Exploring the Potential of Interactive E-books for Enhancing Learning and Teaching in Physics and Astronomy

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ASTRONOMY & PHYSICS EDUCATION

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OUTLINE

1. Universal Design for Learning (UDL) Guidelines
2. Demonstration of HTML interactive e-books and their features
3. Students' feedback

UNIVERSAL DESIGN FOR LEARNING (UDL) GUIDELINES

[1] https://udlguidelines.cast.org/
[2] Almeqdad et al., *Cogent Education* (2023), 10: 221819
[3] Vygotsky, Lev S. *Mind in society: The development of higher psychological processes*. Vol. 86. Harvard university press, 1978.

What is UDL?

- Evidence-based framework [1-2] created to optimize learning and teaching recognizing learners' diversity
- Based on constructivist theories (i.e. Vygotsky's theory of learning [3])

"The goal of UDL is learner agency that is purposeful & reflective, resourceful & authentic, strategic & action-oriented." [1]

UNIVERSAL DESIGN FOR LEARNING (UDL) GUIDELINES – CORE PILLARS

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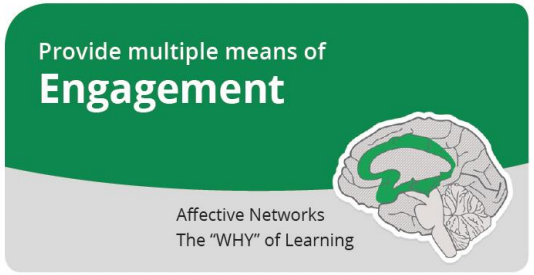
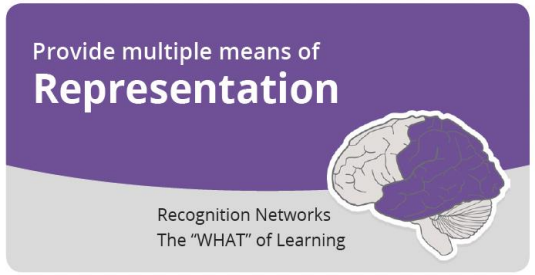
Vygotsky's Theory of Prerequisites for Learning [3]

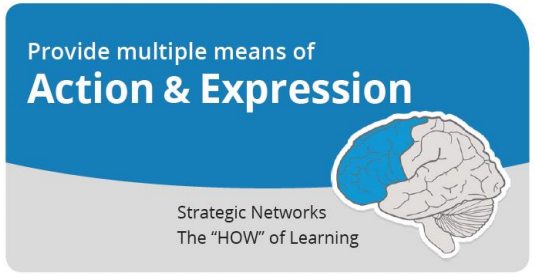
AFFECTIVE NETWORK: engagement with the learning task.

RECOGNITION NETWORK: recognition of the information to be learned.

STRATEGIC NETWORK: application of strategies to process information.







Goal

Expert learners who are...

Purposeful & Motivated	Resourceful & Knowledgeable	Strategic & Goal-Directed

UNIVERSAL DESIGN FOR LEARNING (UDL) GUIDELINES – CORE PILLARS

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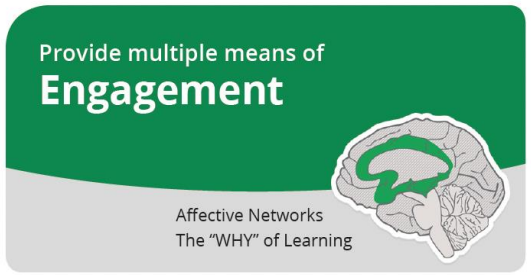
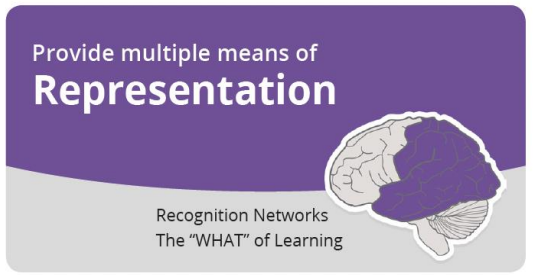
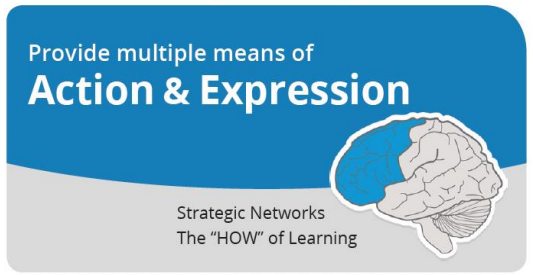


- Motivate students through varied activities, choices, and opportunities for collaboration
- Nurture joy and play
- Address distractions



- Provide information in **various formats** (visual, auditory, etc.) to cater to different learning preferences and abilities.
- Support decoding of text, mathematical notation, and symbols



- Vary methods for **navigation**
- Optimize access to **accessible materials** and assistive technologies
- Use **multiple media** for communication
- Use **multiple tools** for construction, composition, and creativity

Goal

Expert learners who are...

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Material and Formats Conventionally Provided to Students (in the UK)

Material

- Recommended textbooks (digital or printed) — Rarely used by students, mix & match can be overwhelming/ distracting (especially if different notation used)
- Slides — Lack of context, limited information, not good for studying if not complemented
- Notes / e-books — Can be personalized, more complete – provide more context and information

Formats

- PDF (including rendered from LaTeX) — Static, non-customizable, non-interactive, low digital accessibility
- Word — Static, customizable text, non-interactive, higher digital accessibility
- Power Point — Static, customizable text, non-interactive, higher digital accessibility
- HTML — Dynamic, customizable, (potentially) highly interactive, good digital accessibility

TEACHING MATERIAL AND FORMATS PROVIDED FOR MY COURSES

Stellar Physics (Astronomy 1)

- Slides (PPTX → PDF)
- Notes:
  - HTML

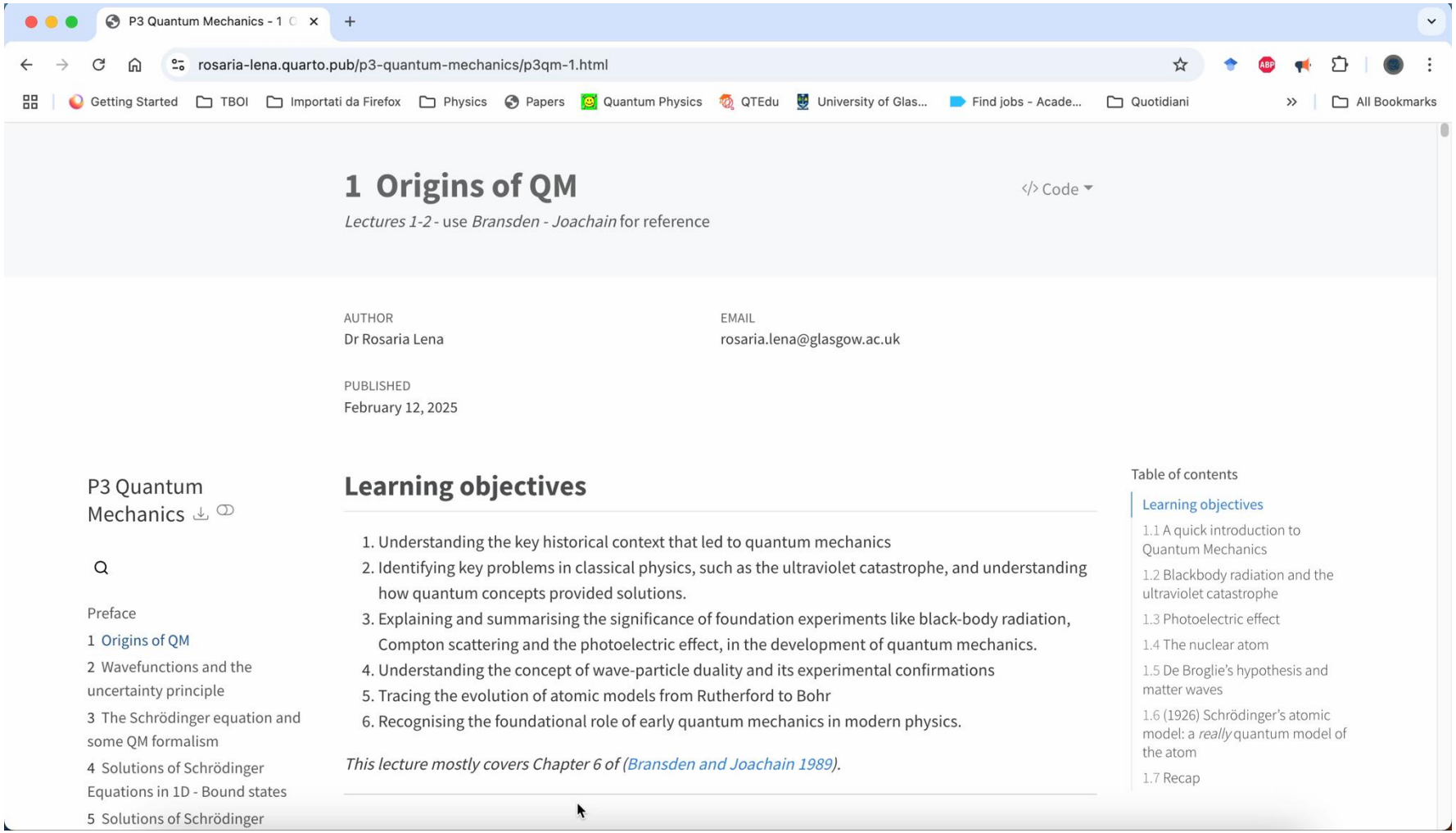
Content difference: almost none; similar content for slides and notes.

Quantum Mechanics (Physics 3)

- Slides (Beamer → PDF)
- Notes:
  - HTML
  - PDF - (~180 pages)
  - Epub

Content difference: notes are much more detailed than slides.

FEATURES OF HTML NOTES – R Markdown/Quarto



FEATURES OF HTML NOTES – R Markdown/Quarto

Highly customizable and interactive material

- Integration of material from **different sources** removing barriers for learning and distractions
- Integration of a diverse range of **visualization tools**
  All-in-one: *all material* embedded (videos, interactive simulations, HTML files/webpages, code snippets, scrollable pdfs…)

Guided approach to learning

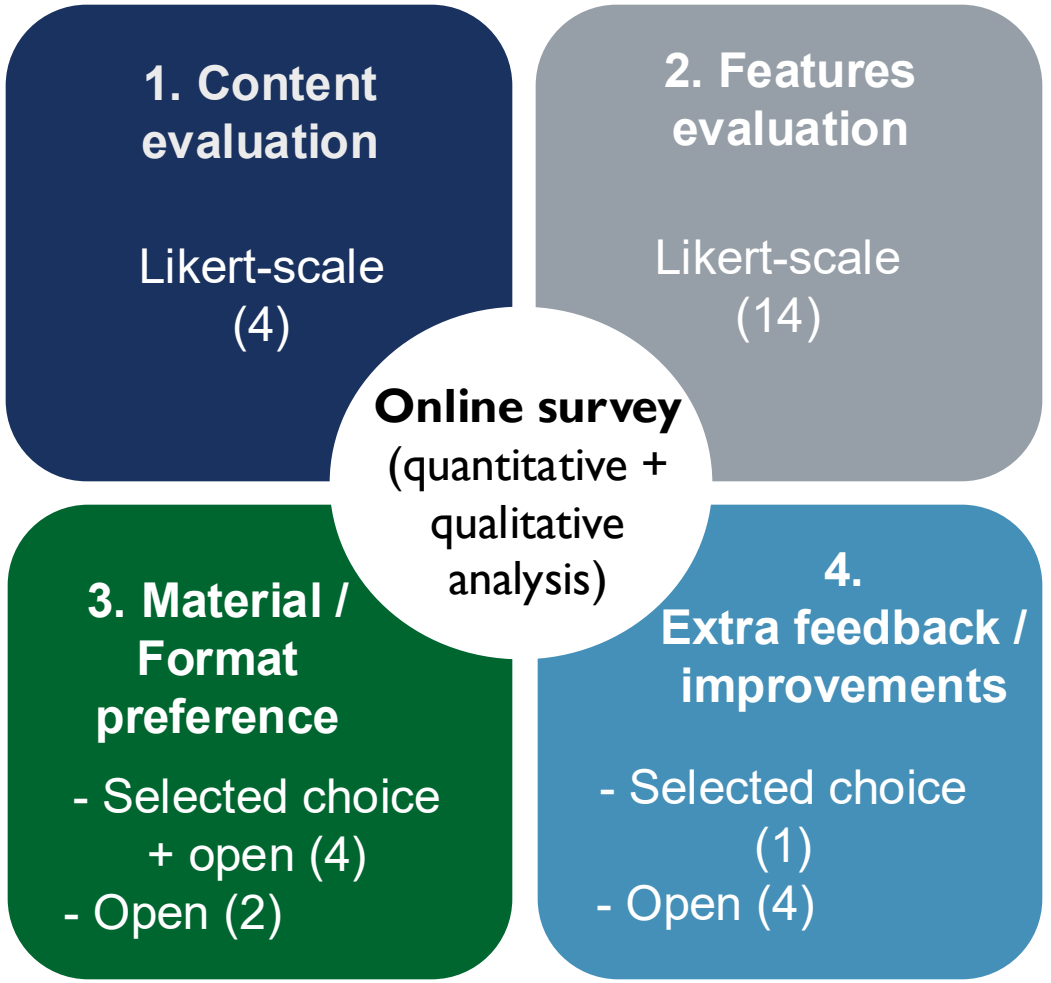
- Aided by hints and feedback (collapsible sections)
- Signposting value of content (callout boxes)
- Enquiry-based and constructive learning with integrated elements

Good digital accessibility, navigation, variety of media

- Structured chapters/sections/subsections
- Search bar
- Dynamic scaling of text
- Maths rendered using MathJax
- Dark/light mode to adjust contrast
- Reading mode with adjustable text font and background
- Text-to-speech feature available

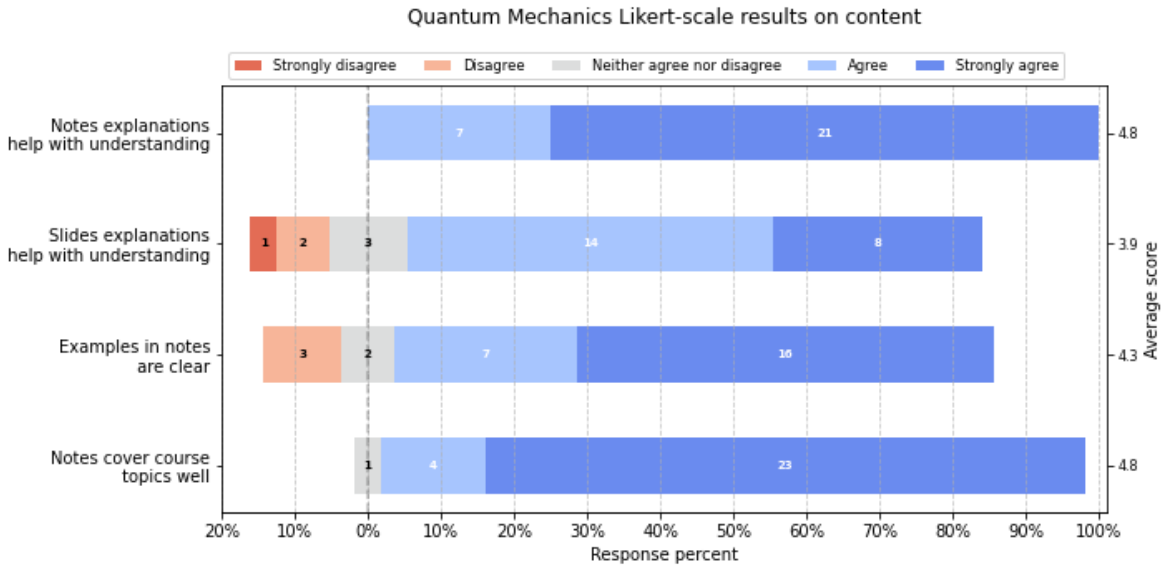
COLLECTING STUDENTS FEEDBACK

- What do students think about the material provided (content and format)?
- What kind of material(s) and format(s) do students use and prefer, and why?
- Do students use the features of the HTML notes?
  And if so, how do they engage with them?

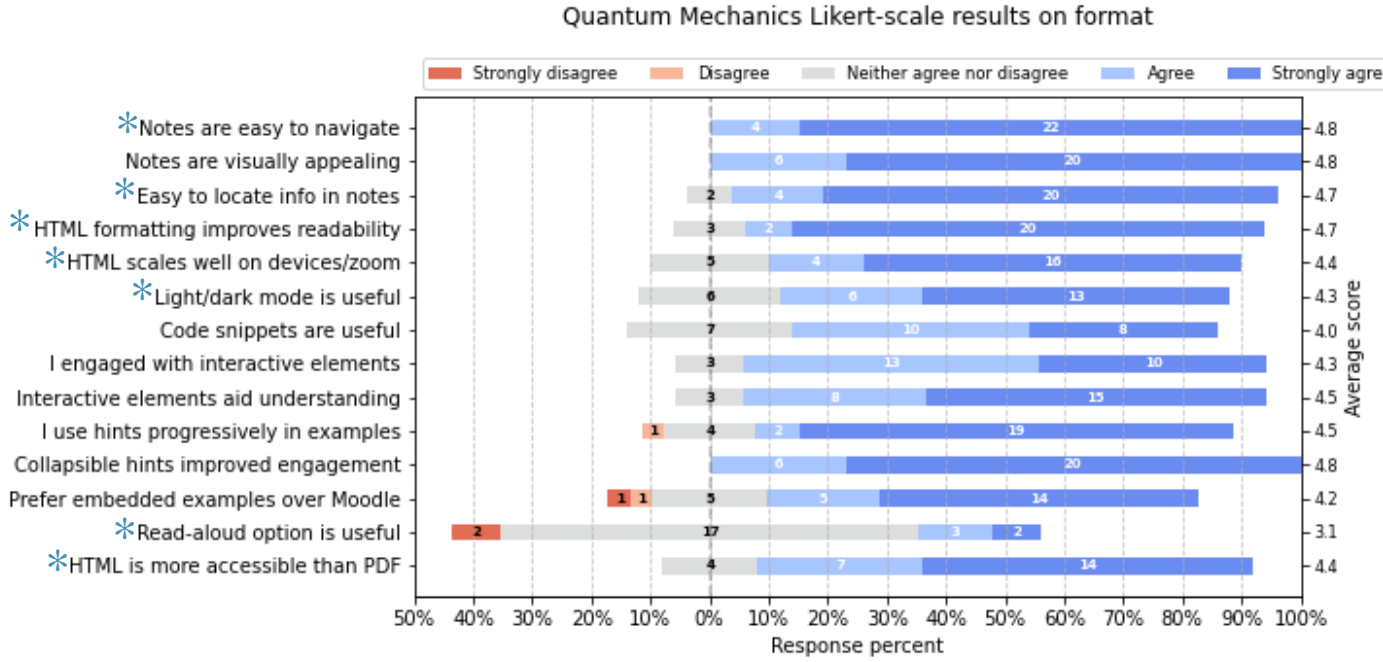


STUDENTS FEEDBACK
1. Content and Features Evaluation – Quantum Mechanics

Content evaluation



Features evaluation

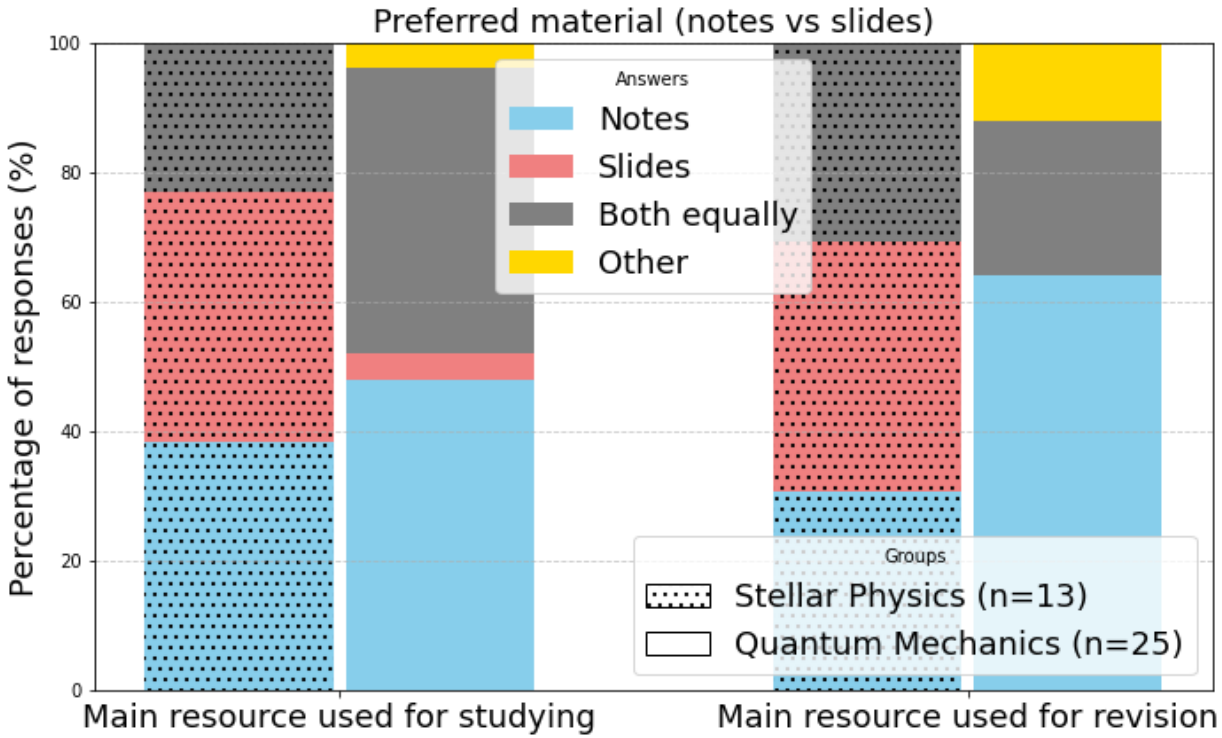


$n_{QM} = 28$
(~20% of population)

* Related to Digital Accessibility

STUDENTS FEEDBACK
3. Material / Format Preference – Slides vs Notes

Preferred material for studying / revision?

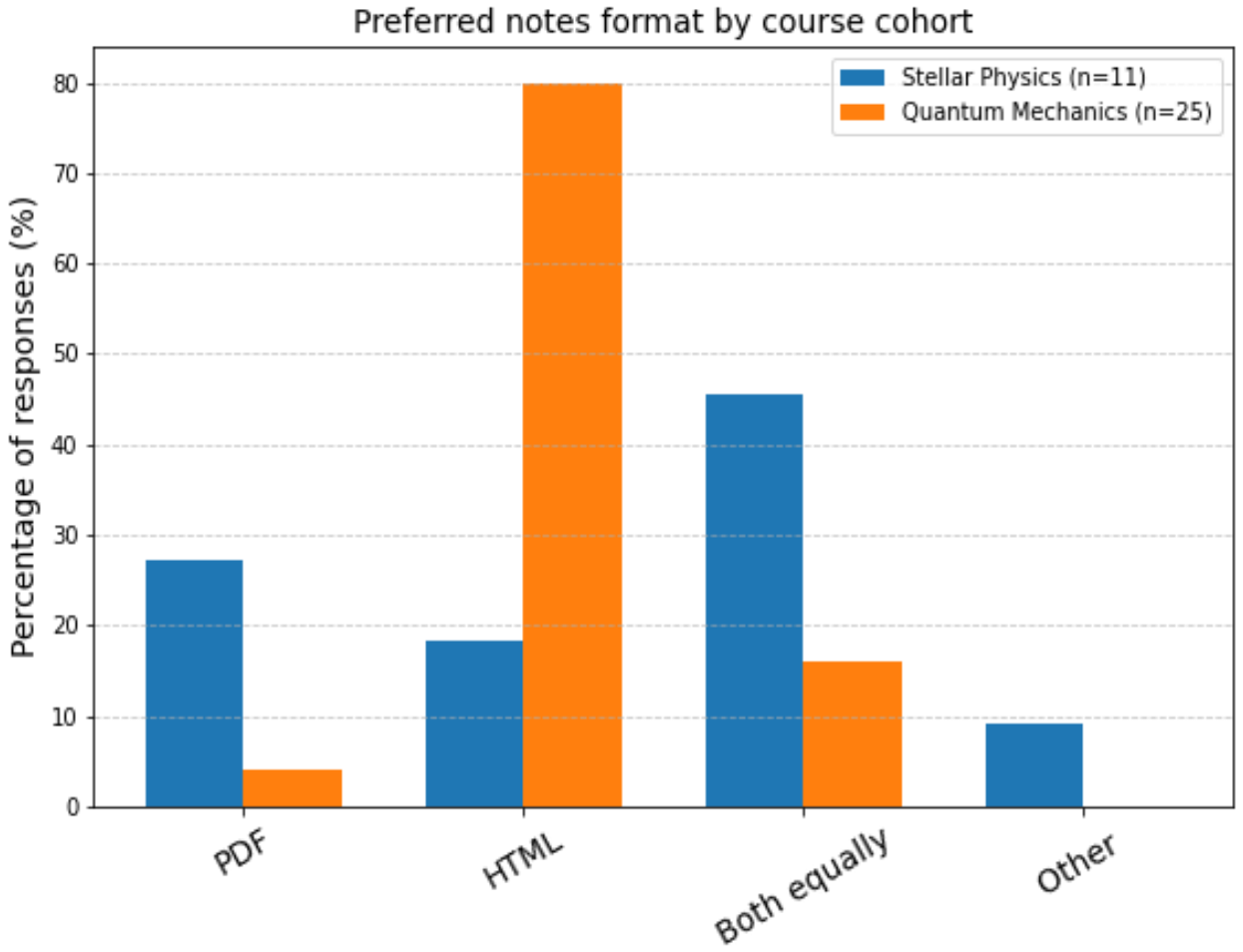


- Stellar Physics: equal preference for slides and notes (expected as the content is not very different)
- Quantum Mechanics:
  - Nearly no preference for slides only when studying
  - Almost equal preference for ‘notes only’ and ‘notes + slides’, for studying
  - No ‘slides only’ preference for revision, mainly ‘notes only’

Other: “youtube”, “own handwritten notes”

STUDENTS FEEDBACK
3. Material / Format Preference – Notes in PDF vs HTML

Preferred format for notes



Note: for Stellar Physics the notes were not rendered in a PDF book; they could be "printed as PDF" from the HTML page (not good practice and not digitally accessible!).

STUDENTS FEEDBACK
3. Material / Format Preference – Notes in PDF vs HTML

Motivation on preferred format for notes (open text)

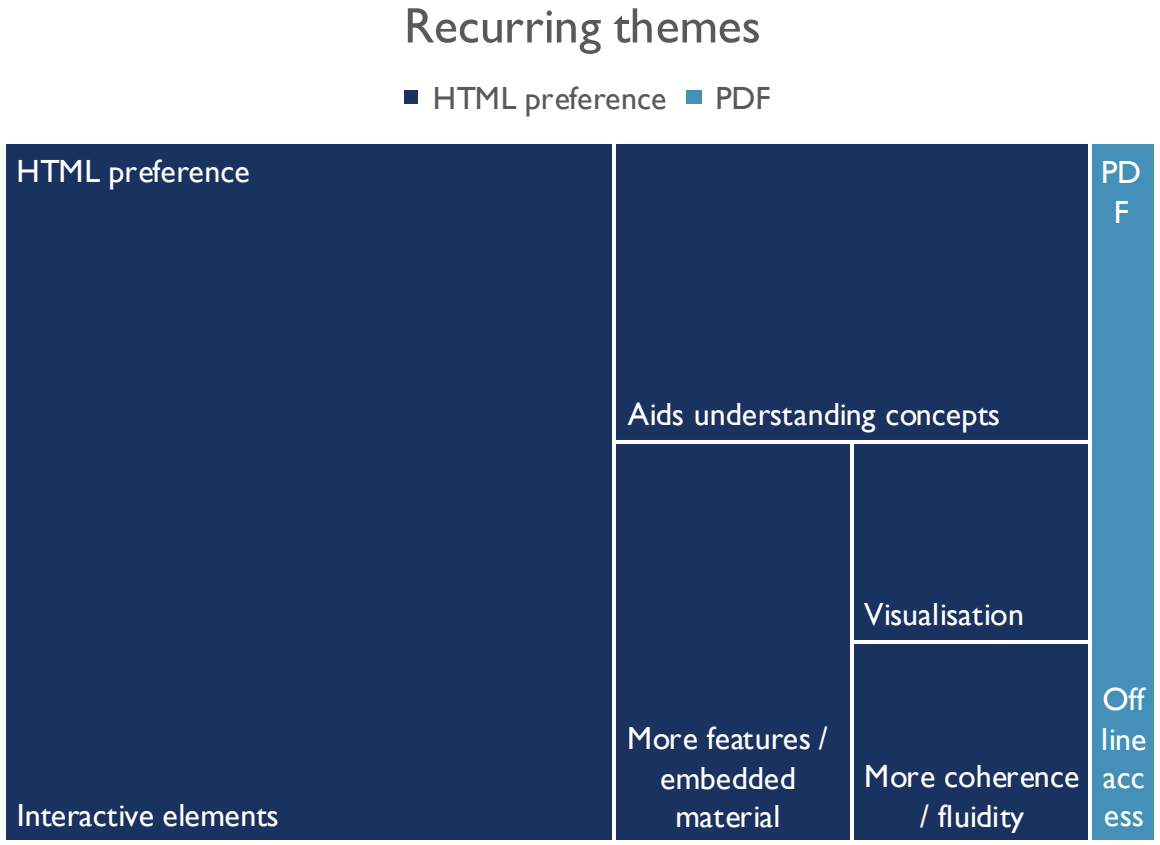
"The notes also work better as being html documents **there are nice interactive features which help visualise** *what you read. The embedded objects being ordered based on material keeps the* **flow of content coherent instead of having to switch tabs** *to read and view visual content."*

"it mainly depends on when i have internet or not"

"HTML is interactive and helps my understanding of topics as I'm going through them"

"I find it much easier to navigate and find the specific section I am looking for"

"Being able to refer back to previous topics and equations with a simple click"



STUDENT FEEDBACK
4. Extra Feedback – Quantum Mechanics

"Feel free to leave any other feedback on anything related to the material provided"

"It was really engaging and I found my self viewing the notes in my spare time, especially during commutes and honestly found them as fun as reading news articles."

"The course content provided for this course was the best out of all third year physics course, i really enjoyed the HTML notes"

"Most useful notes we've ever had in any course so far"

"The HTML notes have been the most useful and understandable notes that have been provided in any course I have taken, would love if all notes were in this format"

"If html notes was used throughout all my course would be much better. Like [course X] *only had lecture slides for that section of the course and I'm struggling to go through them"*

"Thank you for going to the trouble of making the e-book, I find it very useful!"

CONCLUSIONS

- R Markdown/Quarto can be used to create **personalized** e-books/notes in **different formats** (HTML, PDF, ePub)
- HTML e-books/notes have a very good **digital accessibility**
- Full **integration** of diverse materials in a coherent and sequential manner
- HTML format can be more **interactive** and is highly appreciated by the students
- Cons on HTML notes: students not usually aware they can download them for **offline access**
- Good platform ticking many **UDL guidelines** for providing variety of format/content/media
- Future plans:
  - Integrating MCQs with feedback
  - Integrating editable code
  - Heading towards flipped classroom