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ORIGINAL PAPER

The Living Library: a process-based tool for open literature review, probing the boundaries of open science

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Abstract

The Living Library is a novel tool for opening the scientific process of literature reviewing. We here present its core features, set-up and workflow, and provide the open-source code via GitHub (https://github.com/Simon-Dirks/living-library). The Living Library allows researchers to sort articles thematically and temporally, has a built-in open logbook, and uses a responsive methodology. These core features render the Living Library both a practical tool, and an educative framework for reflection on the research process. Its use deepened our understanding of what it means and what it takes to open science, which we summarise in three main lessons: openness is multidirectional, involving sharing *and* receiving; openness is relational and as such requires boundary work; and openness entails judgments of relevance. This highlights the intimate connection between research relevance and open science: Opening science is no categorical practice, but the continuous syncing to a world in motion—opening up *for* it and *to* it, to varying degrees at different boundaries, in response to what is happening and what matters. The Living Library models what such syncing can look like in relation to the evolving academic conversation. We encourage further experimentation with the Living Library to probe the boundaries of open science.

Keywords Open science · Literature review · Research tool · Philosophy of science · Boundaries · Research culture

Introduction: presenting an open science tool

In this paper, we present a new tool for open science research, the Living Library. The Living Library provides an online platform and methodological framework for open, continuous literature reviewing. As a research medium, it explores what open-

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ness means in light of the human dimension and interpretive nature of engaging with societal questions. As a tool, the Living Library allows researchers to collectively sort, dynamically interpret and openly discuss the evolving literature on a topic of interest. The interface is built around a timeline along which articles can be filtered, themes with which articles are coded, and an open researcher logbook that documents the development of the library. The first rendition of a Living Library can be found via this link: https://eduvision-living-library.web.app/, and the code to develop your own Living Library can be found via this link: https://github.com/Simon-Dirks/living-library.

The paper proceeds as follows: in Section "Introduction: Presenting an Open Science Tool", we present a short overview of how the Living Library was conceptualised and developed, connected with an argument that more attention is needed to the opening of scientific processes, not only products. We then introduce the practical elements of the Living Library and their role in (re)conceptualising and opening the reviewing process in Section "Materials and Methods of the Living Library", followed by a series of reflections on the concept of openness in scientific research generally and within the context of the Living Library specifically in Section "Results: Lessons learned". In Section "Discussion", we consider the implications of these lessons for the wider research community, and conclude with a few words on the scope and applications of the Living Library.

Origins and purpose of the Living Library

The name "Living Library" is fitting for several reasons. First, it captures how the process of conducting a literature review is a selective and interpretive endeavour undertaken by *living* people; researchers with interests, perspectives, positions, and purposes (see Akkerman et al. 2021), who foreground some and background other strands of the literature. Second, the literature being reviewed is a *living* stream of conversation, though slower than a face to face one. New articles are being written just as those which have been recently written are being published, newly published articles inspire yet to be written ones, and so on. A conventional literature review typically results in a mostly static and necessarily truncated snapshot of the literature in a particular domain of research. By comparison, maintaining a Living Library encourages researchers to continuously engage with the wider ecology of publications in which they are situated historically and contextually, and it allows to fluently broaden, narrow or shift focus in response to changes in the academic conversation. Thirdly, the Living Library earned its name by having had a life of its own from the very beginning. Its development was not planned and preconceived, but rather set in motion organically, animated by the need to connect with each other, with our values as researchers and educators, and with what is happening and what matters in the world.

Concretely, the Living Library embodies a response to an experience in April to July 2021, where some of the present authors conducted a (conventional) literature review on education during the pandemic, during the pandemic (Meulenbroeks et al. 2022). This reviewing process stretched over a short time period and took a linear, atemporal approach: We combed systematically through a large amount of litera-

ture to create an overview on the academic discourse across a set period of time (in our case limited to articles published since the onset of the pandemic), regarding a defined topic (the effects of the pandemic on education). It soon became evident that this atemporal snapshot approach was insufficient to adequately capture the rapid changes occurring within the literature at that time, and the need to 'sync' with the changing world was urgently felt by the team. The prevailing experiences of disconnect and disorientation were shared by many researchers and educators during this period, as our review found: A theme resounding in many of the articles was the need to reconnect—with each other, with our values, with the changing world—expressed in calls for moving towards what can be conceived of as a "pedagogy of care" (Meulenbroeks et al. 2022).

The recognition of this wider need propelled our search for a more *care*ful and in that sense slower, yet more responsive and in that sense agile way of reviewing literature. As such, we see our project embedded in a larger movement, much like Anderson (2004) observes that a larger cultural need for change can express itself in researchers' felt "calling" to pursue particular questions or topics. We propose that the calls for connection and care identified by Meulenbroeks et al. (2022) and the currently amplifying interest in open scientific practices (see e.g. Christensen et al. 2020) express the same cultural need for realignment and reappraisal within and beyond academia. The Living Library addresses this need. We decided not only to share what we learned from the process, but also to mould the resulting product—the software of the Living Library interface—and the associated methods into an accessible framework to make it easier for others to do what we sought to do.

The Living Library thus has a dual purpose: On the one hand, it serves to *disrupt and provoke existing practice*, challenging researchers to probe the boundaries of openness in scientific processes. On the other hand, it serves to *inspire and support new practices* that enable researchers to enact open science values; to connect with each other and with the evolving academic conversation, to align their research with the ongoing changes in the world, and to share their work at the same time. With these purposes in mind, the meaning of open science deserves revisiting.

From open product to open process

The term "open science" is rapidly joining the list of academic buzzwords in university mission statements and strategy plans worldwide and is probably familiar to most our readers. Yet, whether we all mean the same by it is a different matter: The concept of "open science" has been interpreted in a broad range of manners (Bartling and Friesike 2014), allowing vague usage of the term with selective or minimal commitment. This has led to conceptual confusion (Fecher and Friesike 2014) and even to destructive practices (Hobma 2022). Such openwashing waters down the open science movement and can even directly obstruct it when the figurehead "open science" is used to advance practices that are *counter* to the values of open science (Sanders and Bowie 2020).

To render a wide-angle view on these values, Fecher and Friesike (2014) provide a helpful discourse analysis, which identifies *open science* as "one term, five schools of thoughts", i.e. as an umbrella term that can cover a large set of practices

and principles with interconnected core values. We identify these core values to be transparency, interoperability, collaboration, and accessibility. Transparency refers to the opening up of the processes that contribute to a scientific product by sharing dialogues, musings, notes and difficulties. Doing science is a non-linear and discursive process; pursuing transparency at all stages of research goes hand in hand with a deeper consideration of how the eventual products of scientific research, be they written communications or tangible materials, are created by individuals situated in institutions, guided by norms and values, and pursuing certain purposes (Akkerman et al. 2021). By interoperability, we mean the creation of products that can be used, re-used, added to, and adopted, using information from the accompanying scientific communication. This extends beyond the realm of computing science; it is relevant for all scientific products. By collaboration, we mean the intentional creation of working environments that understand science as a collective process, antithetical to competition. By accessibility, we mean the possibility to participate in the co-creation of scientific information at all stages of the research lifecycle. We recognise that not everyone will identify these as the core principles of open science and see this as a natural consequence of attempting to characterise a large social movement that manifests in unique ways in different contexts. We further acknowledge the temporal fluidity of the concept; indeed, our own understanding of open science has considerably evolved through our engagement with the Living Library, as is its educative purpose. Specifically, we have come to see openness in science as inextricably intertwined with closedness and would characterise it as a way of being in the world, rather than as a set of behaviours (as we will address in further detail in the results and discussion sections of this paper).

Besides the challenging definition of the term "open science", another pitfall is its implementation: Even when the meaning and implications of open science are explicitly outlined, practice does not follow automatically. At Utrecht University, where the present project is embedded, open science has been made integral to the university's mission and has a dedicated program for its innovation and promotion (see Miedema 2022). And yet, a recent survey amongst the academic staff has shown that the full meaning and scope of open science are scarcely understood and its practices poorly integrated in daily work (Brinkman et al. 2021). It stands out not only at Utrecht University, but across Europe (Moradi and Abdi 2023) that open science has become nearly synonymous with open access to scientific products such as data, code or publications. This focus is understandable, considering the still predominant paywalls between scientific products and their readership (e.g. Wenaas 2022). However, most open access practices do little more than shift the financial burden from readers to researchers and their institutions, which ironically still renders access to open access publishing a privilege of socio-economic status[1] (Cascant Sempere et al. 2022). Looking beyond issues within the realm of open access itself, the deeper

[1] In this light, while we are encouraged to see an increasing number of journals making their articles openly available to readers, we are critical of the sometimes exorbitant article processing charges associated with common approaches to open access publishing routes. As authors, we recognise that it is a privilege for us to participate in this open access publication process, owing to the socio-economic standing of the research institutions at which we are situated.

issue we wish to address here lies in a conceptual misunderstanding, namely: An open product of closed science is not equal to a product of *open science.* The primary emphasis on open *products* has contributed to a superficial, if not unsustainable, approach to open science which neglects the various facets of openness at all stages of the research lifecycle.

It has been long argued within philosophy of science, ethnography of science and science and technology studies that research processes shape research products (e.g. Kuhn 1962; Lakatos 1976; Latour 1979; Jasanoff 1995; Hull 2019). These arguments have more recently received empirical support (Landy et al. 2020; Sridhar 2022), making it hard to ignore their significance. Applied to the topic at hand, this means that opening up scientific processes is an integral part of creating open science products. However, the opening of scientific processes asks more of individual researchers than does opening access to products, as will become clear in the following pages. Enactment of the above detailed open science values should therefore be supported by the institutional research culture, which in turn requires the means and facilities to experiment and embed daily work in open practices.

It is in this context that we present the Living Library as a process-based open science tool with focus on the elemental part of the research process that is literature reviewing. The Living Library has a number of features that enable, encourage, even require researchers who use it to remain open about and towards their work throughout the process and explicitly point out shifts in research objectives and search strings. In the following section, we will outline these features, present their practical domains, and reflect on their conceptual significance.

Materials and methods of the Living Library

To present the basic features and uses of the Living Library, we take our prototype as an example. By referring to the first existing Living Library as a "prototype", we imply both that its form may evolve as the open source code is adapted to various purposes, and that its content (i.e. the effects of the pandemic on education) is specific to the project within which the Living Library was created, but by no means representative of the wide range of content areas to which it may be applied. Other researchers may create Living Libraries in a multitude of different fashions as suits their contexts and purposes. Thus, rather than necessary conditions, the following can be seen as a 'starter kit', a general roadmap for developing one's own Living Library. For further directions in a hands-on exploration of the tool, we provide a practical step-by-step guide on GitHub alongside the code (see https://github.com/Simon-Dirks/living-library).

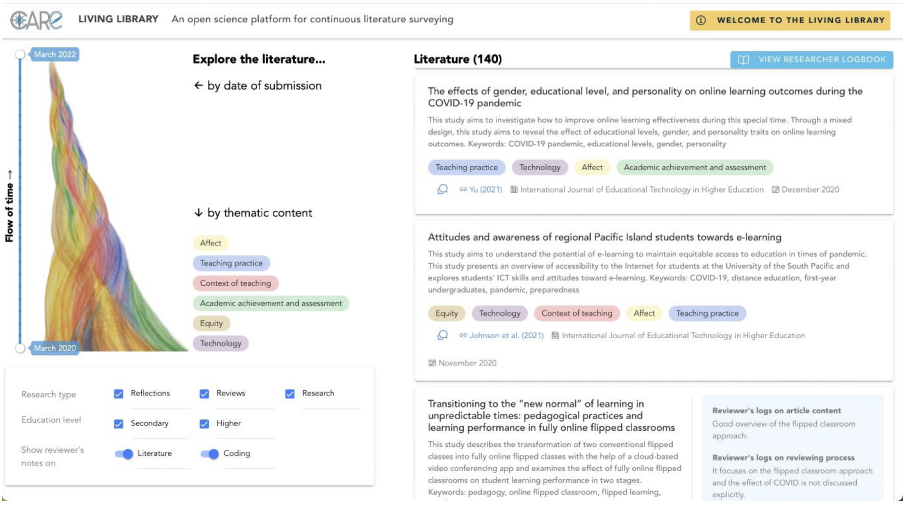

Fig. 1 Landing page of the Living Library prototype platform. The landing page is broken up into three distinct sections. On the far left is a timeline through which you can explore the literature. The literature is represented as a stream composed of intermingling strands of different colours, each representing a theme. The themes are listed in their respective colours as buttons next to the timeline, where the buttons serve to filter articles thematically. Below the timeline is a box with further filters that can be selected and unselected. To the right of the timeline is a list of all of the articles included in the library which a user can scroll through. Each article is shown with a title, abstract and summary and tagged with one or more of the themes. To the right of the title and abstract is a text box that shows researcher notes on the article content and the coding process. At the top right of the page is a button leading to the researcher logbook

Basic functioning and core features

The Living Library is accessible as an online platform with an interface that runs on Google Excel sheets, and the landing page can be seen in Fig. 1.[2] The code for the prototype software is open source and available on the indicated GitHub page. The online platform of any given Living Library is public; the associated Excel sheets are shared and edited amongst the researchers who create and maintain the library (the "librarians"), and these sheets are extractable as CSV files from the public platform.

In one sheet, referred to as the "article repository", researchers thematically code newly published articles and briefly summarise them to facilitate overview on up-to-date literature contents. For each article row, one column is dedicated to researcher notes regarding decisions on the coding, and regarding the content of the article. This encourages researchers to voice observations, ideas, doubts, questions, and reflections throughout the reading, sorting, and coding process. A separate sheet serves as a collective researcher logbook, to document decisions about the reviewing process in general and reflections on the development of the themes in particular (Fig. 2). These

[2] The code for the Living Library is sufficiently pliable to be adapted to other research management softwares. For our prototype, Excel was used and thus we make direct references to the same throughout. The important aspects of a good software for use in a Living Library are shareability, discrete elements that can be linked to the code, the possibility for live updating and pliability.

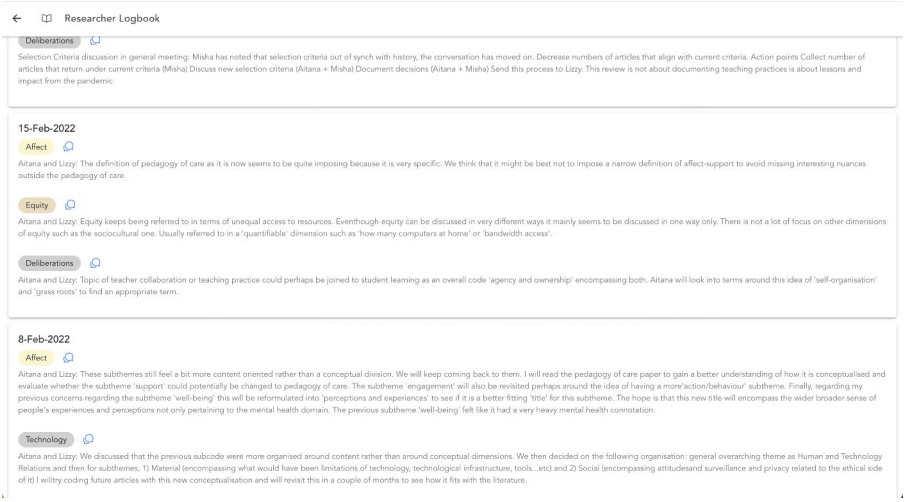

Fig. 2 *Entries from the researcher logbook as seen on the public platform of the Living Library prototype. Each entry is tagged with one or more themes. Entires that are not theme-specific are labelled as "deliberations". In this excerpt, there are three logbook entries (partially) visible.*

two types of process-based documentation are kept separate to distinguish between their temporalities and associated level of detail: Recurring issues in the fine-grained individual researcher notes taken during the coding process may be addressed over a longer period of time collectively in the researcher logbook. Vice versa, larger developments documented in the researcher logbook may be illustrated, retraced, or further investigated via the article-specific notes. This parallel approach to documentation allows the team to zoom in and out as needed to continuously integrate their work.

The contents of both Excel sheets are rendered live on the platform whenever users refresh the page. The platform interface allows library visitors and librarians to filter articles according to the coded themes, article submission dates, as well as a number of other filters that the researchers can customise by editing the code and sheets. Both articles and logbook entries are equipped with a pinboard function (marked by a speech bubble icon), which allows any library visitor to contribute observations, questions, ideas and links to materials related to the contents of the library.

We consider the following three functions as the cornerstones and defining properties of the Living Library: *Iterative thematic coding*, to foster meaningful interpretation and responsive engagement with the literature; *temporal sorting*, to raise awareness of the changing reality giving rise to and the historical context embedding the academic conversation; and the *public researcher logbook and notes*, which provoke new forms of openness and deeper reflection about the reviewing process. Other features, such as the public pinboards, as well as occasional "Why?" buttons on assigned themes that render the researchers' reasoning for their coding decisions, represent further experiments in pushing the boundaries of open science. Note also that these features are yet to be tested in action with library visitors, as the prototype here presented has not been advertised or otherwise called to public attention previous to

the writing of the present paper. The reader is invited to engage with our prototype platform, posting on the pinboards and considering the advantages and drawbacks of opening one's Living Library to public conversation, as well as exploring the public 'backstage' areas of our reviewing process and reflecting on the implications of such radical openness.

Setting up a Living Library

Source code

The Living Library prototype was developed using Vue.js (a JavaScript framework) and Ionic (a UI toolkit). To host the website and save comments submitted to the pinboards, Firebase was used, which is an online development platform offering (initially free) database and hosting functionalities. The Living Library source code and starter guide are publicly available on GitHub using the strong copyleft GPL-3.0 licence. The guide details how Excel sheets are linked to the Living Library platform. On the indicated GitHub page, you can find the guidelines and extended supplemental information needed to start your own Living Library. For the sake of brevity, we will not repeat that information here. Questions are welcome via email to livinglibrary@uu.nl.

Researcher logbook

We recommend beginning by setting up the Google Excel sheet for the logbook and establishing a habit of documenting the researchers' deliberations from the start. Doing so with future newcomers in mind as readers will pay in the long run; a Living Library is an enduring and evolving ecology that may see different researchers, student assistants and other librarians contribute over months and years. The researcher logbook also serves well as a home base to identify and discuss potential themes emerging from the literature during the beginning stage of building a Living Library.

Article repository

The article repository is set up as follows: Each article occupies one row, with the columns containing title, author name(s), submission date, *live* thematic code(s), *piloted* thematic codes, article summary, researcher notes, and a link to the article. The purpose of the *live* vs. *piloted* thematic codes columns will be further explained in section "Maintaining a Living Library". The submission date may be exchanged for the publication date, however only if there is a project-specific conceptual reason for including the duration of the publication process in the timeline (i.e., peer review, revision, etc.). Otherwise, submission date is the recommendable time stamp, seeing that it gives a more accurate view of what is being talked about when.

Depending on the particular purposes of a given Living Library, columns may be added, removed, or their content adjusted. Depending on which of the custom columns the researchers decide to open up to the public (as filters or otherwise visible

features of the interface), the according adjustments can be made to the source code, as is further discussed under "Customisable filters".

Article selection

Once the supporting frameworks are established, the process of filling a Living Library begins—like any traditional literature review—with a selection of the available, relevant literature on a topic of interest. Which articles count as relevant to the topic and how the influx of library material is best kept within manageable bounds needs to be agreed upon by the researchers in the form of concise selection criteria. Over time, as the literature develops, these criteria might need to change, for instance when the amount of newly published articles that meet the criteria exceeds the capacity of the researchers to code them; in the inverse case, when the number of relevant articles dwindles; or, alternatively, when the research team decides to shift focus for other agreed-upon reasons.

Thematic coding

Once a sufficient number of articles has been selected, the first round of coding can begin. The methodology we used in our prototype was an adaptation of open coding (Khandkar 2009). This entails first reading through an article and highlighting those sections that address topics which are central to the article. The highlights are then coded according to the themes in use at the point of coding or labelled as "other" if none of the existing codes apply. Each article can receive several labels.

When setting up our Living Library prototype, we started from the themes we had identified in our earlier literature review (Meulenbroeks et al. 2022) and used these tentatively, adjusting them based on whether and how well they captured the article contents. However, the process can also be started without an existing framework in mind by highlighting key passages from a first set of articles and observing what common themes emerge from those, then—once discussed and agreed-upon by the team—applying these themes to code consecutive articles, adjust if needed, etc.

Customisable filters

As mentioned, the Living Library features several customisable filters to refine literature searches beyond thematic and temporal selection. For instance, researchers interested in tracing the progress of open access publishing across countries might want to create filters for the country of origin and for whether or not and in what manner an article has been published open access. A research team may be interested in filtering articles they had difficulties coding to look for potential patterns across their contents, and/or the types of difficulties they posed, in a more targeted manner. Any such filter can be added as a column to the article repository Excel sheet, and the researchers need to agree on the categories and codes applied therein. The platform interface can then be customised accordingly. To optimally support this process, the Living Library source code has been rendered as transparent and plastic as possible within the scope of our project (Dirks 2023).

Note that columns in the article repository do not all need to be represented as filters on the platform. Each decision to render a column as a filter on the platform is also a decision about which contents to open up to the public.

Maintaining a Living Library

The maintenance of a Living Library unfolds in iterations: A coding scheme is applied to incoming articles, its alignment with their content is closely monitored, signs of misalignment are documented and discussed, realignment of the coding scheme is planned and piloted, then adopted if performing well, and so the circle closes and repeats. In principle, the looping back and forth between literature observation and conceptual adjustment is similar to the back and forth between practice and theory in the design research process (Bakker 2018). However, the responsive methodology of the Living Library differs in that its aim is not incremental improvement of both theory and practice, but rather iterative alignment of theory to the changing academic discourse.

This responsiveness is the beating heart of the Living Library. Academic discourse and the related emerging literature themes can be seen as meaningful movements within a world in motion (Akkerman et al. 2021). These movements are interpreted and reinterpreted in the course of reviewing. This understanding is embodied in the Living Library through responsive open coding. It continually poses the question of what is happening and what matters in the literature and challenges researchers to notice when conceptual categories need changing (Fig. 3). The researcher notes and logbook integral to the Living Library format aid and provoke this reflexive practice. In this manner, the responsive methodology entails acknowledging the positionalities and purposes of individual researchers and research groups as the human and contextual dimensions integral to the research process. This opens opportunities to reflect on and transparently record the ways in which researchers and their supporting networks are shaping the process of knowledge- and meaning-making.

The following outlines the Living Library's responsive methodology in terms of a stepwise procedure, yet this procedure is not meant to be applied *routinely*. Rather, it serves as a *guideline* to be improvised upon in alignment with the development of the literature and the researchers' collective understandings and purposes. We begin by detailing the first iteration upon setting up a Living Library.

1. The tentative coding scheme is piloted for a period of time, either agreed-upon in advance by the team, or open-ended, until the coders have gathered enough experience to warrant further deliberations. Throughout this first piloting phase, the researcher notes during article coding are particularly important. Recurring observations (experiences of difficulties or doubts, as well as of ease and certainty) are informative of alignments and misalignments between the coding scheme and the literature. Perhaps the most informative of misalignments are "boundary cases", i.e. articles and passages that challenge or defy the categories in the tentative coding scheme. Explicitly collecting such boundary cases is therefore recommendable; we found it helpful to collect highlighted passages that presented boundary cases in separate documents, to be shared and discussed

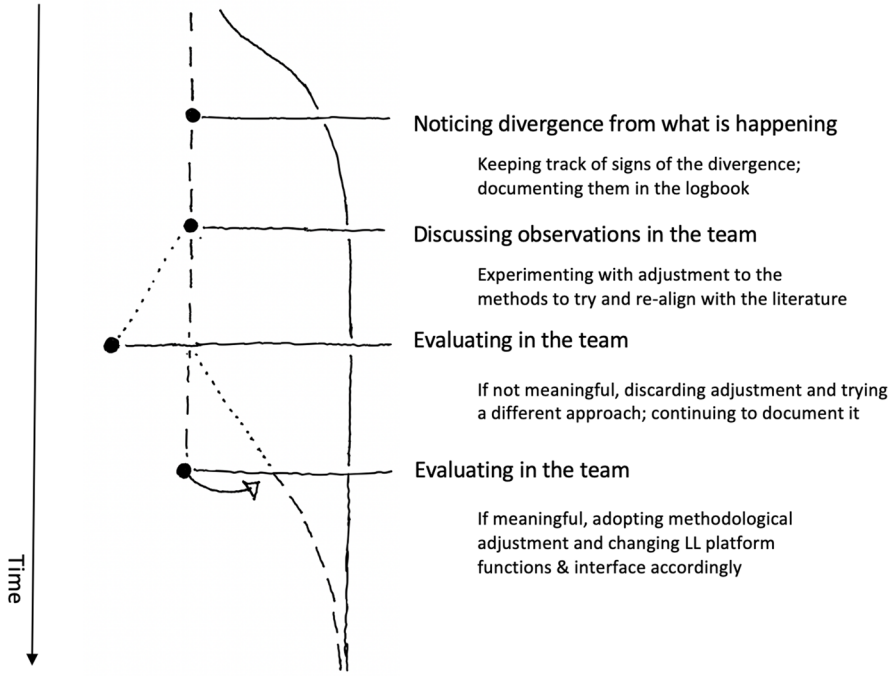

Fig. 3 Visual representation of the Living Library's responsive methodology. On the far left, you can see the temporal direction represented by a straight arrow pointing downward. On the far right, a vertical solid line curving outwards to the right represents a development in the literature over time. A straight vertical dashed line in the middle represents a coding scheme in action. The solid and the dashed line begin quite close together, showing the similarity between the literature and the coding scheme. Overtime, the solid line begins to diverge from the dashed line, indicating that there is a mismatch between what is in the literature and what the coding scheme captures. A point is placed on the dashed line which is connected to a bit of text that reads: Noticing divergence from what is happening: Keeping track of signs of the divergence; documenting them in the logbook. A bit further down the dashed line is another point which is connected to another bit of text that reads: Discussing observations in the team: Experimenting with adjustments to the methods to try and re-align with the literature. Dotted lines show adjustments to the coding scheme being piloted parallel to the active coding scheme. A dotted line moves away from the second point at a 45 degree angle to the left, away from the solid line representing the trends in the literature, joining with another point that does not sit on any line. This represents an attempt to change the coding scheme, and the point the dotted line moves towards is connected to another bit of text which reads: Evaluating in the Team: If not meaningful, discarding adjustment and trying another approach; continuing to document it. As we move further down the dashed line, we see another dotted line emerging at a 45 degree angle to the right, towards the solid line representing the trends in the literature, representing another attempt at changing the coding scheme, which is met with another bit of text reading: Evaluating in the Team: If meaningful, adopting methodological adjustment and changing LL (Living Library) platform functions & interface accordingly. At the bottom of the graphic, the dashed line and the solid converge once more, indicating realignment of the coding scheme with the literature for the time being

in upcoming meetings. Any other form of documentation that seems helpful to the coders at this point is equally encouraged.

2. Once enough material is collected, or the agreed-upon time span concluded, librarians call a meeting with the whole Living Library team. The collected

observations, boundary cases and other material or challenges are discussed, along with samples of the coding scheme. Such an overview allows the team to gain a clearer idea of the different thematic contents to be considered against the boundary cases. The aim of the team's deliberations is to minimise boundary cases and resolve difficulties with the coding scheme by refining and/or adjusting the boundaries between thematic categories (e.g. broadening, narrowing, removing, adding, or merging themes). These discussions familiarise the team members with each other's perspectives and approaches, interweave them in shared understandings, and are therefore key to maintaining the research team's methodological integrity and the library's conceptual coherence.

3. The adjusted coding scheme is piloted, and the process documented again as in step 1.
4. a. If the adjustments succeed in reducing boundary cases and easing decision-making, rendering the coding process more meaningful, then they are adopted. The resulting coding scheme is then applied to the entire first batch of articles in the article repository, and the Living Library platform goes live.

   b. If the adjustments do not render the coding process more meaningful, or if they immediately raise new issues that hinder the work of coding, the librarians again collect their observations, returning to step 1 and repeating until the team agrees that the coding scheme sufficiently captures what is happening and what matters in the selected literature.

   The running maintenance of an established Living Library follows a similar process, except that a currently employed ("live") and a piloted coding scheme run in parallel at times, as illustrated in Fig. 3.

5. New articles are coded with the live coding scheme, while the librarians document boundary cases and recurring issues that warrant further deliberations. This is done in the form of researcher notes during article coding. Whenever such issues are discussed amongst team members, shared observations and insights are documented in the researcher logbook.
6. When enough material is collected or when an issue obstructs the coding process, the librarians bring this to a team meeting. The team discusses the issue, reviews boundary cases and decides on adjustments to the coding scheme.
7. The adjusted coding scheme is piloted in a separate column of the article repository which remains unpublished. In parallel, the coders continue Living Library maintenance with the live coding scheme, keeping track of how boundary cases and issues develop. This allows direct comparison of the coding experience between the two coding schemes.
8. a. If the piloted coding scheme does better than the live coding scheme in capturing the literature, the coders adopt the piloted scheme and continue from step 5.

   b. If not, the coders continue from step 6 and repeat until arriving at 8a.

Results: lessons learned

From developing and maintaining the Living Library prototype, we have learned several lessons about what it means and what it takes to open the scientific process of literature reviewing. The following revisits the various practical features of the Living Library in their educative dimension.

Openness is multidirectional

The first lesson we learned was that opening a scientific process is not as straightforward as conveying one entity (e.g., "science") to another (e.g., "the world") in one direction. Instead, opening up more resembled the process of osmosis, with multiple kinds of boundaries being permeated in different directions. The following accounts illustrate this point.

We soon realised that maintaining a Living Library entailed an "outside-in" openness: the responsive methodology required keeping ourselves *open for* changes in the world. This openness was active. Concretely, we evolved the thematic coding scheme iteratively to 'sync' with the course of the literature, and eventually even the article selection criteria needed adjusting. Our decision-making on these changes was slow and deliberate as team meetings and scientific discussions go; however, relative to the developments in the literature, our responses came in real-time. The article selection criteria became problematic in April 2022, when the librarians noted a dwindling number of clearly eligible articles, that is, articles focussing on education *and* the pandemic. New publications increasingly mentioned the pandemic as contextual, rather than as a main focus, making it difficult to decide whether to include these articles in the library. When such boundary cases outnumbered eligible articles, we had to revise the selection criteria, which meant to engage with the question: What has changed, exactly? Or, to put it in the words of Akkerman et al. (2021): What is happening now, and what matters? The new criteria were to help us direct our attention to articles that foregrounded the shift we were witnessing.

This "outside-in" openness permeated the boundary between the evolving literature and our reviewing work. Opening up our conceptual frameworks for such change expresses care for the world in an attempt to do justice to a reality in motion, and to our meaning-making movements within it (Akkerman et al. 2021). The latter required another kind of openness, an "inside-out" openness at our individual boundaries towards the team. We made conscious efforts to share thoughts and observations, including doubts, mistakes, and criticism on our work. This degree of openness about the inner life of the scientific process was unusual compared to most of our other work experiences. It felt surprisingly vulnerable, especially for the librarians who carried out their coding work in the face of uncertainty and were at times plagued by doubt. Yet, our openness created fruitful conversations about the purposes of the project and the potentials we saw from our various positionalities within it (Akkerman et al. 2021). Oftentimes, leaning into the felt discomfort of boundary friction, rather than trying to avoid it, brought deep insights to the surface that allowed us to make transparent and meaningful decisions on matters that had previously appeared muddled and unsolvable.

We encountered this phenomenon most pointedly when attempting to subdivide the theme "Equity" to allow for the appropriate degree of conceptual fine-graining typical of social scientific research. For all other themes, we found sub-themes to emerge rather naturally from the literature through open coding, allowing us to sharpen our senses to nuances in the academic conversation. However, Equity, as understood and applied to the context of education (including access to and support within education) persisted without sub-themes throughout the project. We noted that sub-categorising the theme seemed artificial and forced: For one, the literature did not warrant it, speaking of Equity in broad strokes. But we also needed to admit (first to ourselves, and then to each other) that theorising about Equity in terms of sub-categories made us *uncomfortable*. With this observation in the open, we noticed that our own hesitancy appeared to resonate with the cautious tone of the literature on the theme. Articles addressing Equity tended to focus on a few well-established categories, usually conceptualised as variables of individual differences in a population (e.g., gender, ethnicity, socio-economic background, neurodiversity, or physical ability). As we tried to make sense of how these issues were talked about, we increasingly sensed a lack of depth in the discourse, as if avoiding ethical complexity. We eventually decided not to force sub-categories on the theme, both in acknowledgement of its personal nature, and of the intricate entanglements between any of its facets that one might attempt to isolate. Notably, had we been primarily concerned with sticking to the implied structure of our coding scheme, we could have resolved the stalemate by adopting a given theoretical framework from the literature on Equity, in which case we may not have come to reflect so deeply on our positionality with regards to the theme, nor wondered about that of other authors. This example highlights the added value of embracing rather than diluting boundary frictions that occur while being open about inner processes in doing science, and the value of acknowledging the role that otherwise often covert perspectival or local biases play in directing and shaping knowledge creation.

In summary, openness can go in different directions and entails negotiation of multiple boundaries: How openly do I speak so to properly enter dialogue? Which things do I say, and which things do I withhold? Conversely, how openly do I look, listen and feel? Which things do I pay attention to, and which things do I ignore? To grapple with these questions is an enactment of care and contributes to collective meaning-making.

Openness is relational and vulnerable

As follows from the above, our work with the Living Library highlighted that openness is relational. Put simply, not only does openness have directionality, it is also directed at or by some other, in relation to whom or which we decided *how* and *how far* to open up the scientific process. We give two examples of how such directional relationalities mattered in our decision-making.

Publishing our logbook and researcher notes proved to be the most difficult act of opening, as it was directed towards an essentially unknown other. This could be anyone with internet access who happened upon the platform, which may entail as varied a range of relationships as colleagues within Utrecht University, fellow researchers,

friends, students, teachers interested in the topic, or simply a random stranger surfing the internet. This raised different issues—practical and ethical—than opening up within the boundaries of our team. The step from an offline pilot version of the logbook and researcher notes to publishing that version of the platform for the logbook and researcher notes to go live was daunting and took months of deliberation. When we first saw the pilot version of our logs and notes within the frame of the Living Library platform, the sight rotated our viewpoint to an outside perspective, looking in. This changed our perception of our own work: a tangible boundary was crossed. Suddenly, our imperfect, sometimes hasty or tentative notes taken during coding or after meetings appeared flawed, although we knew that imperfect writing—including incomplete sentences and typos—and tentative thinking are integral to doing research. Still, it required a team effort and courage to finally decide on the live logbook and researcher notes. Having been enculturated into a habit of disembodying "science" (i.e. products) from the process it entails had led us to become estranged from what science means in actuality. From our confrontation with that implicit norm, we learned two things: First, how little we are still used to revealing the imperfections of our scientific process to others (especially unknown others), and second, how little we are used to seeing other researchers' imperfect processes laid open to view. The human face of the living research process—erring, doubting, hoping, dreaming, persisting—is traditionally all but shielded from the gaze of fellow researchers, and more so from public view.

Another kind of vulnerability in our relationship with "the public" became tangible when we added open pin boards to articles and logbook entries. These pinboards were intended for a certain purpose: To invite library visitors into the conversation, for them to expand the library with links to other media or further literature, but also to voice critique or questions about our interpretation of the literature and suggest alternative interpretations. Yet, how our opening up of the platform was going to be used we could neither predict nor control, which raised ethical questions about moderation. This dilemma taught us that while we may want to open up for public engagement as a general abstract idea, in practice, we were not open to all types of public engagement. This points to a larger issue too, namely, whether the practices promoted under the banner of open science *can* be as universally open as they often purport to be, and whether undifferentiated openness is really desirable. Perhaps, openness can be easily promoted in theory where it is decontextualised, but in practice, where relationality comes into play, cannot be enacted purposefully without also considering more nuanced degrees and kinds of closedness.

Openness entails judgments of relevance

This leads us to the core lesson learned from our work with the Living Library: Openness entails judgments of relevance. To illustrate this, imagine we had been *completely* open in our researcher logbook. What would that have meant? We may have published all our meeting notes without discernment, which would include a range of topics affecting the project, such as individual interests, as well as private, logistical, financial and other circumstantial issues. However, not all that information was deemed equally appropriate to include in our researcher logbook. Indeed, not all

researcher notes, observations and logs we did publish as part of our Living Library prototype will be relevant to the reader. To filter and select them would require taking perspective and making judgements on what we think may be of relevance to "the public"—a difficult and vague task. This points to the blurry, yet often clearly felt boundary between "frontstage" and "backstage" issues. *Where* that boundary is drawn depends on one's positionality, the potential one sees in conveying or receiving certain information, and the purposes one pursues with that conveyance in the given context (Akkerman et al. 2021).

This is why we think twice when we speak or write as researchers: An unfiltered flood of information can drown out what matters. The same counts for our opening up *for* someone or something other, such as for changes in the literature, or for public engagement: Opening up to all things equally makes it difficult to get in touch with what is happening, let alone to find meaning in it and respond meaningfully in turn. In short, undiscerned input equals white noise. Neither is it recommendable to narrow one's openness to a set window of selected sources, since their meaning is contextually bound, and one may miss relevant developments beyond the narrow window. Selecting what to open up about, who to open up to, where, how and when—all these are decisions that enable researchers to foreground what is *relevant* for a given other in a given context in light of the present purpose. Judgements of relevance are thus integral to the process of opening science.

The Living Library was iteratively designed to highlight these issues, and working with it in turn made us conscious of the constant foregrounding and backgrounding that featured in our literature reviewing process. We observed and discussed what we could see of other researchers' relevance judgements: the choice of research question, the degree of detail given in methods sections, what findings were more or less emphasised, the title of publications, etc. On the other hand, publishing researcher notes and logbook entries heightened our awareness for our own relevance judgements and encouraged us to attend more closely to how they came about. For instance, syncing with movements in the academic conversation meant that the relevance of articles should not be determined by our selection criteria—rather, the criteria were adjusted to what appeared as relevant in the literature. This seemed to reverse the habitual relationship between our conceptual frameworks and the happenings to which we bear witness and respond.

Discussion

In this paper, we have presented the Living Library, a new process-based open science tool. From creating and working with the Living Library, we have come to recognise how little we had previously understood about what openness means and what it takes in actuality, confirming the results of recent surveys (Brinkman et al. 2021; Moradi and Abdi 2023). As we have seen, there is no such thing as simple or complete openness—openness is always partial, directional and in relation to some other. Opening science constitutes purposeful and directed action with consequences for the involved, and as such requires judgments of relevance. We now turn to the conceptual, ethical, and practical questions that this perspective raises.

How might we think about open science in a process-based manner?

Although the term "open science" conjures up the rather simplistic idea of "science that is open", matters are more complex than that from a process perspective. As we have seen, scientific processes entail purposeful acts of both opening *and* closing in various directions and to various degrees, depending on what is happening and what matters (Akkerman et al. 2021). This raises the question whether the open science movement is well-advised to push single-mindedly for openness as such.

To answer this question, a historical perspective is needed. At present, the norms and customs of the dominant research culture still lack awareness, support and recognition or reward for open practices (Brinkman et al. 2021; Miedema 2022; Moradi and Abdi 2023). It is in this context that the open science movement originated and continues to pursue a meaningful endeavour. For as long and insofar as closedness is an unquestioned, or at least widely accepted, default for scientific practice, it is desirable as a general tendency to probe the boundaries in the direction of openness as we have done in creating the Living Library. Zooming in, however, from the bigger picture into the particular instance of a researcher's decision-making, a more nuanced guiding principle may be of use: Open science where it *can* be open, closed where it *needs* to be closed (see Wolkorte et al. 2022).

What counts as a "can" and a "need" in a given context and how this may be judged are questions which, as we have seen in the course of our work with the Living Library, lurk behind every methodological decision once we begin to reflect on our actions throughout the research process. We have found that, despite being embedded in an institutional culture that highly values open science, we were yet in need of fruitful angles from which to address these questions in action in a way that can do justice to the nuances and the experienced frictions that come with opening science.

A helpful perspective in the present project has been to attend to the various *boundaries* we encountered and established through our decision-making. Rather than the non-specific open-closed binary, this perspective allowed us to see boundary permeability as running along a gradient; to observe more specifically what is let in and what is let out, to whom or what, when, how, where, and why. We propose that approaching open science from the perspective of boundary work (see Gieryn 1983) could help to make sense of the nuances and challenges of opening science. Using this lens can guide judgments of relevance in a concrete, yet comprehensive manner, asking: *In what ways do the various boundaries at play need to be permeable so as to enable research that is relevant to what is happening and what matters (right now and in the long run)?*

Some researchers have already made cursory steps in so employing the boundary concept by referring to aspects of open science, such as public engagement and transdisciplinary work, as forms of boundary crossing (e.g. Parker and Crona 2012; Boon et al. 2021; Hendriks and Bromme 2022). This could be expanded to research into the opening of scientific processes more widely, including the purposes, affordances, limitations, and the support needed—culturally and organisationally—to meaningfully direct the open science movement.

What does it take for researchers to purposefully open science?

The boundary work of attending to what is happening and what matters and making judgements of relevance is vulnerable. It foregrounds the researcher's responsibility (Akkerman et al. 2021) and thus also the risks of doing science: the risk of judging poorly, of exposing oneself in disadvantageous ways (e.g. Lifshitz-Assaf 2018), facing unanticipated consequences, etc. These risks are inherent to openness, as it is a form of letting go of control. In practice, the uncertainty that comes with openness can be daunting. A good example is our opening up the source code for the Living Library prototype. Providing an open-source software permits and encourages the use, re-use and editing of openly available code, in line with our commitment to transparency, interoperability, collaboration and accessibility. When putting these principles into practice by opening the source code, we had to let go of control and widen the field of unpredictable possibilities. The Living Library may henceforth be used in ways that veer from, or even act counter to the purpose it embodies in our view, and similar risks can be imagined for opening any other process or product. In short, opening science takes the courage to embrace uncertainty.

However, to act courageously does not mean to push on against any fear or concern in the way of openness, as some fears and concerns may be valid (see Fox et al. 2021). On the contrary, it means to face fears, weigh risks, and take responsibility in deciding which risks to avoid and which ones to take. For instance, one may need to weigh the risk of findings or data being used in destructive ways if openly shared (e.g. Fox et al. 2021; Miedema 2022), against the risk of diminishing one's reputation by missing a chance to publish. In many closed scientific processes however, the reasons are less pressing and the risks less dramatic than that, as closedness is still the cultural norm and structurally reinforced. Often, closed processes serve to stabilise conceptual frameworks to increase the researchers' control over the field of possible outcomes, to polish their image (see Lifshitz-Assaf 2018), or simply to arrive at applicable research products. This is additionally motivated—to give but one example—by funding schemes requiring commitment to anticipated outcomes and "impact" of research, as well as favouring researchers with a high number of publications (Akkerman et al. 2021; Miedema 2022).

Thus, there are many reasons for closing off and risks associated with opening up scientific processes, however, what *kinds* of reasons are normalised and what *kinds* of risks are attended to is not always motivated by values such as privacy and research integrity, but by self-serving interests such as convenience, efficiency, and ultimately competition. To resist the pressure of the norm in such cases takes courage, too (see Lifshitz-Assaf 2018 for an example of NASA researchers struggling with such norms in an open innovation project). Indeed, courage is deeply intertwined with the act of 'syncing' to a world in motion, which is to keep opening up and being vulnerable to the concrete, unfolding relationships in the world (Affifi 2023).

How can researchers be enabled and supported in opening science?

If opening science takes courage, what is needed to support researchers in the process are practices and facilities that en*courage* them in facing the complexity of bound-

ary navigation. By "encouraging", we do not mean nudging researchers towards predefined one-size-fits-all "open" behaviours or outcomes. On the contrary, we envision the opening of a space within which researchers are supported in making judgments of relevance based on the situation at hand. What does it take to open such a space, organisationally?

First of all, it requires attending to the full range of risks entailed in doing science: While the risks that come with opening up are usually more readily acknowledged, there are also risks that come with closing off. We have addressed how the risk of going "out of sync" with what is happening and what matters was foregrounded by the pandemic. It dispersed the illusion of human control, confronting us with our (inter)dependencies and the unpredictability of forces other than ourselves in an evolving, living world. This experience highlighted that an integral part of the scientific endeavour is to continuously move with and within an evolving world through observation, experimentation, inquiry and reflection (Akkerman et al. 2021). Combining that lesson with those of the Living Library shows that how we as researchers conceptualise *relevance of research* is intimately intertwined with how we understand and practise *open science*. While relevance is currently predominantly being addressed as the framing by which funding is acquired or reviewers and editors are compelled to accept a paper, this is only the communicative aspect of what already underlies scientific decisions at every step of the research process: A constant weighing of affordances and risks, in light of the purposes and potential we see in our projects, and based on what we know and are learning about a reality in motion (Akkerman et al. 2021). In response, the multiple boundaries involved throughout need to be opened in different directions and to different degrees.

Openness cannot be practised categorically or standardised (read 'gamified', see Fox et al. 2021); it is situated and specific. This means that to demand or force openness is not enough, and may even be counter-productive, seeing the responsibility and responsiveness that openness entails. More fruitfully then, researchers can be provoked, supported, and facilitated in opening their scientific processes. This needs attention to the daily habits and routines of scientific work. Reasons for opening and for concealing are grounded in particulars: timing, place, and context matter. This suggests that open science policy, as well as institutional rules and regulations, may need to give space to context-sensitive adjustments. As Morgan et al. point out, "a study can comply with the underlying philosophy of open science without applying the entire repository of open science practices" (2022, p. 1). The binary rhetoric of "open vs. closed" cannot support such nuance (Morgan et al. 2022), hence talking about degrees of openness at multiple boundaries and in different directions may be better suited.

Furthermore, following given rules, regulations and rewards alone does not make for meaningful open science practice, but rather risks incentivising competitive, irresponsible behaviours as gamified systems often inadvertently do (Fox et al. 2021). Open science tools such as the Living Library can serve as educative structures to raise the questions that allow researchers to familiarise with open science philosophy. More generally, normalising the use of dynamic, process-based research methodologies can contribute to the value-based culture shift implicated in the open science movement. The Living Library provides a framework for such a methodology, allow-

ing researchers to engage in deliberate boundary work beyond the dichotomy of open vs. closed.

It is important here to acknowledge that opening science does not raise new difficulties where there were none before—rather, it reminds researchers of their already existing responsibility in making judgements of relevance. This responsibility is often "outsourced" to rigid methodological frameworks, and in the extreme case to automated processes. A popular example in the realm of literature reviewing is article sorting and analysis software (such as MAXQDA (VERBI Software 2022)), which creates an illusion of ease and detachment. However, this does not relieve researchers of their responsibility to make judgements. Rather, such outsourcing itself embodies judgements of relevance: for instance, that no relevant changes will occur in or during the process of reviewing that would justify opening up the conceptual framework to reconsideration; and that efficiency is more relevant to the project than human decision- and meaning-making throughout the process.

The possibility to slow down is therefore an integral aspect of opening science. Note that slowing down momentarily can allow researchers to respond much more swiftly on a larger timescale. For us, consistently taking not one, but two hours for each team meeting in the long run enabled us to adapt our methodological approach within the span of days, rather than weeks, seeing that all team members had been sufficiently in the loop and continuously open for perceiving and discussing ongoing change. In this light, efficiency-directed work attitudes may be incompatible with opening scientific processes. For instance, the wide-spread habit of calling meetings only when there are urgent points on the agenda (e.g., problems to be solved, decisions to be made) reflects a product-oriented attitude. By contrast, the regular meeting rhythm entailed in the maintenance of a Living Library creates space for more implicit or fine-grained issues and observations to surface, often leading to unexpected insights or serendipitous opportunities to open up. As such, slowing down in the research process may lead to a multitude of interesting and purposeful research products that could not have been anticipated. In our experience, the process of Living Library maintenance itself produces questions and answers, as well as perspective shifts worth talking and writing about; however, the crucial point is that these products serve and emerge from academic engagement with the literature, rather than vice versa.

In light of the above, research institutions with a long-term outlook and an interest in their relevance may wish to make room for researchers to "insource", rather than outsource their judgements throughout the scientific process. This entails providing and promoting structures for generative long-term processes with open-ended potential in which researchers can pursue purposeful inquiry, rather than prioritising short-term efficiency, which can defeat itself in the long run.[3] The Living Library provides a framework with which to initiate and maintain such long-term processes in a dynamic manner, and, in that respect, is more than a tool: It is a medium for insourcing, a human-oriented, rather than human-replacing piece of technology. For that reason, a Living Library is maintained (quasi-)manually and its methodology

[3] Consider, for instance, the inefficiency of the replication crisis—partly a byproduct of the competitive and fast-paced nature of academic research.

revolves around discussion, reflection and discourse. This promotes deep understanding, collaboration and co-creation. To cut short these processes can stifle their generative potential (Akkerman et al. 2021). Thus, the Living Library acknowledges and promotes the laborious collective processes that researchers engage in to reach intersubjective understandings of the phenomena they study. To lay open that process is the contribution that distinctly marks the Living Library as an *open* science tool.

We have explored what it means and what it takes to radically open up scientific processes in this manner, as a provocation and invitation to further probe the boundaries of open science in practice. It took our sustained attention and time investment, which may be an inevitable consequence of practising openness at the level of commitment we have demonstrated. In the long run however, this commitment can generate entirely new possibilities for meaningful research products, deeper engagement, connectedness and understanding between researchers and their topics of interest. To enable this requires funding distribution and organisational support that look beyond ticking the boxes of what counts as "open science" in a given institution, and instead invest in value-driven open scientific practices (see also Bahlai et al. 2019). The present project shows that support for exploratory initiatives and the use of open process-based methodologies can widen and deepen the research community's understanding of open science.

Further scope and applications

We invite further experimentation with the Living Library framework to probe the boundaries of open science in a variety of contexts. The Living Library is an intentionally plastic tool that can be modified to align with the purposes of any research group that feels compelled to engage with it. To name just a few possible uses: First, the Living Library provides a supportive framework wherever there is a wish and a need amongst researchers to connect more openly, intentionally, and continuously with the ongoing academic conversation on a given topic. To enable more immediate responses to changes in the world, a Living Library platform could further be expanded to accommodate regular "mini reviews". Second, maintaining a Living Library can enable (inter- or transdisciplinary) collaboration across institutions and beyond the university, across sectors and countries, by building a shared archive and communication basis via meetings, the open logbook, and pinboards. Here, community engagement could be fostered by inviting the addition of relevant multimedia materials (news articles, videos, podcasts, etc.) to the repository and using the pinboards to exchange thoughts. Third, the Living Library framework can be used for open education and professional development, to facilitate reflexive engagement in questions around the meaning, purpose, and process of opening science.

As the creators of the Living Library, we are only familiar with the ways in which we have approached the tool, and only within the context wherein the project was embedded. To engage with the literature on a topic as fast-changing as education during the pandemic, the adaptivity of the Living Library proved indispensable within months. Other research contexts may afford less dramatic adaptation and reveal evolutions of the literature at a slower pace; they may foreground different features of

the Living Library; or they may inspire adjustments to its functions. Whether and how the use of the Living Library can be generalised to other contexts thus remains to be seen. Like Gutiérrez and Penuel, "we define the generalisability of findings and theories developed through research as contingent on the uptake of research by local actors who must sustain programs." (2014, p. 21) We hope this manuscript will stimulate others to do so and are confident that the flexibility and transparency of the Living Library render it a tool that can be implemented in a variety of contexts. Hand in hand with its affinity for diversification, we also see potential in the Living Library, based on the strong philosophical principles it embodies, to act as a unifying medium between researchers from different backgrounds and in different contexts. Specifically, engagement with the methodology of the Living Library can serve as a common experiential ground on which to expand shared understanding and discussions around open science.

We welcome commentary and questions in GitHub (https://github.com/Simon-Dirks/living-library), where we provide the open-source code along with a step-by-step guide and where we will assist research groups in developing their own Living Libraries.

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Data availability The code for the Living Library is open source and can be found via https://github.com/Simon-Dirks/living-library. Documentations of our research process in developing the Living Library can be found in the open logbook on our prototype platform via https://living-library-uu.web.app.

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

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