Case Study

Inter-Disciplinary Undergraduate Student Co-Creation: Animation and Physics Working Together to Produce High-Quality Teaching Materials

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Abstract

Academic development and delivery increasingly benefits from co-creation with students. This interdisciplinary study looks at a five-year collaboration between physics academics and animation students to co-create innovative and high-quality teaching materials focusing on the conceptually difficult topic of space science and astrophysics. The resulting animation pieces are available online for educators to use. Students gain real-world experience with an external client, building a community outside their usual peer groups and collaborating with people with different areas of expertise. The paper offers a framework for effective animation for visual learning in physics – or indeed any science, technology, engineering and mathematics (STEM) subject.

1. Introduction

Despite many efforts to combat the dichotomy between the arts and science, technology, engineering and mathematics (STEM), students (and sometimes academics) on either side of the divide still regard each as distinct from the other. This perpetuates the common and often firmly held belief in relation to student outcomes that STEM skills are what are needed for employment (Ashton 2023). This misconception is holding many graduates back at a time when the ever-increasing "*needs of the emerging knowledge economy*" (Mashood and Singh, 2013) must be adequately met. Multi-disciplinary lectures are difficult to offer at the undergraduate level, whether in providing content to fulfil accreditation body requirements or in finding the relevant expertise to deliver the material. This suggests that, until the disciplines are integrated at an earlier stage of education, the more appropriate response is interdisciplinary co-creation.

For STEM students, a university will aim to deliver two primary skill areas: discipline-specific and transferable. Though the delivery and assessment of knowledge within a particular field is commonplace, it is harder to determine how well students can apply their transferable skills (Whitcomb *et al*., 2021). Of the latter, communication is of considerable importance. An Institute of Physics study (IOP, 2022), conducted by Emsi Burning Glass, showed that, of the nine employability sectors for physics graduates, the skills' demand density for communication was highest in eight of them and third most important in the final sector out of fifteen skills which included research, planning and investigation. Providing a greater range of good quality media and interdisciplinary examples is likely to capture the interest of undergraduates and generate discussion about this particular transferable skill.

The inclusion of the arts within science – pursuing a science, technology, engineering, the arts and mathematics (STEAM) approach rather than STEM – has been shown to have benefits: for example, in addressing the science gender gap and the "*leaky pipeline*" effect (Wajngurt and Sloan, 2019). Learning with a range of media, rather than from written accounts, may enhance

STEM students' empathy with science history and the people associated with it (Pietri *et al.*, 2021). In turn, this may also encourage new interest in the sciences among students with study focus on a different discipline (Land, 2013).

The project aimed to show the benefits to students of providing experience of the work environment in the form of a client brief, in order to produce resources based on a discipline other than their own. This study looks at the results and effects of a five-year collaboration at Nottingham Trent University (NTU) between two academics within the separate campus departments of Animation and Physics. The project looks at the co-creation and co-production of physics content in a broad range of topics by students studying animation – a learning experience with a portfolio of development work and a final output of benefit to both departments. Though this may seem a commonsense strategy for producing pedagogical materials, there are few published examples in the literature, the closest being Wang and Shao (2016). The student-produced animations are used in physics lectures – as examples from Animation – and in public science outreach, so creating exposure and helping learners in both fields. This work demonstrates an innovative model of collaborative learning across two very different disciplines – integrating animation students into a physics community. As demonstrated in section 2.1, this helps to overcome physics academics' inexperience in multi-media dissemination, so also constituting, through technology and co-creation, a cross-disciplinary solution to a communication problem. The outputs, on YouTube, are available for the long term both to other practitioners and in lectures as a sustainable teaching approach.

The undergraduate students involved in this study were level 5 and studying on the BSc (Hons) Animation course at NTU. They already had background knowledge of storyboarding, of using animation rigs and of delivering outputs to scaffold their learning for this, a live brief assessment (live brief is how the Animation team define this assessment). They represented a spectrum of student nature from confident and outgoing to shy. That team groups (of between four and eight students) could determine their own roles, from producer to artist, allowed them all to amplify their existing skillset or try a new approach to their learning.

2. Methodology

The combination of physics and animation may at first seem an unlikely pairing. However, there are many similarities between the subjects not shared by other departments. An example is the extensive use of software packages and algorithm writing to ensure a high-quality output; physics undergraduates are required to do this produce rigorous data analysis. Animations require a storyboarding process to prepare for how the final piece will be developed and the tasks divided, and physics students are expected to "*have an appreciation of how to plan and execute experiments or simulations*" (QAA, 2025) and work in teams to complete analysis efficiently and in a timely manner.

Producing short animations for physics education (stakeholders being undergraduate students and/or the public) demands this inter-disciplinary approach. The project is pitched to students at level 5 studying BA (Hons) Animation, with the intention of creating a student team working with a client brief to co-produce a visual piece. The main difference from other co-created undergraduate projects is that the student producers are from Animation rather than the primary community benefiting from it, which adds an additional layer of complexity but promotes work-like professionalism.

2.1 Motivation

A common public perception is that STEM subjects are not creative; however, this is far from the truth. In my experience, STEM academics may not explicitly recognise the creativity inherent in their own work – for example, in designing instruments, fabricating components or developing experimental solutions – and therefore rarely describe their work in these terms. This disconnect potentially occurs because laboratory reports, journal articles and academic communications have to be in a professional scientific writing style, which may unintentionally privilege students already familiar with dominant academic and scientific writing conventions, while at the same time creating barriers for first-generation students and for those working with English as an additional language.

Images generated by staff tend to be either low-quality or AI-produced. There is resistance to AI imaging amongst some academics, owing to: 1) a lack of credits to reference library images and 2) their view that the amount of water for cooling of the computers required is unsustainable. An example of the work of one of the authors is shown below in figure 1a) to prove the point about low quality. Panels 1b) and 1c) show a screenshot of the same concept from two separate pieces produced by animation students during the course of this collaboration. The panels produced by the animation students shows more clearly an increase in quality in the form of a continuous video, making the delivery of a complex topic easier to demonstrate.

Figure 1. a) An example of an academic-produced image of a black hole gaining mass via a particle accretion disc. b) A screenshot from a cartoon-style animated gif showing a rotating black hole with a disc of material falling into the centre producing light. c) A later animation piece with particles falling into the black hole uses a mixture of cartoon 2D particles and the black hole inspired by the one used in the film 'Interstellar'.

Enthusiasm about and interest in student co-creation within the department of physics has been noticeably increasing since the Covid pandemic. Co-creation is seen as a powerful means of driving student engagement and interest in the discipline; however, it isn't commonly implemented because it is seen as high risk, it needs trust in students and it may not seem to sit comfortably with the pressure on academics to ensure progression. Giving educators the chance to try new approaches and reflect without fear of the consequences of it not working perfectly, e.g. the cycle of enactment and investigationis key to successful co-creation (Jao *et al*., 2018) and amongst the authors has led to outputs of critical assessment of pedagogic style (Whittaker and Hough, 2025) as well as the introduction of novel laboratory equipment (Whittaker, Elkan and Toms, 2025*)*.

Learning experiences that emulate the work environment, especially client briefs, have been shown to improve both technical and meta-skills to make students real-world ready (Rohm, Stefl and Ward, 2021). The work reported here is part of the level five 20CP module '*CoLab: Research, Exploration and Risk-taking*' within the Department of Animation at NTU, run by Robert Szczerba

(RS). This module includes a live client brief (the focus of this collaboration), creative pieces for different age ranges and software experience.

2.2 The pitch to students

The first stage in the annual production of animation videos for use in physics is the pitch to the students making the interactive piece. The brief for the students is to work with an external partner who pitches a personal idea to the cohort. Groups of between four and six students bid to work with the presenter of their choice. This approach provides the benefits of a short, embedded internship (Jackson and Bridgstock, 2021) and builds professional networks for future employability (English *et al*., 2021). The partners are generally from local charities, councils and institutions, in addition to just one university presenter, Ian Whittaker (IW) from the Department of Physics.

Each pitch to the student group typically lasts ten minutes and requires the following information:

- The content - your key messages / information
- Purpose - to persuade / inform / entertain, or a mixture of these
- Your intended audience *e.g.*, general public, businesses, students (it may be a range)
- Ideas you have about the style and tone of the film you'd like to see
- Duration of the final piece of work

The pitch delivered by IW over the years has consisted of an introduction by the academic and the particular field of research (space weather, rocket science and atmospheric dynamics), immediately followed by the outlines of three discrete possible projects, which convey the opportunity for choice and initially give students the chance to work on something they may be more interested in, familiar with or have a passion about.

Each year, at least one group has applied to work with IW on creating animations, examples from the previous years having been shown in the pitch. The students are allocated the projects by the end of November for completion by the end of February in the same academic year.

2.3 Student animation development

Animation students, using their skills within a physics environment to produce high-quality animation pieces for use in physics, are primarily co-creators: the collaboration between them and the physics academic depends on mutual trust and understanding to co-create powerful education materials based on good science. Every student team (except in 2020) working on a physics project has an invitation to visit the physics laboratories, which are on a different campus, to try out experiments related to the subject of their animation. This means of clarification for the students allows them to try some hands-on physics experiments, which they might not have done since their compulsory education period at least three years before.

This laboratory session lasts for three or four hours. Previous activities have included: Ruebens tube demonstrations, diffraction of laser light, calculating the speed of sound with microphones and an oscilloscope, advanced van de Graff generators and Chladni plates. Experiments like these provide the physics education background and are more advanced than would be seen at sixth-form level. The students have always been enthusiastic at the end of the session, confirming that it has helped their understanding of what they are trying to create.

The students then produce a storyboard and concept art for the piece for presentation to IW over MS Teams, so building a client/animator relationship, rather than an academic/student one, and allowing them to suggest new ideas and negotiate about matters of production: in other words, co-creation and co-production by students as partners. This relationship continues throughout the project until a final piece is produced and showcased.

Discussion between the student team and IW incorporates responsible research skills typical of the real workplace, such as copyright ownership, display embargoes and accurate attributing of the piece to the members of the team and academic involved. The transparency of these conversations, and the requirement for the final output builds trust (Dollinger, Lodge and Coates, 2018) and makes the co-production relationship much smoother.

3. Results and discussion

The students submit their final animations as part of their module. With their consent and for sustainable sharing of these outputs, IW displays their pieces via YouTube.

The pieces created are listed in appendix A to illustrate the range of student interest and the topics covered.

Screenshots taken from these animations, showing variations in style, can be seen in figure 2. Hyperlinks to each of these animations are included in appendix A, except for panel a) which is a series of animated gifs and are provided in this paper's supplementary material. The authors encourage the sharing of these materials with education providers for all ages.

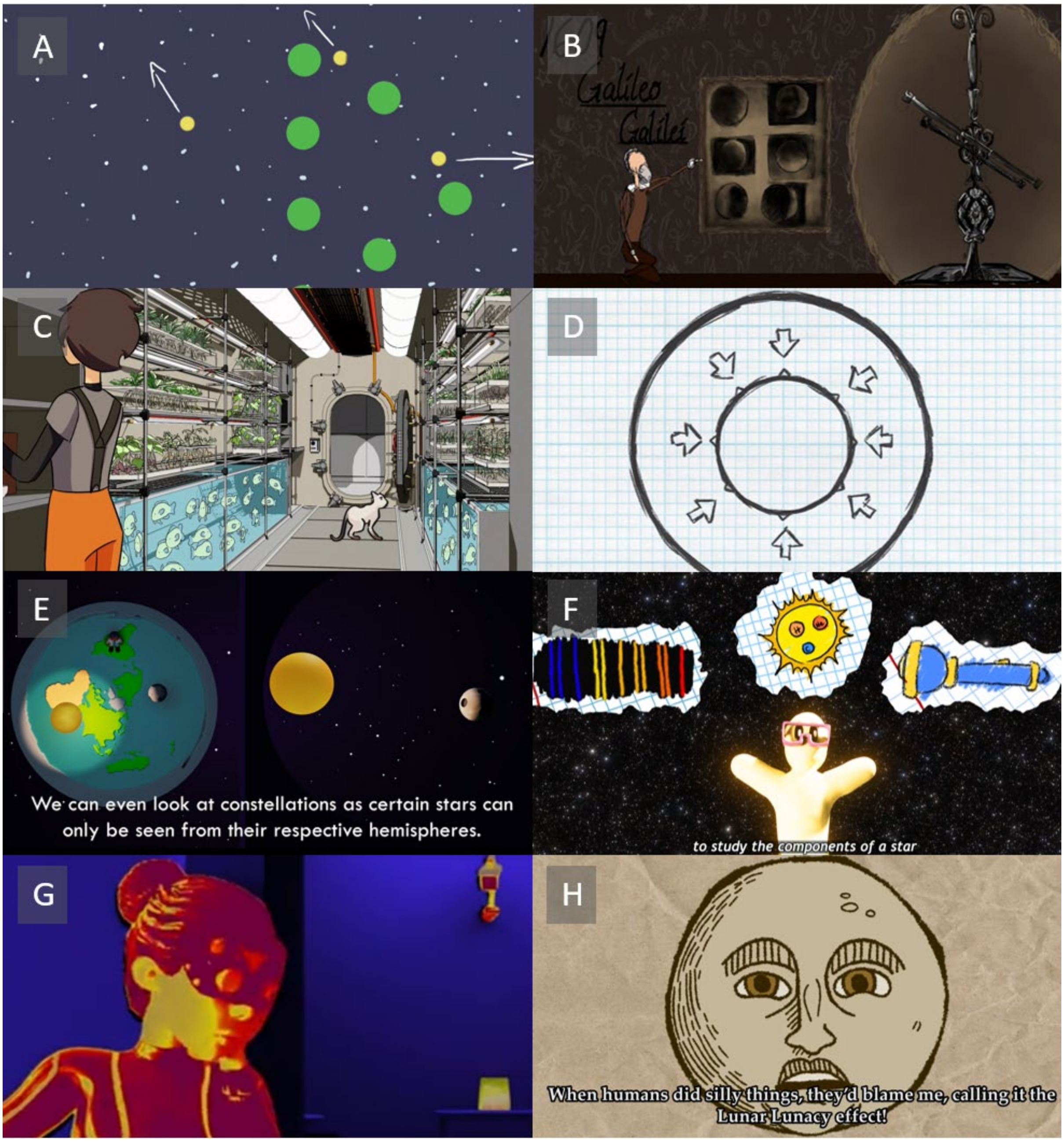

Figure 2. Screenshots taken from each animation listed in Table 1; the styles range from cartoon to realistic and are a mix of 2D and 3D productions.

3.1 Co-creation benefits

We can look at the benefits to students in two specific areas. The first to consider relates to them as co-creators of the animation, going through the production process;

a) The similarity of the pitching process and concept production to industry skills and experience improves the employability of these students. Unlike traditional co-creation pieces, our students produce material for a different cohort of students. This may seem like a risk for the students, but, as Lubicz-Nawrocka and Bovill (2021) confirm, it is challenge of this kind that provides the conditions for student transformation. Production of the material leads to enhanced student/staff relationships and passion for the subject (Dollinger and Lodge, 2019).

That the animations last less than three minutes develops both time management and narrative communication skills. While Kugemeyer (2020) provided a comprehensive framework for 'high explaining quality', this is too complex for use with the students building these animations. Instead, for their creation of pieces designed for academic discussion with students and/or the public, we encourage creativity by means of examples of previous animations, science communication pieces written by IW and regular informal feedback.

Publishing an output piece online measures public engagement and generates comment, helpfully identifying what has worked well and stimulating reflection; this process positively influences future submissions and offers evidence of key employability skills, such as adaptability and the capacity for rapid response to culture change.

Including students in the co-creation of these animations is particularly relevant to a decolonising of the curriculum to make it more accessible within physics (Cook-Sather, 2020). A diverse range of students from different backgrounds generates expression of many viewpoints and encourages greater objectivity in terms of assumptions about student knowledge, as was especially evident in the '*Diverse history of astronomy'*, for which the students provided researched information previously not known to IW but which enhanced the global appeal of the material. Many of the co-creation teams have included international students, whose perspective has clarified the message of their animations and improved accessibility.

As the animation students are entering a new field and incorporating it into what they know, their approach embodies elements of education for sustainable development (ESD): time management to enhance personal efficiency within their team and dealing with and making sense of a wealth of new information in order to produce a high-quality output. Both Animation and Physics department staff guide and offer pastoral support during meetings with the students.

b) The second area of benefit is for those students exposed to higher-quality digital media in the academic setting. While the notion of educational learning types has been debunked (Yfanti and Doukakis, 2021), the quality of visual material may affect some students more than others. Guaranteeing provision of high-quality animations will help all students, as long as these are not replacing existing taught material (Noetel *et al*., 2021).

As the literature covering better-quality videos and animation mostly tends to focus on *online* lecture delivery, there is little evidence, therefore, about which features of such resources are beneficial when used as part of *live* teaching. When students create animated resources for a discipline outside their own, it may be assumed that they do not have background knowledge of the subject material and so to bring them into this alien environment to learn about their chosen topic as co-creators helps us to deduce what aspects of the outputs need to be focused upon, by listening to the questions asked, by discussing with them the topic and storyboard format… in short, by engaging with them as clients would with experts with a particular skillset. This process will produce a result that is the true aim of co-creation in that a symbiotic relationship of expertise is formed. Thus we have been able to put together key requirements, detailed in section 3.4, for producing quality media for students to learn from in live teaching regardless of whether co-created or not.

The collaboration between the two departments has also yielded an additional academic benefit. To make a 2025 grant application in physics more appealing and easier for reviewers to follow, the animation student cohort received instrument images made in MS PowerPoint, together with the request to turn them into clearly drawn isometric view diagrams. The output from this work and detail of the process are included in appendix B and represents a real-world learning experience for the students in a medium in which their output is being used for a genuine professional application.

3.2 Animation student reflections and feedback

The client live brief is not formally assessed but contributes to the students' own professional portfolio; formative feedback is given, based on both the quality of the final piece and reflections from each member of the team. This feedback process encourages an honest student response about how they have found working with each other and their non-expert client.

These reflections are primarily focused on their contributions and the software processes, but three similar themes come out each year from those working with IW: some of the direct quotes from the student reflective pieces are therefore included for context.

These quotes, specifically from the groups working with physics, have been anonymised by a data manager and collected from submitted reflections which the authors do not have identifying information for. Use of these student comments in this format is ethically approved under the Institution Data Governance Policy and also the Student Charter (Statements of which are provided in appendix C).

Community: With a client specialising in a completely different academic discipline there is an equal challenge for all team members. Many individual reflections highlight that working together encouraged peer learning when taking on such an alien task.

- *"Everyone was always willing to work together to problem solve and it has been so useful to learn tips and tricks from each other"*
- *"Having a live client allowed for getting an outsider's perspective and feedback when normally you are within your animation group and teachers from that background. It has definitely taken me out of my comfort zone"*
- *"The group was a wonderful collection of creative and hardworking people who were very kind and accommodating"*
- *"I feel proud to be a part of this group, with everyone very equally putting in the effort to satisfy our client and submit a quality piece of educational animation!",*
- *"The biggest thing I feel I can take from this module, is that I can trust my fellow animation teammates"*

Freedom of choice: Letting students co-create means placing trust in and giving freedom to the team. There was a divide between those who appreciated the openness allowing for their creativity and those who felt a more direct approach – of being told what was wanted – was preferable. This disparity occurred within teams and between years.

- *"I enjoy working for a real client, and being given the independence to develop our own ideas"*
- *"I think we took a lot of risks with this script"*
- *"This brief was a challenge as the client was initially vague, he gave us lots of creative freedom which was great, but also meant we had a lot of visual & story idea exploration and research to do."*

- *"I felt my team had lots of creative freedom, inspired by the limitless and unique theme we had"*

Positive interaction and output: The members of each group took pride in their interactions and their final piece, considering it a positive contribution to their undergraduate experience.

- *"This was the most ambitious piece of animation I had to do for this project, and I am proud of the finished piece"*
- *"For me this module has been an overwhelmingly positive experience"*
- *"… [a pronoun] critically evaluated our animatic and broke down a lot of the complex parts we weren't aware of"*
- *"I enjoy the thought of our final piece being presented on a showreel, or as intended, to an audience of students in a lecture focused on astrophysics. Maybe even a class of pre-school/primary school children who may enjoy the visuals as well as the light-hearted educational nature/humour of the animation".*

Having a client who also understood the university system, deadlines and working requirements gave a slightly different experience from that of the other groups in the cohort. While this aspect was not mentioned as a positive by these groups, an individual student with a different client, *i.e.* external body rather than physics, mentioned "*having to work for people without the knowledge of the animation pipeline and do not at all value the work given to them, nor those who don't exist within a university setting was a miserable experience that far outweighs the valuable real–world working experience that I received from it*".

An individual reflective comment also discussed the pleasure of being able to take a constructive feedback approach to student creativity, *" … [a pronoun] was very helpful when discussing ideas and [a pronoun] never simply teared what we had done apart. [a pronoun] clearly thought about it a great deal which I respect*".[1]

3.3 Use of the animations

While the benefits for students are clear, what about when we use this for the public? The availability of these videos on their own channels is subject to the students' wishes and additional promotion is guided by student consent. Two student groups have promoted their work themselves and placed them on their own YouTube pages to be shown publicly. These have been promoted through the *NTU* physics Instagram page and by student word of mouth as well.

The '*Particle journey into a black hole*' animation has reached 279 views – it has also been used in the level 5 BSc/MSci Physics '*Stars and Galaxies*' module for discussing accretion discs and how a black hole grows. The '*Offworld*' living animation was included in a public science article in 'The Conversation' on the same topic (Whittaker, *2021*). The views of this piece went from <100 to over 1.5k in a single day and the total currently sits at over 7k views. All public comments on both pieces have been respectful and positive.

The other animations have had permission to be uploaded to a central physics YouTube channel which has been made available for readers to access the animations. These are used in a variety

[1] For the purpose of data anonymity, we have replaced some pronouns in the quotes with "[a pronoun]".

of contexts but mostly in level 4 and level 5 undergraduate modules to assist with explanations, although the '*Diverse history of astronomy*' animation was also shown at the start of astrophysics lectures during the first week of Black History Month in 2021 and 2022.

Having these animations ready to be used by any academic also improves the sustainability of excellent teaching. As the science provided does not change, these animations remain relevant and can reduce the workload of busy academics in redesigning lecture images or simulations. These multimedia pieces permit a variety of learning with no change of lecturer and can stimulate discussion on the importance of appropriate science communication styles and interdisciplinary collaboration.

3.4 Implications for practice

Over the running of this collaboration the animations with the highest grades and numbers of engagement have followed the four key principles listed below. Practitioners wishing to follow this type of collaboration should scaffold students or support their own outputs in relation to these elements.

- **No assumed background knowledge** – this may seem as if it is being explained for public understanding, but providing information from a basic level ensures student learning parity and scaffolds any future learning.
- **Visually appealing** – with a dull set-up and explanation, an animation is likely only to be useful for explaining for up to twenty seconds with an average undergraduate student. Inclusion of colour, activity, questions and interactive, relatable or light-hearted features may improve engagement and support effective topic teaching.
- **Application** – ensure the topic has some basis in a student's lived experience. This can be difficult in the case of black holes but linking spectroscopy to what stars are made of and calculating the weight of a galaxy may offer a way in.
- **Narrative** – when content is taught make sure it follows a narrative, building information step by step.

4. Conclusions

This paper describes five years of collaboration between level 5 undergraduate students studying BA (Hons) Animation and physics academics. Though it may at first seem an unlikely interdisciplinary pairing, by providing transparency in the clients' requirements, by allowing access to hands-on application of the task and, most importantly, by promoting creativity in student co-creation, a number of high-quality physics education multi-media pieces have been produced.

These pieces are provided free for academics teaching space concepts, to scaffold students' learning, and are intended to allow reflection and discussion by a range of age groups.

The primary benefits discussed by the students during this co-creation process were an increased sense of student community and belonging, the freedom to develop and be creative while working towards a specific output and the opportunity to receive constructive feedback.

While inter-disciplinary student co-creation is not currently a widely applied method within undergraduate teaching, we have underlined the advantages to both disciplines. For student producers, this is a learning experience that emulates the working world, with a client outside students' area of expertise and with little knowledge about their personal strength: effective animation. The situation requires trust to be quickly built between partners by openness and transparency about the level of previous knowledge and the requirements of the task. To prevent students' wasting time and effort on researching irrelevant topics, working with them on time management and focus provides them with sustainable continuous development.

For academics, the resulting animation provides a professional teaching tool for scaffolding verbally delivered aspects, with a much more efficient use of their time. These materials then positively influence the engagement of students and are more likely to empower them to continue searching for other videos on the topic as part of independent learning. Finally, a framework of factors for good practice is included, which practitioners from other disciplines could use to enhance their teaching approaches by partnering with media expertise departments in their institutions. This collaboration relies on communication and a willingness to find academics to talk to within the institution, which may be a barrier at institutions with several campuses or a complex hierarchy of departments. The main message is to be open to teaching collaborations to promote creativity, co-creation and innovation in teaching and learning. The authors hope that this inter-disciplinary student practice is extended to other disciplines to assist with producing high-quality teaching outputs.

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Appendix A: A description and links to all animations generated.

Academic Year and image label	Topic	Synopsis
A: 2019/20	Black holes and mean free paths	Two short animated gifs produced, based on IW's lecture notes and diagrams. The first shows how material in an accretion disc falls into a black hole and the second looks at how light intensity is reduced by dust cloud density in space.
B: 2020/2021	A diverse history of astronomy	A short animation which shows development of telescopes and observations from a more global perspective and includes what we would consider BAME astronomers; at the time, of course, they were

		just astronomers in their local region! This was used in Black History Month in 2021.
C: 2020/2021	Offworld living	An animation showing the various adaptions and potential problems that a group of lunar colonists would have to go through, including fixing of power sources cultivating food and constant exercise owing to reduced gravity.
D: 2020/2021	A particle's journey into a black hole	A realistic animation of black holes and why they are dark including explanations of what would happen if the Earth was a black hole.
E: 2021/2022	Debunking flat earth	A look at how we see the different phases of the Moon, and then what this would like on a flat version of the Earth, which shows every phase of the moon each night.
F: 2022/2023	Identifying star composition	A video showing how different wavelengths of light correlate to different elements. This is done with a go-kart going along a rainbow road which rapidly loses width depending on which elements are in the star.
G: 2023/2024	Blackbody radiation	This animation follows a spy moving through a warehouse avoiding security by utilising infra-red and ultraviolet transmission properties of materials. The final goal is a special item described by the handler.
H: 2024/2025	Lunar myths	An animation providing historical context to lunar observations and myths behind the blood moon as well as future exploration plans.

Table 1: A list of the student animations produced with the physics collaboration. Links to each output on YouTube are provided by clicking on the titles.

Appendix B: Images to explain theoretical instrumentation.

As described in Section 3.1, an additional benefit of this interdisciplinary work has involved asking students to redraw basic images of equipment within a grant application to make them isometric, clearer, more appealing and easier to follow. An example of two of the PowerPoint instrument images and their drawn counterparts are included below in figure 3. Each request came with a written description of what the instrument should like, why it looks the way it does and additional features. From a physics staff and technician view the results have been positively received and will open up future collaborative requests for students to develop their portfolio and participate in work-like learning.

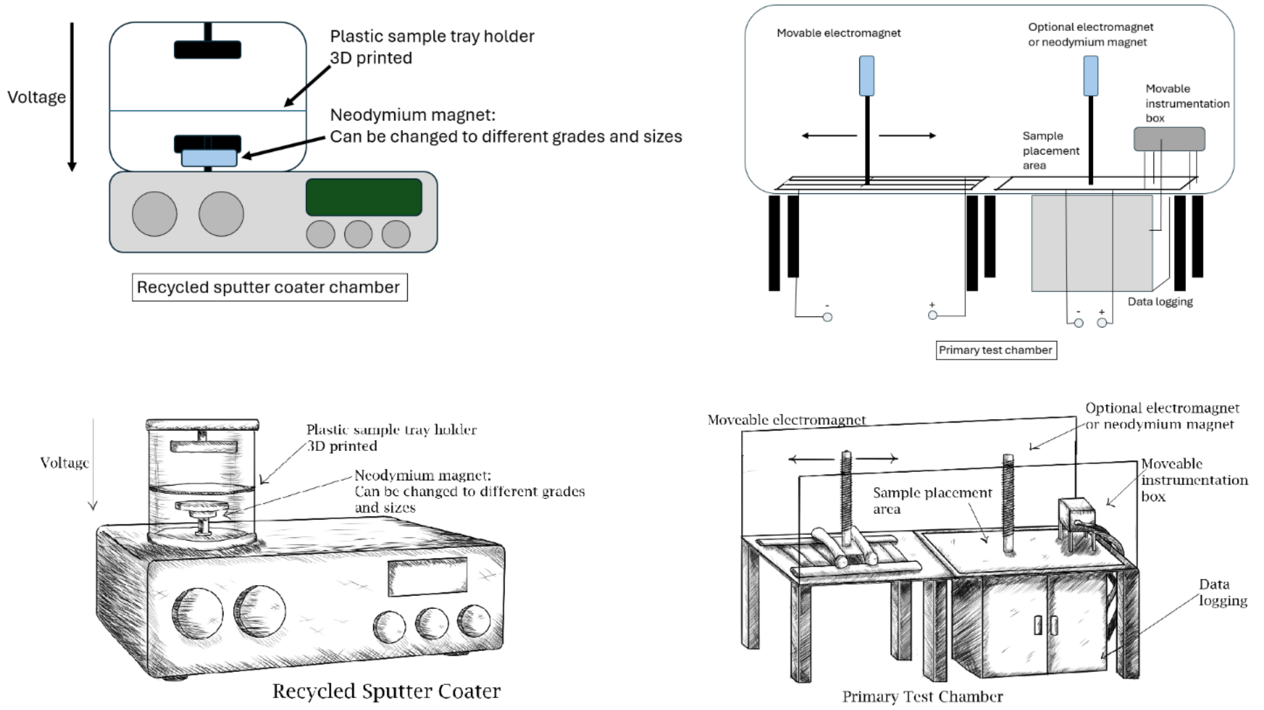

Figure 3. Two example PowerPoint images with the student created version showing a clearer, more easily visualised final image. (Drawings by Taylor Lowe)

Appendix C: Ethical use of data statement.

As mentioned in Section 3.2 the student reflective comments can be used by staff as part of the *NTU* Data Governance policy which students sign when joining. In particular the policy states: "*Anonymised data may be used to inform research and as evidence for quality enhancement. This may be shared with NTU staff and students or in publicly shared research*"