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; Wiley, 2013). 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-Papart from other forms of OP and teaching practices, whilst still benefiting from the OP framework (Andrade et al., 2011)) as a 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 of open licensing: OER-P welcomes participation and contributions, regardless of location and background, and conceptualises the learner as a peer contributor to a broader community that tries to address a particular need or problem. Herein the 5 Rs foster a culture of collaboration that facilitates community-supported growth and innovation (Tietjen and Asino, 2021). One only has to recall the COVID-19 pandemic to see the added potential of such an approach (Tietjen and Asino, 2021)(e.g., Tietjen and

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 under-represented 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

Today, OP and OER-P can draw upon a rich ecosystem of (open) tools designed to document and distribute software and data, such as Project Jupyter. Project Jupyter promotes open standards and is an open-source project for interactive computing that is widely used in data science, machine learning, and scientific computing (Project Jupyter, 2023; Granger and Perez, 2021b)(Project Jupyter,

table 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 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, 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 animationsand traditional course content, as a tool for enhanced geoscientific learning. We demonstrate the applicability of the environment and assess), assess user and student learning experiencesof using and contributing to the course modules, and appraise the co-creation possibilities.

feedback solutions. The students were then asked to work through the course modules in pairs, applying the concepts of pair learning to further enhance collaborative learning (Nagappan et al., 2003; Drey et al., 2022).

In the Geo-SfM module, students were invited to “catalogue” their processing results by voluntarily submitting their work to a gallery page. This was done either in collaboration with instructors or individually through a pull request to a configuration file. Required metadata included a link to the results, the course year and course ID that, once compiled, provided an example gallery and overview of past work.

The GitHub platform, including its Classroom tools, has previously been shown to improve the educational experience for students and teachers (e.g., Zagalsky et al., 2015; Fiksel et al., 2019), and facilitates open hosting of documentation. The use of

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 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, 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 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.

Perhaps the most important reflections came on the use and integration of animations students' reflections were on the integration of GIFs 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 GIFs 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, similar to observations made in educational video design studies (e.g., Guo et al., 2014). During plenum discussions, students largely agreed with our hypothesis also largely agreed 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 chunksas seen through student contributions (Fig. A1). The consecutive use of single-step animations acted as a form of signaling, or cueing, of different parts of the greater process, which has been shown to help direct learner attention and improves knowledge retention and transfer (de Koning et al., 2009; Mayer and Moreno, 2003; Brame, 2015). Further studies are, however, needed to ascertain these findings and find optimal playtime durations for animated and video contentthe animated GIF content, as has previously been done for educational videos (e.g., Guo et al., 2014).

Indeed, some of the technologies and software being used were nascent and unfamiliar to students, though this was easily

Book/GitHub framework. These lay the groundwork for future activities that are needed to quantify student perceptions of these and other aspects, which we only briefly touched upon in the current study. Still, our results provide valuable insight into 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 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).

At the time of submission, a simple search-engine search for *structure from motion photogrammetry tutorial* shows the Geoshould be done with caution, as reflected on in Course 2 evaluations by students. 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, 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 Geo-UAV module with its field days, in particular, showcased the possibility of having interactive and portable documentation that can easily be taken into the field and integrated into field-based teaching. Given this success, we are planning on developing additional modules that target field instruments such as differential positioning and various geophysical imaging tools, some of which are already available through a dedicated module portalIt is also important to note that students benefited from extended introductions to the JupyterBook interface. This became clear to us only after specific feature 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.

With students actively co-creating and maintaining aiding the maintenance of 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.

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)

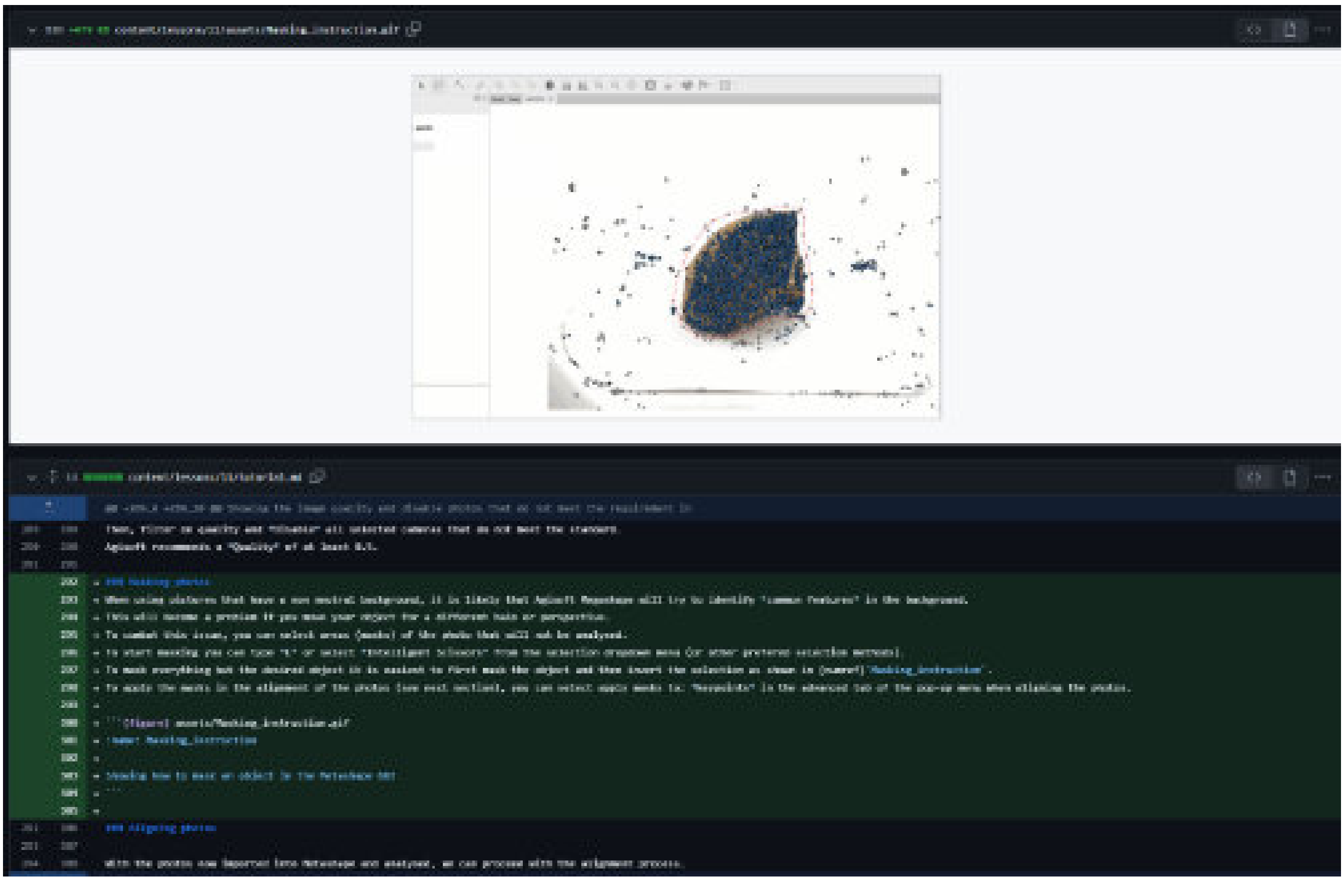

Figure A1. Student contributions ranged from single edits and suggestions, to multi-paragraph revisions and newly-recorded animations. Shown here is the student-contributed revision that documents the masking of photos in Agisoft Metashape and added it to the Geo-SfM tutorial (lesson 1). Note that the contribution is formatted in MyST Markdown and includes both text, an image code-block, and the self-recorded animation. Pull request link: https://github.com/UNISvalbard/Geo-SfM/pull/66.