

CASE STUDY

Zero waste: leveraging blended learning materials in traditional teaching

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Abstract

In recent years, and especially during the Covid-19 pandemic, several university course units have moved from a traditional format, made of face-to-face lectures supplemented by notes and exercise sheets, to a blended learning format based mainly on asynchronous engagement with recorded lectures, videos, and notes, followed by supplementary synchronous sessions to consolidate and expand on the core material. While during Covid-19 the latter format presented clear advantages, as things slowly go back to normal course leaders are free to choose between the two formats, each of which has its own set of advantages and challenges.

In this case study we explore the transition from a blended learning course back to a traditional face-to-face format, focusing on the use of an innovative ‘anthology’ approach to repurpose digital materials. Originally a blended learning course featuring a mix of videos, notes, and quizzes, the course underwent a transformation to adapt to a more conventional format without sacrificing the accumulated digital resources. Through this transition, an anthology of learning materials was created, which serves as supplementary support for student learning, providing a wealth of learning aids, ranging from mandatory activities to entirely optional exercises. Challenges encountered during this transition, specifically avoiding an increase in workload, and the maturity required from students, will be examined. We aim to provide a framework to highlight the potential of effectively reutilising blended learning resources within traditional teaching frameworks, while being mindful of workload issues, to enrich the students' learning experience.

Keywords: blended learning, anthology, digital resources, traditional teaching.

1. Introduction

In the wake of the Covid-19 pandemic, the educational landscape witnessed a transformative shift, characterised predominantly by the rise of blended learning (Anthony et al., 2022). This modality, an amalgamation of traditional synchronous sessions and online asynchronous educational resources, has not been merely a transient response to the pandemic, but rather emerged as a revolutionary method, here to stay. The allure of blended learning stems from its flexibility, its ability to cater to a diverse range of student needs, and the innovative potential it offers for course delivery. Nonetheless, as with any educational modality, it brings along some drawbacks when juxtaposed against traditional teaching methods, such as a reduced ability to build a personal relationship with students. Some educators still voice a preference for traditional teaching methodologies, citing superior outcomes and efficacy (Guppy et al., 2022), but the data is mixed. Further, we wonder: is traditional teaching genuinely superior, or do those educators find greater success with it simply due to their prolonged familiarity and decades of experience in employing it?

We examine a case of ‘reverse’ transition from a blended format to a traditional one. Our case study revolves around a 4th-year course, ‘Noncommutative Algebra’, offered at the University of Manchester (University of Manchester, 2022). The unit is comprised of a cohort that includes MMath and PhD

students. Traditionally delivered face-to-face until 2019, the course adapted to a blended learning format in 2020, offering online asynchronous videos supplemented with review sessions and tutorials on Zoom. 2021 maintained the same approach, but with the addition of in-person synchronous 'review' sessions. After reviewing student feedback, the lecturer decided to return to the traditional mode of delivery in 2022. This oscillation prompted a compelling question: what becomes of the digital resources accumulated over the blended learning years?

In the following, we describe the implementation of an 'anthology' approach, a strategy designed to repurpose the vast reservoir of digital content without compromising the advantages of traditional delivery. Subsequently, we gauge the impact of this approach on student learning, assimilating feedback and outcomes to assess its efficacy. This is not meant as a formal statistical analysis, nor should be taken as such given the high potential for confounders represented by the several changes brought upon by the Covid-19 pandemic. Nevertheless, we describe the approach and provide a critical examination of the strengths and weaknesses of the process, with suggestions for any reader who wishes to apply a similar paradigm.

2. Implementation

2.1 Course format

The course 'Noncommutative Algebra' is a 4th-year advanced unit, rich in examples and diverse in its content, drawing from various mathematical areas previously encountered by students. Structured to facilitate an anthological approach, it aims to provide a broader perspective on the general theory through a detailed exploration of specific examples and fundamental noncommutative algebras such as quaternions, matrix rings over division rings, group representations and Weyl algebras.

Weekly, the course unfolds through two one-hour face-to-face lectures, complemented by a tutorial session, adhering to a traditional delivery format. Assessment within the course involves two take-home tests and a final closed-book exam, leaning heavily towards problem-solving, reflecting its advanced mathematical nature. This strategy aligns with the course's ethos of diving deep into noncommutative algebra's complexities, enabling students to progressively build up knowledge and expertise during the semester and then demonstrate their understanding effectively.

The course normally has approximately 25 students enrolled, half of which are normally 4th year MMath students or MSc students, with the other half made of PhD students in mathematics.

Blackboard, the chosen virtual learning environment, hosts the weekly learning plans and a multitude of resources, ensuring that materials are accessible, organised, and conducive to a consistent learning process.

2.2 The Anthology approach

We were able to make use of the 'leftover' resources from the blended learning implementations by adopting an 'anthology approach', made of an orchestrated interplay of various educational elements, each appropriately contextualised to enhance the students' learning experience within a traditional teaching framework, ensuring their effective and coherent integration to support and enrich the present course. To optimise the benefit for the reader, we choose to describe a refined approach, evolved from its 2022/23 iteration with minor modifications. This enhancement is informed by insightful student feedback, leading to modifications that enrich the overall strategy and execution. However, the core philosophy and elements of implementation remain the same.

The core element is the provision to each student of a meticulously crafted weekly plan, a structured guide curated with explicit learning objectives, providing students with a clear roadmap of the week's

educational journey (see figure 1). It encompasses a full list of available content, paired with practical advice on managing workload, allowing students to navigate their weekly learning paths strategically. The plan is further enhanced with colour-coding of content, explicitly disclosed to students at the start of the course, serving as a visual guide that further facilitates students in organising their study time and focus effectively. The colours are structured as follows: core material (green), supplemental resources (orange), support channels (purple), and deeper dive (blue).

Week 1 (26th September) - Rings and algebras

- In-person sessions:**
 - Wednesday lecture:** Revision of background material. Definitions of rings, ideals, and algebras. Examples (matrices, group algebras, quaternions).
 - Friday lecture:** Important constructions on rings are revised/introduced, including subrings, ring homomorphisms, and product rings. Introduction of the Weyl algebra, one of the main examples in the course.
 - Tutorial:** Exercise sheet 2, exercises [2.1-2.6, 2.9-2.12](#).
- Course notes:** From Section 2.1 up to and including Section 2.7, plus the definition of the Weyl algebra from 2.8.
- Additional exercises:**
 - [2019-20 exam paper, exercise 2.](#)
 - Exercises (1-32) for chapter 0, Noncommutative Algebra, B. Farb, K. Dennis, Springer-Verlag, 1993.
- Videos:**
 - [Rings, subrings and ideals](#) (32 minutes)
 - [The quaternions](#) (7 minutes)
 - [Ring homomorphisms and product rings](#) (13 minutes)
 - [Algebras](#) (20 minutes)
 - [Endomorphism algebras and the definition of the Weyl algebra](#) (17 minutes)
- Additional support:**
 - [Ask questions on our discussion board on Blackboard.](#)
 - Email me: cesaregiulio.ardito@manchester.ac.uk or come to my office hour.
- Deeper dive:**
 - [Group algebras](#) (video - 23 minutes)
 - [Generalised quaternions: a visual approach](#) (interactive web page).

Figure 2: Example of a weekly plan as displayed on Blackboard.

In line with a traditional delivery format, the plan emphasizes and identifies as ‘core activities’ the in-person review sessions and the tutorial. However, attendance is encouraged but not mandatory, allowing students the flexibility to choose engagement levels based on their individual learning needs and preferences. This flexibility ensures that the sessions are optimally beneficial, and attended by students who find real value and learning enhancement through these interactions.

The course is accompanied by a set of course notes, that form the ‘single point of truth’ for the main definitions and concepts and are meant for all students to be engaged with. Engagement with the ‘core’ activities, colour-coded as green, is sufficient to satisfy all intended learning objectives and to learn all the assessed content of the course.

The material is supplemented by concise, piecemeal videos, each ranging from 5 to 15 minutes and concentrating on distinct topics, colour-coded as orange. These videos mirror the lectures and the notes, acting as supplementary resources that provide additional perspectives and explanations and are meant to be engaged when additional support is beneficial for navigating more challenging subjects. Featuring a variety of academics beyond the course leaders, the videos introduce diverse teaching styles and explanations, offering students multiple approaches to understanding the material. The videos are independent of each other, allowing for flexibility and ease of reference, aligning precisely with the week's learning objectives or specific areas where students seek deeper understanding or clarification.

Exercises within the course are strategically organised into four distinct categories to foster a comprehensive and layered learning experience.

- Quick questions are seamlessly embedded within the course notes, serving as immediate touchpoints for reflection and consolidation of learning as students navigate through the course material (green).
- Traditional exercise sheets emulate the nature of exam questions, with a limited and manageable number, typically not exceeding ten each week. These exercises are instrumental for students to gauge their understanding and readiness for assessments (green).
- Complementary exercises provide an additional layer of engagement. Sourced from a variety of materials, they are designed for students seeking extra practice and reinforcement of concepts, either during the semester or the revision period (orange).
- Deeper dive exercises present an opportunity to explore beyond the conventional boundaries of the course. These challenges delve into advanced concepts or introduce novel notions not covered in the regular course notes. Specifically non-examinable, they cater to students with a heightened interest in a broader or more in-depth exploration of topics (blue).

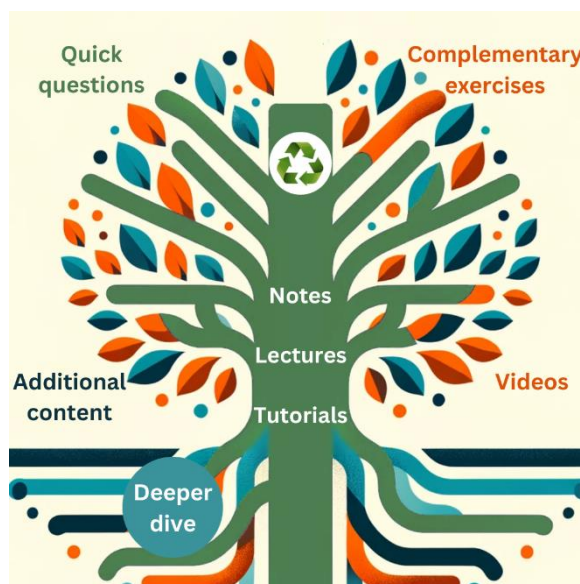


Figure 3: Visual diagram of the Anthology approach.

Furthermore, the 'deeper dive' section is enriched with additional content in a spectrum of formats, curated to guide and support students keen on delving into more advanced, additional topics outside the standard course outline.

Lastly, an online discussion forum is incorporated, fostering a space for collaborative learning, discussion, and peer interaction. This forum allows students to engage in discussions, seek and offer clarification, and explore various perspectives on the course content, enriching their learning experience. The forum is pseudonymised, meaning that each user is assigned an alias. Students are encouraged to participate and answer others' questions, and staff moderate and occasionally intervene to answer more complex queries.

In summation, the Noncommutative Algebra course is structured to facilitate a comprehensive and adaptable week-by-week learning experience. The course interweaves various educational elements, such as in-person sessions, digital videos, and a range of exercises, aiming to offer a balanced and supportive learning environment. Each component is curated to allow students the flexibility to tailor

their learning paths according to individual needs and preferences while preserving a common core. The anthology approach (see figure 2), marked by thoughtful organisation and an abundance of resources, serves to guide students through the course, providing a roadmap that aligns with their academic objectives and learning styles. This design aims to foster an environment conducive to focused and individualised exploration of noncommutative algebra, encouraging students to engage deeply with the material in a manner that resonates with their unique educational journey.

2.3 Impact

Before going into detail, it's essential to note that while the observed outcomes are positive, they cannot be exclusively or conclusively attributed to this approach alone. The unprecedented challenge of the Covid-19 pandemic brought sudden changes in student engagement and behaviour, which makes it challenging to definitively link any results to one specific factor or strategy.

A notable impact has been the augmentation of student engagement and participation with respect to previous years in the 2022-23 iteration. All 23 students consistently engaged with in-person activities. Further, a significant majority of students engaged with some of the supplemental materials provided within the course (see figure 3), suggesting that resources such as piecemeal videos and various exercise categories were found to be beneficial by the learners. Interestingly, there was no mention of workload issues in the end-of-year feedback survey, indicating that the course's design, with its emphasis on flexibility and student autonomy, effectively managed to avoid overwhelming the students.

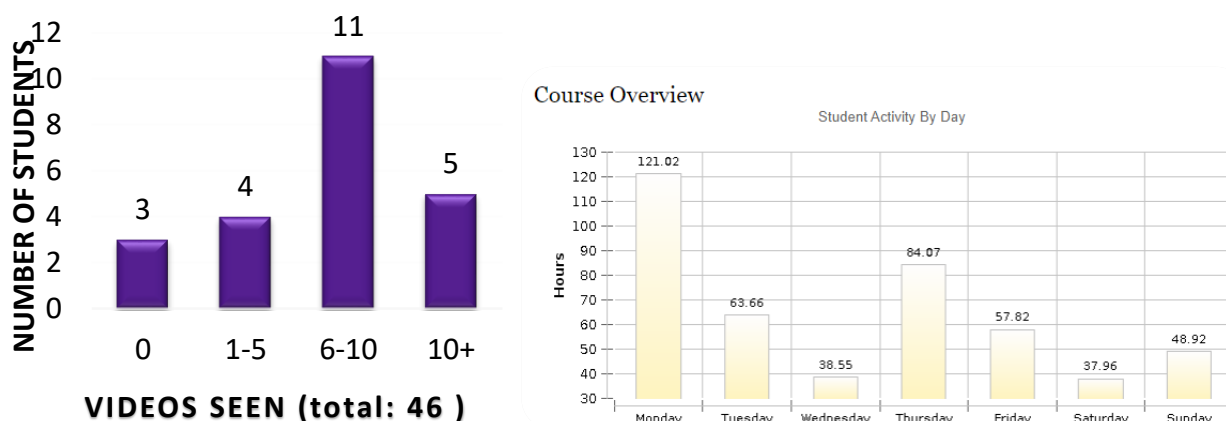


Figure 3: Students engagement with videos and with the Virtual Learning Environment

The course's design, which facilitated regular feedback loops, allowed for ongoing adjustments and refinements, ensuring that the course remained responsive to students' needs and experiences. This adaptability is a vital aspect of the course's impact, allowing for a continually evolving educational experience that aligns with each student cohort's needs and preferences.

Looking ahead, the experience suggests a promising trajectory for the course's future iterations. The insights gained from students' experiences and reflections provide valuable inputs that will inform and shape future adaptations and improvements in the course, ensuring that it remains aligned with students' needs and expectations.

Success rates in assessments have also seen improvement, indicating a potentially enhanced grasp of course material among students. This could be reflective of the course's ability to cater more effectively to different learning needs and styles, facilitating better preparation and understanding. A

consequence of the multitude of resources available is also improved accessibility and flexibility, particularly beneficial for diverse learners, due to content being presented in different formats.

In terms of quantitative data, feedback from students and internal teaching evaluations have been predominantly positive. Over 90% of students reported high satisfaction levels, which speaks volumes about the course's effectiveness and its ability to meet student needs and expectations. The course received a User Experience Questionnaire (UEQ) score of 4.8/5, reflecting a high level of student satisfaction and positive user experience. This score, coupled with the qualitative feedback, paints a picture of a course that has been well-received by students, managing to meet their educational needs effectively while providing a positive and supportive learning environment.

3. Discussion

The implementation of the anthology approach in the Noncommutative Algebra course unfolded on what can be considered an ideal testing ground. Comprising 4th-year and PhD students, the course was populated by experienced learners, well-versed in independent learning and efficient time management. These attributes facilitated a conducive environment for the anthology approach to be employed and evaluated. Moreover, the course's intrinsic structure, characterised as an anthological collection from a broader mathematical tapestry, naturally aligned with the approach, allowing for seamless integration of 'deeper dive' content and other enriched materials.

A significant asset in this implementation was the existing 'piecemeal' format of the videos, as mentioned above. This modular construction allowed for effortless adaptation and customisation of the content, aligning with the evolving needs and focuses of the course (Thompson et al., 2021). Modern resources, such as Canva (<https://www.canva.com/>), proved invaluable in this aspect, enabling easy editing and modification of video content and minimising the amount of technical work needed for the lecturer to implement this approach.

The anthology approach's implementation did not necessitate an exhaustive investment of time or resources. Its design allowed for the flexible inclusion of various materials, even as optional content, ensuring that the course could remain responsive to changing needs or focuses without requiring extensive modifications. We highlight that the approach is suitable even when only a limited amount of 'deeper dive' material is available for distribution.

Suitability emerges as a key consideration in the discussion. The course's advanced level, combined with the experienced learner demographic, was identified as particularly congruent with the anthology approach. This suitability suggests a potential direction for the consideration of this approach in future course designs, highlighting advanced courses with experienced learners as particularly promising arenas for its application and evaluation.

Incorporating insights from the course's execution, the approach reveals a pattern of positive impacts, such as increased student engagement and successful assessments. However, it also brings forth areas for consideration and refinement, such as the diversification of resource formats and the continual gathering of evidence to assess and enhance the approach's effectiveness. These reflections form a basis for ongoing improvement, ensuring that the approach remains dynamic and responsive in meeting the educational objectives and needs of future courses.

4. Aspects to consider for the future

Implementing the anthology approach in courses with less experienced students, such as those in their first year, would necessitate thoughtful considerations about potential workload challenges (Meehan and McCallig, 2019). The substantial volume of materials, while rich in content and diversity, could

potentially overwhelm students who may not yet have honed the skills necessary for efficient and critical engagement with extensive resources. There's a risk of these students feeling overwhelmed if they attempt to engage uncritically with the entirety of the material available, without a strategic approach to prioritise their engagement based on relevance and individual learning needs (Phillips, Schumacher and Arif, 2016; Banihashem et al., 2023). On the other hand, the abundance of available pre-recorded material may also reduce attendance for in-person activities, which can be negatively correlated with academic performance (Trenholm et al., 2019).

Another aspect to consider is the temporal fixation of video content. This permanence can pose challenges when updates or changes in the course are needed, as the videos may not easily allow for modifications or adaptations in line with the evolving curriculum or new pedagogical insights.

Keeping track of a vast array of materials also emerges as a potential area requiring attention. This necessitates an ongoing commitment to oversight and coordination to ensure that the contents remain relevant, updated, and conducive to the course's learning objectives and overall coherence.

Internal coherence within the course is paramount. Careful attention must be given to maintain consistency, such as in notation and the presentation of concepts, to ensure that the course unfolds as a cohesive and integrated learning journey. This is essential to avoid confusion and to support students in building a structured and coherent understanding of the subject matter.

Lastly, while the approach brings flexibility and richness of content, it may also introduce constraints when considering substantial course revisions or shifts in direction. The presence of an extensive array of existing materials may inadvertently influence or limit the scope and direction of future course enhancements and redesigns.

In conclusion, while the anthology approach presents numerous advantages and has demonstrated preliminary positive impacts in its application, a thoughtful and critical evaluation of these aspects is essential to navigate its future implementations successfully, ensuring that it continues to serve as an effective and supportive educational strategy, and it may not ultimately be suited for all courses in higher education.

5. References

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