

Jupyter Book as an open online teaching environment in the geosciences: Lessons learned from Geo-SfM and Geo-UAV

comprised both field and classroom teaching and were iteratively revised over a four-year period. The modules covered the acquisition of drone data and subsequent processing of 3D models and were iteratively revised over a four-year period. Each module

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1 Introduction

The concept of openness and sharing has become a core value and commitment across many disciplines and fields. The open-source and FAIR (findable, accessible, interoperable, reusable) data (Wilkinson et al., 2016) stewardship movements share common principles with in relation to both teaching and research. With teaching specifically, open pedagogy (OP) (Rocca-Serra et al., 2023; Wiley and Hilton, 2018). Through open-source tools, FAIR data, and open educational materials, OP provides envisions a more democratised, accessible, and affordable learning environment wherein neither students nor educators are bound by expensive software licences, proprietary data, or the limited perspectives or costs of individual textbooks (Abernathy, 2023). Specifically, (Abernathy, 2023; Wiley and Hilton, 2018; McNally and Christiansen, 2019;

Harrison et al., 2022; Matkin, 2009). OP is an educational approach that emphasizes transparency, collaboration, student-driven learning, and the use of open educational resource resources (OERs) (Hegarty, 2015; Wiley and Hilton, 2018). Specifically, it is defined as any type of educational teaching that is in the public domain or accessible with an open licence (Audrey Azoulay, 2019). Unlike conventional, proprietary educational materials and practices,

Despite increasing adoption, OP remains far from a formalised and recognised standard, but rather a loose set of aspirational guidelines that are difficult to navigate and interpret as a whole (Christiansen and McNally, 2022; Tietjen and Asino, 2021; Weller, 2014; Wiley and Hilton, 2018). At its core, OP encourages educators and students to actively engage in the creation, adaptation, and sharing of educational materials, rather than relying on conventional, proprietary educational materials and practices. In so doing, it encourages OP facilitates transparency in teaching practices and makes learning materials openly accessible to a broader audience, enhancing the visibility of educational content and allowing for wider participation (Jhangiani and Biswas-Diener, 2017).

Despite the increasingly wide adoption, OP remains far from a formalised and recognised standard, but rather a loose set of aspirational guidelines that are “essentially impossible” to reconcile (Wiley and Hilton, 2018; Tietjen and Asino, 2021; Christiansen and McNally, 2022; Weller, 2014). (McNally and Christiansen, 2019) suggest OPopenness can be evaluated based on the eight primary factors, including copyright, accessibility, language, support costs, assessment, digital distribution, file format, and cultural considerations. None of these are binary “open”, underlining the difficulty of defining what is and is not open (McNally and Christiansen, 2019). The OER-enabled pedagogy (OER-P) subset of OP implements many of these factors and is governed by a set of five specific rights, the so-called 5 Rs of OER that regulate openness and reduce the problem of disposable assignment (Wiley, 2013). These consist of the right to

1.1 Open Educational Resources in pedagogy

The creation and use of OERs is integral to OP. OERs, being any type of teaching material that is in the public domain or accessible with an open licence, are best examined through the 5Rs (retain, reuse, revise, remiXand redistributeeducational content (Tietjen and Asino, 2021; Wiley, 2013; Wiley and Hilton, 2018). , redistribute) (Audrey Azoulay, 2019). They serve as both a critique and alternative to conventional scholarly and educational publishing and have seen an uptake in recent years (Tietjen and Asino, 2021; Wiley, 2013; Wiley and Hilton, 2018).

OER-Ps can be seen as an extension of the knowledge-building framework, which values students’ work primarily for what it contributes to the community, and secondarily for what it reveals about individual students’ knowledge (Bereiter and Scardamalia, 2014; Tietjen and Asino, 2021). After all, having the right to freely distribute materials with the broader outside world inherently increases the value of the work (Wiley, 2013), and it is this key element that sets Wiley and Hilton (2018) propose the use of OER-enabled pedagogy (OER-P) apart from other forms of OP and teaching practices, whilst still benefiting from the OP framework (Andrade et al., 2011) as way of conceptualizing what can be pedagogically possible through use of the 5Rs of OER.

Open distribution and access further saves money and reduces cost, for instance, by minimising duplication and the generation of disposable material, and extend the usability of resources (Wiley and Hilton, 2018). As a subset of OP, OER-P benefits from the participatory nature of OP while acknowledging the role

Asino, 2021): Where small departments or single lecturers with little experience in online teaching may struggle to hybridise a class, a community of (networked) OER-P practitioners with complementing expertises have far better chances to update and revise educational materials and courses, especially when aided by student-led co-creation. Co-creation by pursued in collaboration with students.

1.2 OER-P and co-cration with students

Importantly, co-creation of OERs and through OER-P practices with students has the benefit of increasing diversity in teaching materials, thereby enhancing engagement and improving learning outcomes of individuals who are otherwise underrepresented in education (Biddle and Clinton-Lisell, 2023; Lambert, 2018; Kelly et al., 2022; Nusbaum, 2020). Overlapping with scholarship on Students as Partners, OER-P strategies enable what Bovill and Woolmer (2019) describe as co-creation *in* curriculum and co-creation *of* curriculum. Significantly, co-creation in/of the curriculum strategies are clearly noted for their potential to redress power relations between teachers and students, reframe knowledge and knowledge production and "counter the increasing commodification of learning" (Bovill and Woolmer, 2019, p. 408). It is from this point, that our project emerges - we are curious about the potential of OER resource development as a transformative pedagogical practice that is undertaken collaboratively with students.

1.3 Tools for OER development

2020), akin a user-editable and annotatable "unbook" that is not subject to the dramatic inflation of traditional textbooks (Woodworth, 2011; Harrison et al., 2022; Matkin, 2009)and . Simply put, Jupyter Book provides an interface for building publication-ready books ("Jupyter Books") from computational (e.g., Jupyter Notebooks) and narrative (e.g., text files, images) content (Executable Books Community, 2020). The environment can be easily integrated with co-creation and version/source control solutions such as git. With a strong focus on the collaborative development, creation, and expansion of documentation, along with open licencing options, we decided to test whether Jupyter Books can indeed act as an a diverse, equitable and inclusive learning environment that embraces the three pillars of "open" social justice (i.e., redistributive, recognitive, and representational) described by Lambert (2018) and Biddle and Clinton-Lisell (2023).

This article documents In this contribution, we first document the implementation of Jupyter Books Book and GitHub in the design of two geoscience undergraduate modules on data acquisition and processing as part of a transition to OER-P teaching. The two integrated, interactive online

95 textbooks cover and detail best practices in the acquisition and processing of unmanned aerial vehicle (UAV) -based data (Geo-UAV) and the subsequent multi-view stereo (MVS) data acquisition and structure-from-motion (SfM) photogrammetry processing(Geo-SfM). Our design was informed and inspired by existing textbooks and tutorials published using Sphinx and Jupyter Book (Henrikki Tenkanen et al., 2023, 2022; Lehmann, 2011; Executable Books Community, 2020; Rhoads and Gan, 2022) that showcases the ease of integrating interactive components within narrative course content. Animations and animated gifs are an important design-choice to increase engagement and lower the barriers for participation (Bakhshi et al., 2016). Because of their capacity to capture short animations, and generally small file sizes, gifs have become a key communication tool on par with other visual media (Miltner and Highfield, 2017; Bakhshi et al., 2016). The adoption of gifs for commercial purposes illustrates the adaptability of the format, and gifs are increasingly used to illustrate points, provide information, advertise, and even augment news and information (Miltner and Highfield, 2017). It is thus not surprising that gifs have been previously used in educational settings (e.g., Altintas et al., 2017; Talati et al., 2020; Russell, 1999; Brisbourne et al., 2002). In this contribution, we apply these and other pedagogical learnings and discusses the implementation of the Jupyter Book environment, including the integrated , respectively, 100 as part of a transition to OER-P teaching at a small campus. We then demonstrate the openness and accessibility of the framework (aided by the use of animations and traditional course content, as a tool for enhanced geoscientific learning. We demonstrate the applicability of the environment and assess), assess user and student learning experiences of using and contributing to the course modules, and appraise the co-creation possibilities.

2 Methods and data

105 2.1 Context and participants

UAV module was developed as a teaching-aid based on experiences and best-practices acquired through the Svalbox project and its spin-offs (Senger et al., 2021; Betlem et al., 2023). As fieldwork forms a large component of data acquisition, our study implicitly tested the portability of Geo-UAV into field-based teaching, either by accessing the tutorial online in the field, or by exporting PDF pages prior to heading out.

135 2.2 Module and course design

Our design was informed and inspired by existing textbooks and tutorials published using Sphinx and Jupyter Book (Henrikki Tenkanen et al., 2023, 2022; Lehmann, 2011; Executable Books Community, 2020; Rhoads and Gan, 2022) each detailing the ease of integrating interactive components and narrative course content. The Geo-SfM and Geo-UAV modules `modules` were designed to facilitate a learning environment that is inclusive, accessible, and diverse in terms
140 of representation of information, learning styles and perspectives. The Jupyter Book environment was implemented as the

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presentations replaced graded assessments and exams. Classroom teaching further implemented the colloquial sharing of results and experiences during daily recaps in which students presented both their results and stumbles, with feedback and possible solutions mostly provided by other working groups. Peer-to-peer evaluation was also encouraged for pull-requests and revisions suggested to the courses, though were not part of the grading process. The setup of the modules, implementing gradual and asynchronous learning, naturally facilitated grading through module completion and participation.

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In Course 2, the shared assessment for the individual sessions was certified and documented in a course certificate, listing the accomplished learning objectives, and stating their equivalent.

170 Both GIFs, given their capacity to capture short animations and generally small file sizes, have become a key communication tool on par with other visual media (Bakhshi et al., 2016; Miltner and Highfield, 2017) and their inclusion has been shown to increase engagement and lower the barriers for participation (Bakhshi et al., 2016). For this reason, we implemented both shorter and longer animations and videos were implemented in addition to to supplement videos, detailed plain-language summaries and static figures in order to improve the accessibility of learning materials. Specifically, we were interested in determining

Book and GitHub platforms. Fig. 2, Fig. 3 list several questions and statements from the survey along with quantified student feedback. Students' questionnaire feedback was categorised and coded as either *constructive criticism* or *Positive feedback* with examples provided alongside.

Implementing feedback from the 2023 courses, we provided the class of 2024 was provided (Geo-SfM module) with a more extensive, preparatory three-hour tutorial on how to contribute through so-called forks and pull-requests. Forks and pull-requests As these tools allow more sophisticated changes to be made to the content pages but require a (documented) review by other participants and course instructors (source code of the) pages, a review and approval by others is needed prior to integration into the live module pages. Herein each students were given a prominent role to review one-another's proposed revisions and additions before final approval by instructors. As each pull-request interaction is documented and , the process automatically attributes co-creators . Assessment of the class of 2024 thus in addition focussed on what can be done to lower the barrier to the revised resource. Naturally, the focus of our pedagogics study broadened slightly to understand what the use of these tools meant in terms of lowering the barrier for co-creation within the implemented Jupyter Book/GitHub framework, as well as its apparent value to participants their apparent learning value to the students.

and how they perceived the multimedia use in the modules. The open-ended remarks Open-ended remarks (Table 1) on the use of animations and videos within the modules resonated well with the quantitative feedback (Fig. 3) given by the students.

260 Perhaps the most important reflections came on the use and integration of animations and videos in addition to the rich text descriptions, which were stated to greatly benefit the diversity and accessibility of the course content. Overall, students reported agreement that the use of animations and videos greatly supplemented the main text, and that the quality of animations and videos was high. Indeed, many students reflected students also indicated that the playtime of animations multi-step animations (GIFs), in particular, was long and that the medium would benefit from being able to be paused. Similar reflections were mentioned in the a
265 pause-function would have been a welcome addition (Fig. 3). This was in agreement with open-ended responses, including such as that students did not like having “to wait for the loop to end to see again the info [they] wanted to see” and that they “had to play it [animations, videos GIFs] several times to identify all steps” (as also indicated by playtime statistics in , which is further evident from self-reported playtime statistics (Table S2). Nonetheless, That said, students largely agreed that the use of GIFs was perceived as “useful to assist with processes and to reduce the amount of learning through reading”.

270 For both modules, a selection of students reflected on a perceived information disparity between the main body text, multimedia elements, and instructions. This included
occurrences of (outdated) animations that were recorded for a previous version of the software, content displayed in multimedia but not the main text body (and vice versa), and the
275 extent of operations covered by the modules versus more advanced usage. The ease with which students recorded and updated short animations
(Fig. S2) point us to the hypothesis that GIFs form a lower participation barrier for cocreation than videos, which is partly
supported by our findings. Important work, however, remains to be done to ascertain optimal implementations and other
benefits of educational GIF content, as previously done for educational videos (e.g., Guo et al., 2014).

290 4 Discussion

Unlike proprietary lecture materials and technologies, the entry barriers to entry for students learning with open-source
resources such as Jupyter Book can be very low (Barba et al., 2019). For many of the students in our courses, the Geo-UAV
and Geo-SfM modules were their first foray formed their first introduction into the large and growing ecosystem of such tools. Like
open-source software (Khan and Ur Rehman, 2012), OERs have the unique opportunity to deliver inherently collaborative,
295 transparent workspaces that extend beyond the original authoring institution or idea (Caswell et al., 2008).

The present study explored students' perceptions of two Jupyter Book-based modules that were designed with the explicit goals to increase openness, diversity, and student
co-creation in creating OERs in OP. Certainly, OERs are hardly new to the academy; however, what could or should "count" as OERs
has become a source of concern for scholars and advocates who note the casual use of the term "open" for materials that
neglect or obstruct the 5Rs (typically because of copyright restrictions) (Wiley and Hilton, 2018). It can be useful then to
300 consider how "openness" can be understood and assessed. McNally and Christiansen (2019) suggest OER openness can
be evaluated based on the eight primary factors, including copyright, accessibility, language, support costs, assessment,

digital distribution, file format, and cultural considerations. They experiment with using these criteria with a three-part scale (closed, mixed, most open) - meaning that resources may be “most open” with regard to some criteria and “mixed” or “closed” in relation to others. Their work suggests that the relative openness of OERs (conceptualized through the 5Rs) can and should be evaluated by educators, as we have done here.

In the discussion that follows, we use students’ survey responses to assess these evaluate relative openness/accessibility and other pedagogical factors and summarise our findings grade the two course modules accordingly through an *Open Enough* rubric (Christiansen and McNally, 2022) (Table 2; treating *Harvestability* as a *Technical* rather than *Pedagogical* factor). Both Geo-UAV and Geo-SfM (and the Jupyter Book/GitHub framework as a whole) rank high on openness, outranking many of those rated by Christiansen and McNally (2022). Key considerations are the modules’ learner-centred design and the implementation of collaborative design choices.

Although interactivity First, the interactivity of the modules, exposure to pre-written code (snippets), and integrated multimedia use provided a rich and diverse learning experience certainly helped demystify the abstract notions of scientific data acquisition and processing. . Second, we noticed that the availability of co-creation examples and introductions to the unformatted from previous years to learn from, as well as being introduced to the unformatted source code of the teaching resources lowered the barrier for students to become contributors. Students affirmed as much and specifically noted the efficacy of Third, students noted the learning effectiveness of the modules through their step-by-step instructions that were provided in various formats, different voices, and different levels of interactivity. Students also Fourth, students affirmed what we had hypothesised – that for students to become

clarity, and ease of use. Both modules generally rated positively on diversity of content, navigation, and their modern design, though would benefit from being translated into additional languages . Perhaps the most important reflections came on the use and integration of animations and videos in addition to the rich text descriptions, which were stated to greatly benefit the diversity and accessibility of the course content. Where shorter animations of up to a few seconds were preferred to explain single steps, students seemed to prefer pausable videos for content with longer playtimes that covered multistep processes. During plenum discussions, students largely agreed with our hypothesis that videos form a higher participation-barrier for co-creation, especially given the ease with which short animations can be re-recorded and updated, and higher cost of videos in terms of time, IT skills, and storage requirements. Thus, in addition to being low-bandwidth, animated gifs were found to be ideally suited as long as the content was sufficiently decomposed into digestible chunks. Further studies are, however, needed to ascertain these findings and find optimal playtime durations for animated and video content.

(improving upon the modules' current Closed language rating in the Open Enough rubric, Table 2). Indeed, some of the technologies and software being used were nascent and unfamiliar to students, though this was easily overcome through active

4.2 Design choices - lessons learned and future directions

365 how to design and co-create future OER-P content.

From the perspective of instructors, we are excited **As instructors, it is encouraging** to see that **open-source off-the-shelf** software and infrastructure **has matured to have reached** the point where open-source curricula can be easily created, shared, adapted, and, importantly, used and found **. Like us and our students, other educators** (e.g., Chen and Asta, 2022; Kim et al., 2021; Executable Books Community, 2020). **With these tools, instructors and learners alike** have access to and can remix different compendium versions **and works** for
370 their course-specific **needs. These** (learning) needs. Moreover, using for example the **GitHub backend**, adaptations can be easily tracked **through the GitHub backend** and reintegrated where applicable **with the source, alternatively form the foundation for derived educational content**. Indeed, **such adaptations often find their way back to the original modules and contribute to a** in doing so, such adaptations and **co-creations contribute to the** community-driven development of OERs **that makes learning more accessible** (e.g., Kim et al., 2021).

possible point of concern, with students and practitioners often unaware of existing modules developed elsewhere (e.g., Python GIS;
380 **Henrikki Tenkanen et al. (2022)**). The need to better address resource availability also **, as for example dedicated modules on Python and GIS** (e.g., **Henrikki Tenkanen et al., 2022; QGIS Project, 2024**). The latter, in particular, became evident from student responses that requested additional compendiums on GIS and programming, **as well as feature requests such as the implementation of a search bar - all of which are** already readily available either within the modules, or through other open modules elsewhere. **Herein tutoring plays an important role, at least where** it concerns aiding students with how to best find (educational) resources online, and it may be beneficial to establish
385 **curated (and searchable) portals for thematic content**.

should be done with caution, as reflected on in Course 2 evaluations by students. Extensive Students in particular mentioned
405 the extensive cross-linking between the Geo-UAV and Geo-SfM modules was often mentioned as a point of confusion , and it may thus
be better to integrate, rather than link, (Table 1), underlining the importance to sort corresponding materials in the correct pedagogical
structure.

Course 2 also illustrated that the chosen JupyterBook /GitHub framework worked well for both in- and outdoor settings. The It is important to note that students
benefited from extended introductions to the JupyterBook interface. This became clear to us only after specific feature
410 requests such as the implementation of a search bar were made, even though search and a search bar is automatically
included in the JupyterBook menubar. Here it sits next to buttons used for raising issues and generating portable PDF
documents, which students frequently used to contribute and when exporting notes to bring along in the field. The latter
was best observed during Course 2. The use of the Geo-UAV module with its field days, in particular, showcased the possibility while in
the field showcased the benefits of having interactive and portable documentation that can easily be exported, taken into the
415 field, and integrated into field-based teaching. Given this success our and our students' experiences, we are planning on currently
developing additional modules that target field instruments such as (e.g., differential positioning and various geophysical imaging
tools, some of which are already available through a dedicated module portal) to further investigate the framework's suitability in field teaching.
The development (and future implementation) of these modules largely builds upon the key take-aways presented in this
study, itemised in Appendix S1.

420 4.3 The teachers' perspective

With students actively co-creating and maintaining learning resources, we experienced a significant drop in preparatory workload
and instead enabled work on more in-depth resources and specific content requested by students. We also observed that this

450 *Data availability.* The source material for the Geo-UAV and Geo-SfM modules, as well as that of Geo-MOD (Course 2) is freely available from their respective Zenodo repositories, available alongside URLs to the compiled books in Table 3.

Table 3: Data availability of the modules, including URL references.

Module	URL	Reference
Geo-MOD	https://unisvalbard.github.io/Geo-MOD	Betlem et al. (2024)
Geo-UAV	https://unisvalbard.github.io/Geo-UAV	Rodes et al. (2024)
Geo-SfM	https://unisvalbard.github.io/Geo-SfM	Betlem and Rodes (2024)

620 **Supplementary Material S1: Do's and don'ts for implementing the Jupyter Book/GitHub framework**

The below provides a brief cheat-sheet for implementing Jupyter Book/GitHub as a teaching platform, mostly targeting narrative content and summarising some of our key experiences and learnings.

- 625 – **Read and share the docs:** The Executable Books (Executable Books Community, 2020) project provides extensive documentation for both Jupyter Book and the MyST Markdown language used to write the books. The documentation includes a start-up guide, as well as easy-to-follow topic guides written in simple language. Do not forget to share this with your students for inspiration.
- **Create a minimal working book:** Generate an outline of the to-be-covered topics and create a separate chapter (i.e., one or multiple files) for each and populate the chapter pages with the minimum educational material that needs to be covered in class.
- 630 – **Keep it simple:** Going back and forth between different sections (and modules), was shown to confuse students, as was the (attempted) inclusion of too many topics at once. First, try to avoid extensive cross-linking between pages and content blocks and instead design the module to follow a single red thread. Second, rather create supplementary books covering related topics than including too much content at once.
- 635 – **Provide examples:** Both narrative and multimedia content should be included in the minimal working book, as well as computational content when applicable. The overlapping multimedia approach provides diverse and asynchronous learning options, in addition to providing a quick lookup sheet for student to adapt source-code snippets from during co-creation.
- 640 – **Familiarise students with the framework:** Do not expect students to create content out of thin air. First, students need to be comfortable using the tools and be given ample opportunity and freedom to revise content. This means one must first lay the foundation for co-creation. For example, start with the basics by explaining students how to navigate the Jupyter Book pages, provide a basic introduction on how to use the GitHub backend. A simple "hello world" post on GitHub is an easy start. Then extend their co-creation skills by introducing more extensive revisions through forks and pull requests, for example asking students to fix spelling mistakes or replace a figure. Another example, taken from the Geo-SfM module, is to ask students to share their results by updating a built-in gallery, in Geo-SfM done by pull-requesting a model tag into a configuration file on the "Uploaded examples" page. Remember, for those without a programming background, such a revision may already feel like extensive programming and quite the achievement.
- 645 – **Co-creation over time:** Do not expect pages worth of content to be added by students at once, rather, the minimal working book will evolve over time as revisions and additions culminate in a compendium co-shaped by students.
- 650 – **Encourage additions and revisions:** Faster-paced students, those who have taken similar courses elsewhere, or those interested in more advanced scenarios may be eager to extend the course content. This is best done by

giving them a well-defined task, which can be as simple as asking them to e.g. document (both text and GIFs) what function X does in program Y or expand a pre-existing section. .

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– **Usability vs. functionality:** Use open and/or pre-installed softwares, such as the snipping tool, that are easy to use by both instructors and students alike, rather than overly-complex softwares and tools. These typically make for straight-forward tools that capture content in sufficient quality to be included in the course while being time- and resource-efficient.

– **Keep it concise:** Describe things stepwise and to the point. Try to include only one step per accompanying GIF at a time, opting rather for several than for one long animation.

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– **Learning first and foremost:** The students' main focus should be on absorbing and shaping course content, and not on dealing with compilation errors and software bugs. Thus, it is highly advised that instructors maintain control over the "build" process of the Jupyter Book pages. This also allows instructors to inspect changes prior to publishing. Secondly, it is advised to only sporadically re-build the books from their source, ideally when students are not using the resource. This to prevent confusion due to e.g. mismatching pages and unexpected changes.

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– **Disseminate:** The open sharing and listing of Jupyter Books (for example in the Jupyter Book Gallery) helps others find, access, integrate and reuse their resources. External collaborators may even contribute to the Jupyter Book, supporting co-creation and collaboration within the greater community.

Table S3: Questions and answer options.

Question/statement	Answers	Ref.
BACKGROUND INFORMATION		
I am affiliated/enrolled with UNIS...	YES NO	
My (educational/scientific) background mostly corresponds to....Biology	YES NO	
My (educational/scientific) background mostly corresponds to....Geology	YES NO	
My (educational/scientific) background mostly corresponds to....Geophysics	YES NO	
My (educational/scientific) background mostly corresponds to....Technology	YES NO	
My (educational/scientific) background mostly corresponds to....Safety	YES NO	
My (educational/scientific) background mostly corresponds to....Guiding	YES NO	
My (educational/scientific) background mostly corresponds to....Other	YES NO	
BACKGROUND KNOWLEDGE		
I was familiar with programming (e.g., Python, R, matlab)	- - + + + + +	Fig. S1
I was familiar with Jupyter Notebook/Lab	- - + + + + +	Fig. S1
I was familiar with Jupyter Book/Executable Book Project/Sphinx/Read The Docs	- - + + + + +	Fig. S1
I was familiar with YouTube	- - + + + + +	Fig. S1
I was familiar with animated GIFs	- - + + + + +	Fig. S1
I was familiar with git (e.g., GitHub)	- - + + + + +	Fig. S1
DEVICE USED		
I used the following device to read/interact with the compendiums:.Mobile phone	YES NO	
I used the following device to read/interact with the compendiums:.Tablet	YES NO	
I used the following device to read/interact with the compendiums:.Desktop	YES NO	
RATINGS AND OBJECTIVES		
What were your (learning) objectives when following the XXX Compendium?	Open	
Future documentations - your compendium ideas?	Open	
Rate your overall experience of using the XXX Compendium on a scale from 0 to 10, with 0 being extremely dissatisfied and 10 being extremely satisfied.	0 to 10	
Rate your overall experience of learning with the XXX Compendium on a scale from 0 to 10, with 0 being extremely dissatisfied and 10 being extremely satisfied.	0 to 10	
COMPENDIUM INFORMATION		
The XXX Compendium met my needs	- - + + + + +	Fig 2
The topics covered by the XXX Compendium were relevant to the course	- - + + + + +	Fig 2
The XXX Compendium pages were easy to navigate	- - + + + + +	Fig 2
The XXX Compendium content was clear	- - + + + + +	Fig 2
The XXX Compendium content was too difficult	- - + + + + +	Fig 2
I enjoyed using the XXX Compendium	- - + + + + +	Fig 2
I would recommend the XXX Compendium to others	- - + + + + +	Fig 2
I will use/have used the XXX Compendium after the module ended	- - + + + + +	Fig 2
What did you like most about the XXX Compendium? Try to come up with at least two examples.	Open	Table 1
What did you like least about the XXX Compendium? Try to come up with at least two examples.	Open	Table 1
MULTIMEDIA QUESTIONS		
The animated GIFs and videos explained the content clearly	- - + + + + +	Fig. 3
The animated GIFs and videos supplemented and clarified the text	- - + + + + +	Fig. 3

continued ...

...continued

Question/statement	Answers	Ref.
The use of animated GIFs and videos helped me better understand the material	- - + + + + +	Fig. 3
The quality of the animated GIFs was high	- - + + + + +	Fig. 3
The quality of the videos was high	- - + + + + +	Fig. 3
The animated GIFs played too fast	- - + + + + +	Fig. 3
The videos played too fast	- - + + + + +	Fig. 3
The animated GIFs lasted too long	- - + + + + +	Fig. 3
The videos lasted too long	- - + + + + +	Fig. 3
Being able to pause the animated GIFs would be useful	- - + + + + +	Fig. 3
A voice-over/spoken instruction would make the animations and videos better to understand	- - + + + + +	Fig. 3
I typically watched the videos at faster playback speeds	- - + + + + +	Fig. 3
I typically watched the videos at slower playback speeds	- - + + + + +	Fig. 3
On average, I rewatched individual animated GIFs x times	0 1 - 3 4 - 6 7 - 10	Table S2
On average, I rewatched individual YouTube videos x times	0 1 - 3 4 - 6 7 - 10	Table S2
On average, I paused YouTube videos x times	0 1 - 3 4 - 6 7 - 10	Table S2
What did you like about the mixed use of animated GIFs and videos in the compendiums? What worked?	Open	Table 1
What did you dislike about the mixed use of animated GIFs and videos in the compendiums? What did not work?	Open	Table 1
DID YOU KNOW?		
Individual compendium pages can be generated as PDFs from within the pages themselves?	YES NO	
You can contribute and suggest changes directly from the compendium pages?	YES NO	
The raw material for each compendium is openly available on GitHub?	YES NO	
GitHub hosts an issue and bug tracker for each of the compendiums?	YES NO	

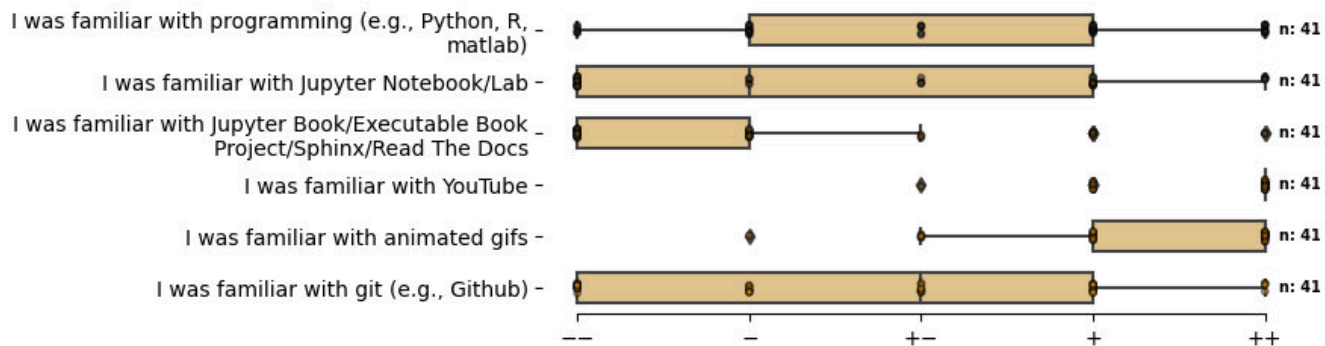


Figure S1. Assessment of prior knowledge/experience to the implemented digital tool sets one which the compendiums are built.