

# **Digital Companion Choice to Support Teachers' Stress Self-Management: A systematic approach through taxonomy creation**

Julia Bland Manning, Ann Blandford, Julian Edbrooke-Childs, Paul Marshall

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# Digital Companion Choice to Support Teachers' Stress Self-Management: A systematic approach through taxonomy creation

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## Abstract

**Background:** There are thousands of digital companions (DC) designed for emotional wellbeing and stress, including interactive websites, wearables and smartphone apps. Although public evaluation frameworks and ratings exist, they do not facilitate DC choice based on contextual or individual information such as occupation or personal management strategies.

**Objective:** The aim of this study was to establish a process of creating a taxonomy to support systematic choice of DCs for teachers' stress self-management.

**Methods:** We employed a 4-step study design. In step 1, we identified the dimension of stress self-management and strategic classifications. In step 2 we identified the dimension of digital techniques and conceptual descriptions. In step 3 we created six criteria for inclusion of DCs. In step 4 we used the taxonomy framework created by steps 1 and 2 and populated it with DCs for stress self-management as identified in step 3.

**Results:** First, in the dimension of stress self-management we identified 4 classes of strategies: educational, physiological, cognitive and social. Second, in the digital techniques dimension we derived 4 conceptual descriptions of DCs' mechanisms of action: fostering reflection, suggesting treatment, peer-to-peer support and entertainment. Third, we created 6 criteria for DC inclusion in the taxonomy: suitability, availability, evaluation, security, validity and cost. Using the taxonomy framework and criteria, we populated it with DCs for stress management ahead of presentation to teachers in a stress study workshop.

**Conclusions:** We believe elements of our approach will generalise as principles for the creation of taxonomies for other occupations or conditions. Taxonomies such as this could be a valuable resource for individuals understanding what DC could be of help in their personal context.

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# Digital Companion Choice to Support Teachers' Stress Self-Management: A systematic approach through taxonomy creation

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### Background

There are thousands of digital companions (DC) designed for emotional wellbeing and stress, including interactive websites, wearables and smartphone apps. Although public evaluation frameworks and ratings exist, they do not facilitate DC choice based on contextual or individual information such as occupation or personal management strategies.

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The aim of this study was to establish a process of creating a taxonomy to support systematic choice of DCs for teachers' stress self-management.

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We employed a 4-step study design. In step 1, we identified the dimension of stress self-management and strategic classifications. In step 2 we identified the dimension of digital techniques and conceptual descriptions. In step 3 we created six criteria for inclusion of DCs. In step 4 we used the taxonomy framework created by steps 1 and 2 and populated it with DCs for stress self-management as identified in step 3.

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First, in the dimension of stress self-management we identified 4 classes of strategies: educational, physiological, cognitive and social. Second, in the digital techniques dimension we derived 4 conceptual descriptions of DCs' mechanisms of action: fostering reflection, suggesting treatment, peer-to-peer support and entertainment. Third, we created 6 criteria for DC inclusion in the taxonomy: suitability, availability, evaluation, security, validity and cost. Using the taxonomy framework and criteria, we populated it with DCs for stress management ahead of presentation to teachers in a stress study workshop.

### Conclusions

We believe elements of our approach will generalise as principles for the creation of taxonomies for other occupations or conditions. Taxonomies such as this could be a valuable resource for individuals understanding what DC could be of help in their personal context.

Keywords: Digital technology; digital health; psychological treatment; stress; self-management

## Introduction

Self-care digital health smartphone apps, websites and wearables, referred to collectively in this

paper as digital companions (DC), are ubiquitous, but understanding which will best support individual needs in a given context is complex. The selection presented to the potential user is immense, with at least 10,000 DCs targeting behavioral and mental health [1] and the existing approach to DC selection is often opportunistic. Availability of mental health apps is hampered by high turnover: 50% of search results change within 4 months with an app is removed every 2.9 days from online platforms [2] and more than 200 health apps added every day to app stores [3]. Routes to adoption of DCs for psychological support include recommendations from health professionals [4], though one US based study found social media, personal searches, and word of mouth to be more common access routes [5].

User recommendation on app stores is another common route but it has its limitations, such as including different types and amounts of coverage. Additionally, the sources of the reviews are unknown. Taking the reviews at face value, a more detailed exploration of user recommendations of psychological apps has been achieved by machine learning sentiment analysis, revealing the top positive and negative themes for user satisfaction [6]. High cost, app instability, low quality content and privacy/security concerns were the most common dissatisfaction themes. Tracking, outcome visualisation and analytics, and content quality and variety were the most common satisfaction themes. Another study into anxiety apps alone also revealed that price negatively affects adoption, while ratings and reviews positively affect downloads, but only up to a point [7]. We also know that app descriptions influence adoption but can be unhelpful. Potentially stigmatising labelling such as app titles that imply a diagnosis for a mental health condition can constrain access or even cause harm [8]. Some apps use scientific language in their descriptions to verify their clinical validity. Yet one study of 73 popular mental and emotional health apps found that although 44% used such language, only two apps provided direct scientific evidence associated with app use [9].

More recent studies have begun to elucidate some relevant information on types of use for technology. One small survey recently showed that although smartphone apps were the most used DC to support mental health and wellbeing, they were often used in conjunction with another tool (eg, social media [10]). Importantly this study showed a relationship between DC medium and purpose: apps are used more for guided activities, relaxation, and tracking; social media for sharing experiences and to gain personal understanding; and Web-based provision for daily stress and anxiety management. This survey did not ask about use of wearables for stress, but the wearable medical device market continues to grow, with 60% growth predicted between 2019 and 2024 to \$27Bn [11]. Early evidence shows wearables can accurately capture exposure to psychosocial stress in everyday life [12]. Currently decisions on wearable choice seems to be guided by perceived value, design and brand [13] rather than condition management.

Self-management or treatment techniques are often search terms for DCs, but critically relevant information such as suitability of the intervention for an individual's context, occupation or existing self-management practices are often missing [14]. In meta-analyses of occupational studies where a DC has been used to support general wellbeing [15] or for anxiety, stress and depression [16] positive effects in these contexts over the short to medium term were noted. However, there is both considerable variation in occupation and little evidence in these studies of any attempt to align an intervention with a particular role or existing individual management strategy. The tendency is



simply to trial a DC that supports one or more strategy with an occupational cohort irrespective of the cohort's existing stress management strategies and preferences.

We know that the contexts in which people live and work influence their use of and ability to use health technology [17-20] and previous research has called for tailoring of healthcare technologies to specific users [21,22]. Contextual or strategic data and insight could logically aid both choice and strategy, and therefore potential efficacy of DCs and user outcomes. As has been noted elsewhere, research on DCs designed to have a work-related relevance for the mental and physical health of employees is scarce [23]. In this paper we present the processes of developing both dimensions for a taxonomy and the population criteria that facilitate selection of contextually appropriate digital support for stress. We chose to work with teachers and focus on their stress self-management due to the very high prevalence of work-related stress, averaging 2,100 cases per 100,000 educators in the UK in 2018 [24]. There are indications that Covid-19 may have exacerbated primary stressors for teachers [25], but we already know that contextual factors such as school organization and culture are critical factors for teachers' experience and management of stress [26-30].

Within the context of schools, individual stress-management support could be facilitated by DCs, particularly if teachers had a taxonomy to inform their choice.

This paper therefore makes the following contributions:

1. The selection of dimensions within which to classify stress self-management and digital health techniques that could offer support.
2. The process applied to develop the taxonomy: one that can potentially be adapted and applied in other contexts where digital support is sought for an individual's health condition to match their practices and values.
3. The methodology for populating the taxonomy.
4. A populated intervention taxonomy developed for teachers managing stress, with illustrative examples of apps that address teachers' needs, available at the time of writing.

## Related Work

We describe here prior work and evidence that fed into our choice of dimensions, classification and selection. This includes teachers' stress self-management research and previous frameworks and taxonomies on design and selection of technologies.

## Teacher Self-management of Stress

Approaches to aid teachers in stress management have been drawn from the literature on occupational stress and often applied population wide, though not without acknowledgement that "some (strategies) were unnecessary or differentially effective in individual cases" [31] (pg 127). There is evidence of benefits to teachers from stress awareness education [32] and physiological interventions including adapted mindfulness and relaxation training [33,34] and also exercise [35]. Psychological intervention evidence includes, for example, cognitive behavioral therapy (CBT) based programs [36,37] and mindfulness embedded in psychoeducation with social support adapted

for teachers [38]. Reflective supervision and consultation [39] and environmental adjustment or social support [32] have also been shown to be helpful.

Recent systematic reviews have examined teacher stress interventions and found a greater effect size associated with longer duration of intervention but most interventions were guided and not self-managed [40,41]. Those interventions that were self-managed demonstrated positive effects, although these varied in size. Such interventions targeted stress or burnout symptom reduction including positive psychology through gratitude journaling [42] and CBT-based education through bibliotherapy [37].

## Digital Companions for teachers' stress management

Delivering stress management interventions digitally could enable uptake. For example, digital delivery could reduce the cost of provision, improving accessibility and reducing risks of stigma [43] <sup>1</sup> which could be highly relevant to teachers. One tailored ehealth (ie, internet or mobile delivered healthcare) randomized-controlled trial (RCT) for teachers utilized an internet-based Problem-Solving Therapy (a form of CBT). Teachers receiving the CBT intervention reported significantly reduced symptoms of depression as well as a reduction in their perceived stress after the trial (7 weeks) and at 3 and 6 month follow-up [44]. Another study looked at stress as a contributor to insomnia amongst teachers, finding that unguided online CBT with psychoeducation amongst mostly female teachers significantly improved sleep [45]. A recent review of the effectiveness of occupational e-mental health interventions identified just one other study that included education sector personnel [46]. This was a self-administered online CBT-based intervention, but participants also received weekly personalized feedback on the modules. The effect on reduction in perceived stress across all sectors was large [47].

### Taxonomy creation and digital technology selection

We identified two approaches in the literature relevant to our goal of creating and populating a taxonomy. One is the evolution of designer and researcher focused frameworks, seeking to improve efficacy and evidence. The other is more focused on clinician and consumer adoption.

#### *a) Designer and researcher frameworks*

Frameworks focused on developing and evaluating technologies have led to better formalizing, detailing and defining of DC design. Fogg's persuasive design principles [48], expanded further by Oinas-Kukkonen [49] and complemented by Ritterband's design model [50] all informed the development of Mohr's Behavior Intervention Technologies (BIT) model for developers [51]. This model, along with other theory-based [14,52] and empirically-based [20,53] taxonomies and frameworks have sought to enable both better conceptual design and easier evaluation of DCs. Stoyanov's Mobile App Rating Scale (MARS) for designers has been used extensively in the scientific community and also led to a consumer assessment version, uMARS [54]. For our taxonomy these models informed our consideration of the digital techniques dimension of the taxonomy.

### *b) Clinician and individual frameworks*

Both the MARS and uMARS scales have been used for evaluating apps, with the latter using less technical language for patients to feed back on the engagement, functionality, aesthetics, information and subjective appreciation of quality and impact. The uMARS scale allows classic Human-Computer Interaction (HCI) features and elements to be evaluated to assist design iteration but it was not created to inform final user adoption. Three other relevant “Expert Review Evaluation Frameworks” (Reviews) have been created for users.

The ORCHA (Organisation for Review of Care and Health Apps) model, now paywalled, was specifically designed to inform adoption of mostly apps and has some online interventions too. Search is by condition or DC name. Data privacy, user experience and clinical assurance are each given a score [55,56].

The two other Reviews focus on psychological health: these are the Mindtools and Psyberguide websites [57]. Psyberguide is a public-facing website enabling search based on condition or treatment approach. The approach taken is that the user understands what concepts or treatment they want to choose (eg, tracking or social support) and the focus is on apps. Both websites publish assessment scores on credibility, user experience and transparency though Mindtools does not seem to have been updated since 2017. Psyberguide drew on the MARS framework incorporating additional privacy and security considerations. The American Psychiatric Association (APA) app framework [58,59] has also done this. Their framework provides a template for user assessment rather than presenting their own assessment scores. It offers both a quick eight question ‘screener’ as well as a much more detailed 5 step, 105 question app evaluation process which allows the end user to judge what is important and a good match. The starting point for this framework is the clinical diagnosis which informs the potential app selection. In theory their questions could be applied to websites and wearables as well although this does not appear to have been tested yet.

The main difference between these scales, Reviews and frameworks and our intended approach is the starting point. Our goal was to enable DC selection to be framed by someone’s occupation, condition and self-management behavior. For this, we required a taxonomy derived for teachers and stress from which they could identify their self-management strategy and supportive technology concept, then identify a DC that aligned with these to trial in a future study. To reach this goal firstly required selecting an logical dimension within which to classify stress self-management. Secondly the selection of a dimension within which to classify digital techniques that could support these strategies. Finally, the creation of a rationale for DC inclusion and selection of credible candidates. This outcome is illustrated in Figure 1: a populated taxonomy. This paper describes why we chose the dimensions of self-management strategies and digital companion concepts, how we categorised them and then our approach to identifying potential candidates.

## TEACHERS' DIGITAL STRESS COMPANION CHOICES

Stress Self-Management Strategies Digital Companion Concepts	Educational e.g. knowledge and awareness	Physiological e.g. relaxation, exercise, reminder	Cognitive e.g. problem solving, time management	Social e.g. seeking social support or social skill development
Fostering Reflection via Information - Health or Context	Stress Management at Work Fit2 Teach** TeacherTapp	Withings Steel SR	Daylio Fit2 Teach PRO**	Withings Steel SR TeacherTapp
Suggesting Treatment and Guided Self-Management	Equoo	Headspace* Calm* Sleepio	SilverCloud Wysa Big White Wall	Big White Wall
Peer-to-Peer Social Support	Fit2 Teach PRO**	Withings Steel SR Sleepio	Fit2 Teach PRO** Big White Wall	Fit2 Teach**
Utilizing Entertainment	Equoo	Nintendo/PS4 etc***	SilverCloud	Equoo

\*Only partial encryption of data \*\*Withdrawn due to lack of updates \*\*\*User to provide own device

Figure 1 - Populated taxonomy with digital stress companion choices for teachers

### Methodology

The study design process is summarised in Figure 2.

### The Study Design

#### Stress Management Dimension

To choose categories for the stress self-management dimension, we initially extracted descriptions from the qualitative data on the experiences of 14 senior teachers interviewed in a previous study [60]. Participants had provided over 80 accounts of how they managed their stress. These descriptions were complemented by evidence from systematic reviews of occupational stress [40,61,62].

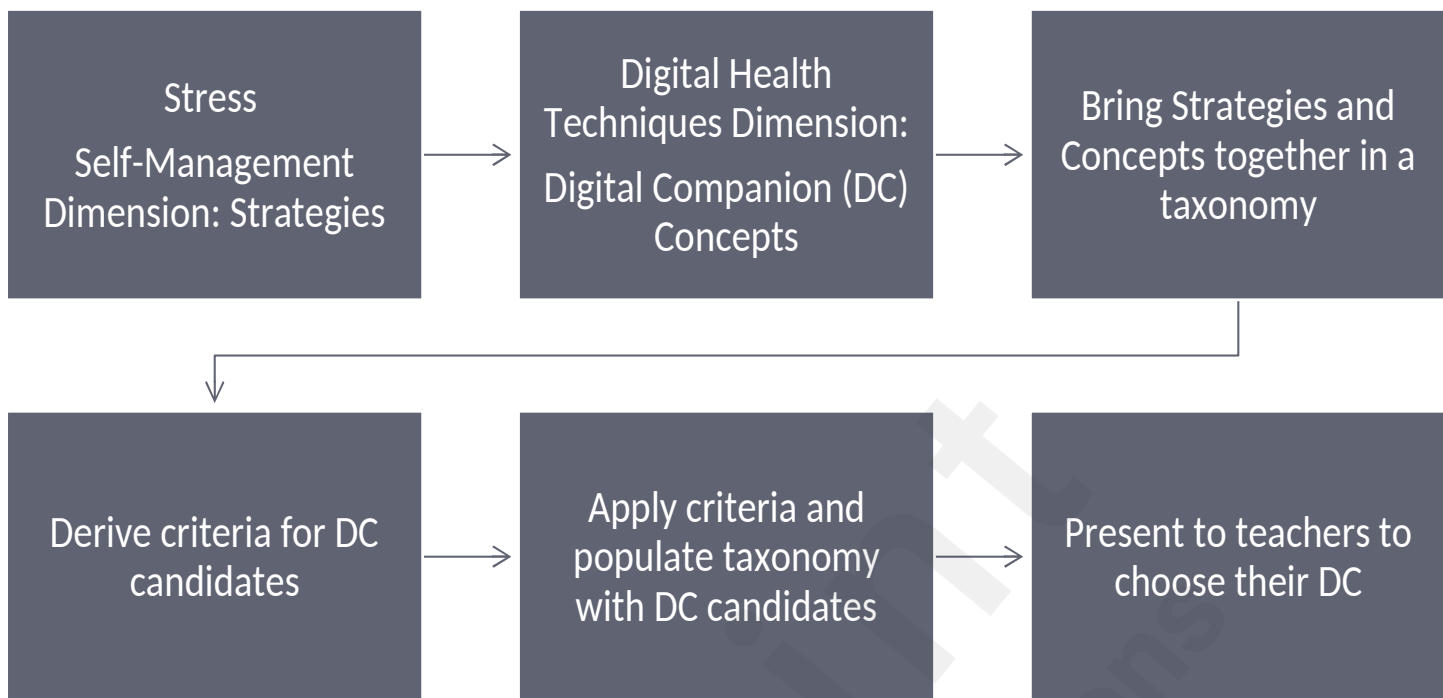


Figure 2 – Study design process summary

These interventions informed the ‘PICO’ literature search criteria: Patient and Problem (e.g., teacher and stress), Intervention (e.g., information, tracking, exercise or mindfulness), Comparison (often none), Outcome (e.g., identifying, support, management, reduction). We adapted the narrative method used in other studies [63,64], including checking references of relevant papers, alerts and citation tracking along with searches of academic databases including PsychINFO, Google Scholar, Cochrane and PubMed. Literature relevant to teachers’ self-management of stress was reviewed until repetition of themes revealed no further insight. Quality of papers was determined through their being published in peer-reviewed journals.

## Digital Health Techniques Dimension

For the health techniques dimension we reviewed the literature on persuasive design, digital health taxonomies and trends in digital health self-care, again using the snowballing method as described above. We were aware of drawing on the different but complementary cultures of HCI and health and that their definitions of lifecycles, evaluation and implementation differ [65]. Our interest was in producing conceptual descriptions of mechanisms of action that could support the methods of stress management already identified in the literature and those given by teachers in interviews. These concepts would necessarily comprise elements of design, behavior and theory, and draw on evidenced deployment of a DC for health self-management. Our aim was to create a conceptual description of the prevalent overarching technique or action of the DC that could be understood without ambiguity or complexity by the end user.

This approach was chosen for several reasons including that (i) many DCs use multiple techniques and we wanted to facilitate choice by the primary featured enabled action; and (ii) other systematic reviews have overlooked or found a paucity in description of behavior change techniques which would make categorization of DCs by such theory harder to achieve [66,67].

## Technology selection

To identify candidate DCs, we took the following steps to inform our decisions:

- (a) Suitability: we began with digital interventions utilized by teachers as described in a previous qualitative study, followed by a review of the literature for other candidates.
- (b) Availability: we looked at whether the technology is accessible on the two main mobile operating systems and had been updated within the last six months.
- (c) Evaluation: we checked whether the technology was ranked positively on 1 of 3 expert review evaluation framework (REVIEW) websites for apps and online tools (Orcha.co.uk and Mindtools.io) or apps only (Psyberguide.org) for credibility and evidence base, and user experience.
- (d) Security: we reviewed the privacy and security policy to assess whether the technology used encryption for data connection and storage (where relevant).
- (e) Validity: we searched for significant, published positive clinical trial results, and
- (f) Cost: Given that the commercial model for apps that are free means very limited access or a trade in personal data which we did not want to promote, we set a bar of £50 annual fee for smartphone and website apps, and £150 for a wearable.

## Taxonomy Creation

The process of reviewing existing literature for creation of the stress management and digital technique dimensions revealed different approaches to classification. Below we present our findings and rationale for our choice of classification of strategies and concepts and then share the procedure we followed to enable technology selection.

### Stress self-management dimension

We found 3 main approaches to categorization of interventions specifically for the support or management of stress experienced by teachers. It is worth emphasising that the value and goal of this conceptual categorization for our taxonomy was in identifying a practical, actionable strategy for the individual [68]. The classification approaches found were a) the level targeted by the intervention, b) the target of intervention or c) the intervention strategy. We describe each of these and why we considered the intervention strategy to have the most relevance and explanatory power for the stress dimension.

### Level of Intervention

Organizational, individual-organizational or individual level interventions were frequently described [61,69-72] with an additional level of a classroom focused approach being noted more recently [73]. The level of the intervention appears to be a way of describing the agent or group responsible for the stress management strategy. For example, the school leadership team or Multi-Academy Trust directors would be at the organizational level. As our focus is on self-management, this

categorization would not provide a practical framework for teachers' own stress management.

## Target of Intervention

Primary targets of interventions are the stressors themselves, which could be aspects of the work environment such as maintaining discipline or time pressures and workload [74]. The corresponding stress reduction strategies would then seek to reduce the occurrence of occupational stress amongst employees, such as workload reduction. This primary preventative approach for individuals should be the priority and a normal part of organisational management, as has long been argued in the healthcare sector [75,76]. Whilst many targets are well-described in the teaching literature they are beyond the control of the individual.

Secondary targets are the perception or responses of the individual person to the stressor itself and interventions are preventative or reactive. By targeting the way someone manages or copes with stress, the aim is to modify in a positive way the individual's response rather than remove the stressor itself. This can include for example peer-support groups or Cognitive Behavioral Techniques.

Tertiary targets of intervention are stress symptoms themselves, such as anxiety, insomnia or racing heart rate, and the intervention is reactive. The aim of targeting symptoms is to manage or treat the emotional, cognitive, behavioral or physical changes brought about by stress. Whilst identifying secondary and tertiary targets enables a better understanding of stress, they do not indicate a set of potential self-management choices. For instance, if a teacher becomes aware that their response to stress is a behavioral habit (both a response and a symptom), such as to start pacing the floor, this knowledge in itself does not provide any signposting to what action an individual can then take to combat the stress. Additionally, stress symptoms are not always obvious to the individual, such as nervous tics or fatigue. Levels and targets of interventions were used in a prior categorization of occupational stress management from general employee work [77,78] but for our purposes this conceptual framework does not always facilitate individual identification of action that could be taken to self-manage stress.

## Intervention Strategies

The third approach we identified was stress management strategies or training approaches [41,79-81]. We identified 5 overarching, non-mutually exclusive categories that could be supported digitally: 1. Educational 2. Physiological 3. Situational 4. Cognitive 5. Social.

Previous strategies had been described as i) Stress awareness and education, ii) Relaxation techniques, iii) Cognitive coping, iv) Biofeedback, v) Meditation, vi) Exercise, vii) Lifestyle advice, viii) Interpersonal skills training [80] (pg 105). We considered that several of these could be grouped together along with more detailed activities simply listed as exemplars. Thus education, awareness and lifestyle advice were grouped under education; bio-feedback, relaxation, meditation, breathing, aerobic activity or mindfulness were grouped under physiological; and cognitive coping strategies, such as controlling emotions, problem-solving or time management under cognitive.

Social support had been mentioned by authors but not listed as a category. It goes beyond interpersonal skills training embracing socialising and the therapeutic value of peer support [82] and



self-enhancing humor [83]. This social element along with descriptions of social support has been described in teachers' stress management research [32,38,41], hence our adding it as a category. We also noted in the literature some variation in the meaning of mindfulness amongst educators. It could mean the application of the established 8 week 'mindfulness based stress reduction' (MBSR) program [84,85], or the incorporation of MBSR as part of a stress reduction program [38] or simply a meditative component of a multi-strategic stress reduction study [29]. Whereas other authors have used mindfulness-based interventions for categorization [40] the ambiguity in use of the term meant we decided against using it as a category for strategy.

## Digital Technique Dimension

Our aim was to create a concise choice architecture that would be meaningful for potential users. This meaning would be established through the description of how a DC would provide support.

Other condition specific intervention reviews demonstrate varying approaches to classification of technologies. Suijkerbuijk categorised dementia interventions by purpose, such as support in daily life, safety, meaningful activities or communication [86]. Singh categorised HIV apps and websites by functionality, such as prevention, testing and management [87]. These approaches sometimes blended the strategy with the mechanism or contained the mechanism within each function and helped us to recognise that the primary focus for our categorisation should be the broad mechanism of how the technology technique enabled self-care.

Despite an increasing number of studies on the use of DCs in the workplace for occupational stress [88], reviews often focus on the type of intervention, such as CBT or mindfulness [16], and grouping them as such [40]. Reviews of the mechanism of action or concepts used by these apps are scarce and others have noted this lack of detail of persuasive technology design [89]. Also, reviews of wearables mostly seem to have focused on those for physical activity [90], but others reported on the incorporation of Behavior Change Technique 'clusters' [91]. These enabled us to compare and make a high-level reconciliation with the motivational affordances described by Orji [92], whose categorization was not always exclusive to one of the condensed descriptions below –see Table 2.

We found Nunes' focus on self-care which conceptualised the 'action-enabled design feature' [93] was similar to descriptions given by Klasnja to 'life-companion' apps [94]. We therefore reviewed the descriptions against each other to compare technique concepts. We then cross-checked them with the descriptions given by Orji and Chia to arrive at 5 comprehensive conceptual themes which we now describe as our digital companion concepts.

### *A. Fostering reflection by making health and contextual information available*

Both Klasnja and Nunes described the ability to track health data first and we retained Nunes' definition of "fostering reflection by making health and contextual information available". This data-enabled reflection has been found to be significant for those with severe mental illness [95] bipolar disorder [96] and stress [97] amongst other psychological conditions.

### *B. Suggesting care activities or treatment adjustments and guided self-management*

Nunes' second description of "suggesting care activities or treatment adjustments" went beyond the



mere “increasing accessibility” of health information described by Klasnja, to actual adjustments that an individual can make. However, this category needed to also more explicitly include delivering guided self-management described in the literature on stress, such as directed breathing or a CBT program. Hence the second category was adapted to “suggesting care activities or treatment adjustments and guided self-management”.

### *C. Peer-to-peer social support*

Nunes specifically describes a trend as “sharing self-care activities and learning from others with the same chronic condition” (pg 23). The limitation of this for our purposes was the medical emphasis but we did want to include the significance of peer relationships. Klasnja talked about “leveraging social influence”, capturing the social-sharing concept, building on Oinas-Kukkonen’s social support principles [49], so we re-defined this category as ‘peer-to-peer social support’.

### *D. Utilising entertainment*

Klasnja also described utilising entertainment. This went beyond the gamification techniques recognised by Nunes which can be used in the technology design of any of his categories. Taking part in a purely fun tech-enabled activity not intentionally designed for symptom management has been shown to reduce stress symptoms [98,99].

### *E. Involving the healthcare team*

Nunes gave a strong emphasis to the patient (not medical) perspective, but 2 (of his 5) categories still recognised the shared-care dynamic between patients and their formal and informal carers. Klasnja recognised this shared approach but described it under a single form of intervention (involving healthcare team) and for our purposes this sufficed.

For our taxonomy we did not require the concept of involving the healthcare team as we were focusing on self-management. We therefore brought the 4 digital companion concepts with the 4 stress self-management strategies together in a matrix to give us a taxonomy that could then be the framework for DC selection. As a stand-alone taxonomy, this framework gives a structure for anyone seeking to choose a tool to support stress management. Figure 3 depicts the taxonomy.

## DIGITAL STRESS SUPPORT TAXONOMY MATRIX

Stress Self-Management Strategies → Digital Companion Concepts ↓	Educational e.g. knowledge and awareness	Physiological e.g. relaxation, exercise, reminder	Cognitive e.g. problem solving, time management	Social e.g. seeking social support or social skill development
Fostering Reflection via Information - Health or Context				
Suggesting Treatment and Guided Self-Management				
Peer-to-Peer Social Support				
Utilizing Entertainment				

Figure 3 - Taxonomy Matrix

### Taxonomy population

To populate the taxonomy we applied the technology selection steps. This selection process was important for ensuring trustworthy DC candidates from which teachers in a subsequent study could make an informed choice. The process for population is summarized in table 1.

Technology Selection Steps		Rationale
a)	Suitability: Qualitative data from occupation and behavior	We began with digital interventions utilized by teachers as described in data in a previous qualitative study
b)	Availability: Verify whether the technology is accessible on the two main mobile operating systems and had been updated within the last six months	Ensures the technology is available to a wider audience and supported by the developers
c)	Evaluation: Search one or more of the Expert Review Evaluation Frameworks (Review) to see if the technology is ranked positively	Gives professional or third-party view on the credibility, evidence base and user experience
d)	Security: Review the privacy & security policy	Shows whether the data is stored and transmitted securely with encryption to give an indication of risk
e)	Validity: Search for research papers on the technology	Enables any trials with the technology to be considered
f)	Cost: Assess cost	Considers whether the technology is in budget

*Table 1 Summary of DC population process*

Our starting point were suitability and availability, based on the previous qualitative study exploring teachers' familiarity and use of digital tools for stress management [60]. This reflected insight on the influence of context to design as described in both usability study methodologies [100] and the person-based approach [20]. Where that did not provide a candidate we reviewed the literature, the NHS App Library and Carlo's behavioral health app review [101] and the scientific literature. Of the 12 apps originally named by teachers, eight were available on both iOS and Android platforms (Teacher Tapp, Fit2Teach, Headspace, Mindshift, Pacifica (now called Sanvello), Calm, Insight Timer and Happy not Perfect), but one of these (Fit2Teach) had not been updated for over two years. Given that it was uniquely tailored in its approach, and that the associated facebook group had recently been updated, we contacted the developer but unfortunately we had no response. Neither Fit2Teach or TeacherTapp had been designed for stress, but both offer education tips and insight, and the opportunity for reflection.

The two apps that used diarising as their prevalent tracking strategy (My Wonderful Days and Now Then Free), were not available on both platforms and another two app descriptions were not complete enough for certain identification. The online Cognitive Behavioral Therapy program that had been described by one teacher was only available in one English county. The wearables being used by teachers were Fitbit models (Charge, Alta, Blaze), Samsung Gear 2, Polar M340 and Apple Watch. No other candidate technologies were identified from the literature on teachers' stress.

We searched for available DCs within the positive expert review evaluation frameworks (Review) but due to disparities observed between Review assessments [101] and our concern with privacy and safety we read through all the security and privacy policies. This was also important for all wearables as none of them are covered in the Reviews. Occasionally, security through encryption was still not evident from the published policy and in these cases the developer was emailed for further information.

Many DCs have not been tested through trials, so this step (validity) was not a reason to exclude them, especially wearables where data is sparse. Conversely, some popular apps that did not satisfy the safety inclusion criterion had significant published evidence of their efficacy. For these we presented this scientific evidence as a reason for inclusion despite no or partial encryption. Finally, cost was considered.

Our final selection of DCs for presentation to teachers comprised 4 apps named by teachers in the previous study (Headspace, Calm, TeacherTapp, Fit2Teach), 4 alternative apps sourced from one or more of the Reviews (Equoo, Sleepio, Daylio) and 1 app from the scientific literature (Wysa, an AI chatbot). For websites, 1 was sourced from a Review (Big White Wall, now Togetherall), 1 from the NHS (Stress Management at Work) and 1 from scientific literature (SliverCloud). For wearables, 1 was identified from the scientific literature with medical grade data assurance (Withings Steel HR watch).

The stress self-management strategies, digital companion concepts and selected apps were brought together in the taxonomy matrix shown in the introduction in Figure 1 with caveats shown by the asterisks.

## Discussion.

This paper describes the process of creating a context-based framework to facilitate DC intervention choice. Using the dimension of stress self-management, we created classifications of strategies that were derived from empirical research and the literature. Using the dimension of digital techniques we created conceptual descriptions of the DCs' mechanisms of action informed by the literature. Bringing these together in a taxonomy gave the framework which we could populate with DCs for teachers' stress self-management according to availability, evaluation, security, validity and cost. It is a starting structure for presentation and selection of contextually appropriate DCs.

Populating the taxonomy presented some significant challenges. The transience of apps or their ratings (availability and evaluation) meant that by the time we came to present our taxonomy to teachers one peer-to-peer supported CBT website had been removed. Likewise, a highly rated diarising app had one of its Review ratings plummet during our study, although we found no cause for concern on re-checking of the privacy policy. Another CBT course with extensive validation through research publications was included as it had been commissioned by the local NHS in the areas where the teachers we planned to work with were employed. However, when one participant tried to access it, a referral from the GP was required which precluded pure self-management. Some apps we considered were described as designed for stress but included reference to medical conditions such as psychosis and schizophrenia. We were concerned that their inclusion would imply a medical need, or such diagnostic association could be too sensitive for a study that was focused on occupational stress.

It became clear as we reviewed candidate smartphone apps that a number do not offer comprehensive (if any) encryption of data, even those where the funding model requires user payment (thus requiring input of more sensitive data). Our search was not exhaustive: that would have been impossible. To ensure candidates in each category, when we were able to reference scientific studies on app efficacy, (eg, Headspace and Calm), it was decided to include them in the taxonomy with the caveat that whilst widely used, there was no or only partial encryption of stored and/or transmitted user data.

The sequence of application of our selection criteria was affected for wearables due to their cost. Of the six different wearables described in the teachers' study, price excluded the Samsung Gear 2, Polar 340 and Apple Watch. Obsolescence excluded 2 of the Fitbits (Blaze, Alta) leaving the Fitbit Charge. This failed the encryption requirement being non-specific and considered on external evaluation to be inadequate<sup>6</sup>. Database search, paper retrieval and website scrutiny enabled us to identify one wearable from Withings that satisfied all the set criteria, offered support for 2 of the 4 stress self-management strategies and fell into the set price bracket.

Importantly, using qualitative field data as a starting point was crucial for identifying DCs that would not have appeared in a search based on the condition of stress. For example, TeacherTapp was

designed as a research tool to give voice to teachers' opinions. Yet its educational content and sense of peer-connection were considered valuable for relieving feelings of stress. Likewise, Fit2teach, although designed for wellbeing and work-life balance, is listed under 'education' not 'stress' in app stores.

In a world in which automated or unsubstantiated rating systems are prevalent there is still a need for autonomous, informed, human decision making that draws on personal knowledge and understanding [103]. Individuals need to be able to confidently identify their personal preferences to improve chances of adherence [5]. Improving app selection by context-based condition management and conceptual categorisation could logically aid both adoption and potential efficacy of digital health tools and reduce attrition before the desired outcome. Our findings illustrate however that there is no quick route to informed adoption.

The populated taxonomy was presented to eight high-school mid-management teachers in workshops to enable them identify how they currently managed their stress and how it could be supported by digital means. Their chosen DCs were then used during a planned longitudinal study in the school summer term (during partial covid lockdown) and on into a serendipitous study in the autumn (where teachers were back in hygiene-adjusted school settings). Six out of eight teachers were still using their DC choice six months after beginning. Analysis of these findings will be the subject of a subsequent paper.

## Limitations

Our review of the literature was not exhaustive and other research may reveal stress-management strategies beyond those we identified. Additionally, there could be disagreement on the way that we have grouped or limited the explanatory power of DC concepts, or that they are relevant for conditions other than stress. Only further research will be able to substantiate whether these issues are significant.

We have already noted in our process and discussion that selection of technology can never be complete and is only ever a reflection of what apps and information is available at the time of the search. Additionally, our starting point for apps was a previous small study where the participants had self-selected; a different or wider cohort could have produced other findings. There is no circumventing the reality that populating a taxonomy will always have to be revisited at the time of use.

Another limitation of our approach is potentially in embedding the notion that dealing or coping with workplace stress is just the responsibility of the individual. This individualized approach can place a profound burden on a teacher as it fails to acknowledge the complexity of the origins of stress [104]. It is not our intention to imply that managing stress is only the responsibility of the individual, and through our context-based approach we are acknowledge the structural and environmental influences, in addition to the socio-cultural factors within a school.

## Conclusion

There is no quick and easy solution to identifying a safe, efficacious, contextually and individually

appropriate app, website or wearable to support self-management of health, wellbeing or a specific health condition. Evaluation frameworks are valuable and evolving but would benefit from complementary information for users to be able to identify their preferences and consider whether the technology on offer fits their current behaviors or contexts.

If an individual can use a taxonomy to identify their preferred management strategy and from there make an informed selection of a DC for support, the user starts from a strong position. We hope that these procedures can generally inform professionals seeking to facilitate the selection of a DC for an individual's self-management of a named health or wellbeing condition. We also hope that our populated taxonomy can be a specific starting point for teachers' DC supported stress self-management, and one which can be refreshed through re-population in the future.

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## Conflicts of Interest

None declared.

## Abbreviations

DC Digital Companion

CBT Cognitive Behavioural Therapy

RCT Randomised Controlled Trial

MBSR Mindfulness based stress reduction

MARS Mobile App Rating Scale

PICO Patient or Problem, Intervention, Comparison, Outcome

HCI Human Computer Interaction

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