times to fit in their schedule.

5 Discussion

Through our design and evaluation of Pears – a novel hybrid physical-digital system to support and encourage peer support amongst PGR students experiencing isolation – we have highlighted how peer-support systems can be utilised to support PGR student life. Participants valued their interactions with new-found connections, but at the same time there were also tensions between participants' differing expectations and aims for use of the system, and in some cases, Pears even contributed to their stress or anxiety. Pears is not unique in aiming to facilitate peer-support between PGR students, and indeed "buddying" schemes and other forms of peer-support are relatively commonplace in universities for new PGR students. However, Pears offers novelty in how it brings together students studying at different levels from across the university and includes elements such as the blended physical-digital approach with the app, workbook and face-to-face meetings, and the guided activities to share with other participants. We build on these points in the following sections, contributing knowledge on the design of future systems addressing issues of loneliness and social isolation amongst PGR students and other populations, and offer directions for future research in HCI.

5.1 Styles of use and facilitating peer support

Despite Pears offering a defined purpose to a specific audience – facilitating peer-support between PGR students – not all of our participants had similar goals in mind when using the system. Instead, we observed two distinct use cases, closely aligned to the struggles that participants faced in their lives, namely either to 1) seek peer support and assistance with challenges related to their academic life, or 2) to seek social connections and new friends, particularly for non-academic activities. Although at first glance there is potential for significant cross-over between these two styles of use, instead these misalignments resulted in incongruous meetings and frustrating cross-purposes conversations between work and social activities.

Pears was not targeted towards students from any particular field, nor stage, of study: our participants included those who had started their PGR studies within the previous months to those who were at the closing stages of writing up their thesis. This was in contrast to the majority of peer-support systems designed for PGR students, which tend to focus on new students learning from more experienced students, within a similar field of study [46]. One could argue that the more traditional approach of supporting PGR students at the beginning of their studies might be more appropriate, especially as those at this stage appeared to gain most from using the system and were perhaps best positioned to create new relationships.

However, solely focusing on new students restricts those at other stages from taking part – something that our design workshops indicated that students were interested in – and our approach provided many benefits that participants at all stages appreciated. These included the rich and varied conversations, reflections and knowledge that those at different stages and in different disciples were able to share, which helped participants realise that they shared similarities in experience with PGR students from across the university, potentially resulting in further connections between participants.

Even with our broader approach, Pears' target audience remained focused towards self-selected PGR students studying full-time at the main campus of a single university. However, despite their similarities, misalignments often occurred because of participants' distinct uses for the system. "Matchmaking" based on various personal attributes is a key element when bringing people together in various domains including online dating [37] and gaming [77], and prior work (e.g. [64]) has highlighted the importance of appropriately matching peers in support systems, showing how similarities between peers' characteristics (such as *"shared feelings, beliefs and needs"* (p.1479)) were prioritized above their medical diagnoses. Peer-matching was considered within the design of pears, but following the design workshops we incorrectly anticipated that our entire sample would use the system similarly, so elected to prioritise the facilitation of the maximum number of meetings over the scheduled time frame. Given the differing use-styles, a level of matchmaking or more specifically *expectation management* would have been beneficial. This could be facilitated by the system using matching techniques based on a user-profile and preferences, by the participants themselves, or other techniques could be utilised to guide use of the system, such as conversation prompts for meetings as discussed in section 5.3.

Because Pears was evaluated over a 4-week trial, all participants started and finished within a similar time frame. To some extent the decision to schedule three meetings a week was because of the pressures of maximising the number of meetings scheduled over a sensible trial-period. If the system was to be rolled out more broadly, an alternative could be to provide an ongoing "roster" of students wanting to participate in peer-support, including those at any stage of study. In this scenario, rather than a set 3-times-a-week schedule, students could sign up and organise meetings when they felt they could offer, or needed, support. This solution could also help tackle struggles and social isolation sooner, bringing students together in a timelier manner, while also providing a range of perspectives and "top-down" peer support from those further along in their studies. Moving the agency of matching and arranging meetings to users would also remove one of the more laborious elements of the system – the regularly scheduled meetings. Many participants felt that 3 meetings each week over the 4-week period was too frequent, and indeed, some struggled to fit these meetings around their schedule. The regularity of meetings also gave participants little opportunity to further develop relationships with those they met through the study, outside of the confines of it. By reducing the frequency of new meetings facilitated through the system participants would have had more opportunity to schedule further meetings with those they had already met. However, to retain engagement the frequency of meetings would need to carefully trade-of maintaining interest in the system against relaxing the amount of commitment required – our participants indicated meetings would become a lower priority and might never be staged if they were given complete autonomy over organising them.

Beyond matching of peers, the incongruous styles of use highlight the importance of more broadly managing expectations, thus ensuring that intentions are clear to all parties from the outset. Systems should either be designed more specifically around a particular use (be that peer-support or loneliness), or allow users to be more upfront about needs/ desires as to avoid incongruities and provide that safer space for support. Managing expectations is especially relevant for peer support tools aimed towards vulnerable populations, as we have seen in our study, incongruous conversations are not always supportive and can potentially be detrimental to wellbeing. In this regard peer-support systems could learn from online dating platforms, which attempt to solve this problem by fore-fronting desires for meetings (e.g., for "casual sex" or a "committed relationship" [90]) on user profiles, albeit sometimes with mixed results [59]. Regardless,

Pears did provide greatest value in facilitating peer support, rather than social connections, amongst participants, and was particularly valuable for those who were previously more isolated from other peers.

5.2 Reflection, impression management and disclosure

Pears offered opportunities for participants to reflect on various aspects of their PGR experience, compare this with others (as suggested in [24]), both through the guided activities in the workbooks which they could share through the app, and through conversations in meetings, similar to the data-enabled conversations between pairs of PGR students in [26]. Regardless of mechanism, self-reflection was often associated with positive outcomes, such as gaining new perspectives on their work-life balance and time management, and in some cases even led to "transformative reflection" [25], whereby participants made fundamental changes to their behaviour as a result.

The workbook activities were key for facilitating self-reflection, but reflecting on experience and progress did contribute to stress and anxiety for some, typically when a participant was unhappy with their performance or thought they compared negatively against their peers. This was made especially evident as participants were asked to share their completed reflective activities with others through the app. Moreover, participants did not always find completing the activities straightforward. Although creative activities such as drawing and "mindful colouring" have been used to effect in other reflective systems (e.g. [4]), and evidence suggests they may be a useful for self-care [19], even for reducing symptoms of depression and anxiety [27], the creative activities were not universally enjoyed in our study. Participants reported the more creative activities to be childish, and others who initially enjoyed them found they required too much effort over time, resulting in participants completing fewer of these potentially beneficial activities. However, the activities that participants had more difficulties completing were also reported to have been most shared and viewed, so for the purposes of sharing content and encouraging participants to interact with shared content, these could be considered successful. When setting content, careful attention should be paid to the trade-off between effort and reward of reflective activities such as these, and tailoring workbook activities to individuals could result in fewer direct comparisons and encourage longer-term engagement.

Self-presentation played a significant role within our participant's interactions with Pears and the conversations they had with others they met through the study. This impact was most apparent in the guided workbook activities, whereby participants either completed these in such a way as to portray their "ideal self" rather than a more realistic depiction, or where they chose to not share activities that felt too personal or portrayed them negatively. Our participants did this to avoid stigmatisation, judgement, or negative comparisons with their peers, while often at the same time avoiding looking at the activities that their peers shared because they deemed this to be intrusive or voyeuristic – despite this being part of the design of the system. This closely mirrored some uses of social media systems where users present themselves in a particular way to "fit in" or please others [38,13] and aligns with Goffman's [31] notion of the on-stage and off-stage self. One challenge is that participants were required to present themselves to their peers, all of whom they had only met once, in a fully identifiable manner. The Pears app automatically connected all participants who met face-to-face and offered participants no way of "disconnecting" from peers with whom they might have had a negative interaction or unsupportive meeting. Furthermore, the design of Pears meant that they were not able to present themselves differently to certain participants, meaning that there was no opportunity for them to portray a more authentic version of themselves to some, while hiding some attributes from others. An alternative, as highlighted by Park (2018) [67] would be to allow students to anonymously share without judgement, though this would remove the opportunity for participants to discuss their shared activities with others, making anonymous elements difficult to integrate.

It is vital that digital tools designed for peer support fit within a broader agenda of supporting "digital wellbeing" [11], but unfortunately, as research in social network services (SNS) has shown (e.g. [21,1]), this effect whereby only positive facet of one's life are presented to others can result in unrealistic expectations, issues with self-esteem and can even contribute to mental health problems. In peer support

systems, where social comparisons are likely to be made, this has the potential to further exacerbate negative feelings amongst those who might already be struggling with mental health or pragmatic issues, perhaps leading them to believe that they compare more negatively to their peers, as research in other domains has demonstrated (e.g. [22,48]). For example, never seeing others share negative content and instead only seeing successes and positive stories may result in individuals feeling worse about their own progress. Although image-sharing SNS may compare positively to text-based services with regard to experiences of loneliness [69], research also suggests that positive impression management is greater on image sharing platforms [47]. Accordingly, bringing participants together for face-to-face meetings in Pears may have further exacerbated participants need to maintain a positive impression in the activities they shared, perhaps going some way towards explaining the professional and distant meetings that some of our participants reported.

5.3 Dissonance and supply of social support

Appropriately matching dimensions of social-support to challenges faced is essential for the success of peer support [16]. Yet, in Pears, participants generally failed to offer one another emotional support or empathy in their responses to others, even when a participant did feel able to more honestly open up about a personal or emotionally sensitive topic. If a participant did choose to open up, the scarcity of any empathetic, emotional response was perceived as being unsupportive in nature. These less supportive, more formal, portrayals were particularly difficult for those who were experiencing heightened stress or anxiety and may need more professional support than offered by peer support systems, which might not be best suited to them.

One potential solution to better facilitate support during meetings could be to provide conversational prompts, or discussion guidance for participants in in-person meetings. We were keen to not be overly prescriptive to the topics that participants talked about, and designed the workbook activities as a way to provide potential conversational topics and facilitate shared sensemaking and reflection around the topics at hand (similar to [26]). Although we have some evidence that this happened (as participants reported conversations around the workbook topics) this was not as prevalent as we had expected and the majority of participants did not openly look at activities shared by others – suggesting this was too personal or voyeuristic – and rarely looked at these activities during meetings. Previous work [23] has shown the effectiveness of delivering different content based on the individual, alternative workbook content, or tailoring of content for each PGR student, could help appropriately communicate desires and manage expectations. Conversational prompts were suggested made by a small number of participants in the study and could represent an alternative solution – guided chats were successfully used to facilitate online "talk therapy" between people experiencing mental illnesses [65], facilitating deep and valuable conversations, but which raised concerns that participants did not want to share – similar to problems we experienced in this study. This technique should be further trialled for in-person meetings designed to facilitate peer support in different settings. Whether sticking to discussions around a particular topic or activity, or using pre-determined conversational prompts, this would create guidance and expectations around the topic being discussed.

From the study it was clear that peer support was not suitable for all challenges that participants faced. The lived experience of being a PGR student does not necessarily equate to all other PGR experiences, because of the wide variety of challenges that students face. PGR students may not have the experience or capability to offer support, emotional or otherwise, to others facing differing challenges, such as mental health or other circumstances that may affect their lives. Thus, peer support should not be relied upon as a replacement for more traditional, professional support services. However, confirming previous findings (e.g. [101]), the PGR students in our sample felt that university-provided support systems were more aimed towards undergraduate students and where therefore unsuitable, or unavailable, to them. It is vital that such services are available to students at all levels, and clearly advertised as being so. For PGR students who do not have support networks outside of the university, there is a space for emotional support outside of the

student's supervisors' role, but could be fulfilled by the broader academic-support network; for example, through student services teams or healthcare services. For undergraduate and taught-postgraduate students, this role is often fulfilled in a professional capacity by a personal tutor – a role that is becoming increasingly focusing on pastoral care [74], but this is generally not the case for PGR students.

It is worth further reflecting on why Pears did not appear to facilitate emotional support. This was perhaps, in some part at least, because of the lack of closeness between participants, all of whom had met each other for the first time through the study and had little opportunity for relationships to develop. In addition, Park [67] notes that to create a successful support network, it is important that peers have "similar backgrounds" to relate to one another. Although our participants were more closely matched in terms of their current situation, this presents a design challenge when dealing with the wide variety of backgrounds PGR students have, although a challenge lessened by a more configurable system. Furthermore, in our sample, a strong reason for this lack of closeness and emotional support may be dictated by our participants wanting to maintain a professional image in meetings, treating these more as a networking opportunity, rather than somewhere they felt they were able to open up around emotional issues.

5.4 Connectivity and changing perspectives

Throughout the trial, Pears provided those participants who engaged with the face-to-face meetings with a greater number of weak-tie relationships which in many cases were useful for instrumental, informational and sometimes emotional support within the context of the study. Our participants did not create any new close, or ongoing long-term, relationships as a result of using Pears, either socially or for continued peer-support. However, judging peer-support systems by measuring the number of new strong-tie relationships created as a result is not necessarily a good indicator of success. Instead, our participants specifically lamented the pleasure of having grown their networks through the study, and more importantly reported having learned a fresh appreciation of the benefits of increased social connectivity with other PGR students.

Pears *was* successful in changing many of our participants' attitudes and perspectives towards the value of peer support, and their willingness to seek peer support and help others in the future. Even participants who were initially unsure of the value of meeting other PGR students began to associate greater value to these encounters, reporting gaining insights into practice and tacit knowledge during conversations with other participants as the study progressed. Pears was also successful in heightening participants awareness of the shared experiences they did have with other PGR students, even those studying in different fields, and the benefits of sharing experiences and talking to others. This appeared to be particularly true for those who had previously had a more solitary PGR experience and had therefore been less aware of the potential value of peer support. This relationship draws parallels between objective social isolation and the subjective feeling of loneliness [99,68]: many of those participants who entered the study with an objective lack of work-connections appeared to be relatively unaware of their isolation, but by facilitating peer support by bringing them together with other PGR students they became more aware of their isolation and began to seek connections of their own volition, even beyond the study period, as illustrated by response to our follow-up questioning.

The number of face-to-face scheduled meetings that our participants attended increased throughout the study, as they came to better value these social interactions and became more accustomed to dedicating time to interacting with others into their routines. Importantly, we as researchers did not provide participants with any additional encouragement to attend these meetings beyond the scheduled meeting notification used throughout the study. Indeed, the only contact we had with participants during the trial of Pears was when they experienced technical problems: typically issues with charging the phone, or forgotten login credentials.

5.5 Implications for design and technology

Peer support systems addressing issues of loneliness and social isolation must be designed carefully in order to provide users with support, while at the same time avoiding any negative consequences of use. Drawing from our evaluation of Pears, we present lessons learnt and make suggestions for implications for the design of peer support systems.

We found that ***managing expectations should be as paramount as peer-matching***. Pears did not match peers, but instead facilitated interactions between a wide variety of students with different backgrounds, disciplines and stages of study. As a result, participants were positively exposed to a broad variety of perspectives and many realised they had a shared experience with students studying outside of their fields. However, some participants had different and incongruous goals for using of the system, which resulted in frustrating and even negative interactions. These incongruities were related to poorly aligned expectations, so we argue that pairing users with similar *desires and expectations*, rather than their backgrounds, could help avoid these instances of potentially negative and incongruous uses.

Based on our findings, ***users should have some autonomy over their schedules and with whom they decide to connect.*** The intensity of meetings within the Pears trial, which scheduled 3 meetings each week, was too high for many and provided participants with little time to strengthen their relationships with peers, if they wished. However, a careful balance must be made when giving users scheduling autonomy, as participants ruminated that if they had complete autonomy over scheduling meetings that they might never happen, owing to their already busy schedules. Similarly, users should be able to anonymously "unmatch" from someone, so as to avoid potentially negative or harmful interactions.

Facilitating the creation of weak-tie relationships with others can still make a peer support system successful. It is often assumed that peer support systems should focus on encouraging ongoing, strong-tie, relationships, however we found these are not always necessary for effective peer support. Our participants appreciated growing their network and realised they could still benefit from casual, brief interactions with weak ties. To this end, we argue peer-support systems should facilitate a first meeting between users, and allow users to arrange additional meetings if they wish.

When it comes to peer support for PGR students more specifically, ***there is benefit in targeting students from different fields or stages of study.*** In the design workshops participants expressed concern that they would not benefit from being matched with someone from a different discipline. However, as they took part in the Pears trial, they were surprised to learn of the similarities they shared with PGR students in other disciplines and actually appreciated the shared experiences and conversations they had with peers from different disciplines across the university. While similarities are important for peer-support, we found that these do not need to be constrained to the specific field or stages of study.

Finally, we wish to stress that ***peer support systems for PGR students should not be a replacement for more traditional, professional sources of support***. Peer support should instead only form part of a larger support offering that provides users with timely access to professional sources of support (e.g., academic support from supervisors and student support services or counselling), as well access to support for times of crisis (e.g., services such as Nightline or Samaritans). Furthermore, within our study, PGR students suggested that support services were often targeted towards students at lower levels. Thus, we argue that within higher education settings, sources of support should always be tailored towards, and advertised as available to, all potential users.

5.6 Limitations

One novel aspect of Pears is that it facilitates bringing users together for face-to-face meetings, verified by participants physically "touching-in" on NFC tags located within each-other's workbooks. As a way to coordinate these face-to-face meetings (which have been shown to facilitate greater levels of peer support [95]), we only recruited students located on the main campus of one university in North East England. Our goal was to allow participants to meet in safe and familiar spaces – such as university-owned cafés and eateries – without needing to travel long distances. From the outset we were aware that this excluded those who studied elsewhere than the main campus – among those who might be most isolated – from taking part, including students studying at remote areas of the campus (including other areas of the city, country and even remote campus' abroad), and those who worked from home completing their studies at a distance. Furthermore, given the social distancing policies and the new ways of working as a result of the COVID-19 pandemic, there is space for more research comparing and considering means to promote paired, PGR peer support at a distance, perhaps facilitating video chat functionalities, especially given the increase in loneliness and decrease in productivity [18] which have the potential to cause further struggles and challenges amongst PGR populations.

A further limitation of our sample was that all participants in the trial were studying at same university in North East England, and as such some of our findings may represent use of Pears within this context and might not be replicable elsewhere. For example, use of Pears may be distinct when considering the support available to PGR students within the university, challenges participants encountered around PGR student culture and integration, or when considering their work towards the progress evaluations that were common to all PGR students across the university. However, although these challenges might not apply to every university setting, similar challenges are typically observed elsewhere. For example; the lack of accessible support services for PGR students is something that has been raised in prior research [101]; hotdesking policies for PGR students are typical across many universities, along with the resulting tendency for students to work from home or elsewhere; and progress evaluations of some sort are also typical for PGR students.

There were also some important ethical considerations learnt as a result of this study. A small subset of participants experienced increased stress or anxiety as a result of taking part, and found that peer support was unsuitable for the some of the challenges they faced during the study. As when undertaking any research, researchers should be aware of the potential for studies to create, or exacerbate, any issues in their sample, and ensure that participants are appropriately safeguarded. Within Pears our procedure included the provision of a debrief sheet with a list of resources for support (including details about the university's own student support services and external services such as Nightline and the Samaritans), to provide to participants in the final interview should they have wished to seek support for any difficulties the study may have raised. Additionally, we actively monitored the activities that participants shared, along with their responses to the EMA messages, in attempts to detect any concerns. During the trial our participant's behaviours did not raise any cause for concern, partially because they themselves retreated from some study activities, such as sharing their workbook activities and taking part in face-to-face meetings with others. However, further reflecting on the issues raised during the study, it would have been sensible to signpost support resources to participants from the outset of the study, along with providing more explicit recommendations for participants to identify concerns about their own mental health and guidance on what to do if they were concerned about a fellow participant. While this is generally good practice in research, we are highlighting here as similar support should be considered for other unmoderated platforms providing peer support.

6 Conclusions

In designing and evaluating Pears with PGR students, we have contributed knowledge beneficial for the design of related peer-support systems. We found that Pears itself offered support and respite for some

students: those who had existing peer support in their local departments and groups found Pears to be most valuable as a tool to grow social relationships outside their local community. Other participants found it to be useful in realising a shared PhD experience with other students – even those across other departments and faculties, with whom they had not previously realised they shared similarities. Participants shared advice and guidance with one another, particularly with students further along their PhD journey sharing tips with those who were starting out. However, for a small number of students experiencing difficulties in their studies, they found the notion of sharing their progress, and talking to other students, anxiety inducing and stressful. Peer support systems should be designed so that they are not detrimental to the wellbeing of any student and should not act as a replacement for other sources of support, particularly more professional, sources of support such as offered by student services, which would be more beneficial in some cases.

ACKNOWLEDGMENTS

This work was supported by RCUK grant ES/M003558/1.

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