

The shift from static college textbooks to customizable content: A case study at zyBooks

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Abstract—College textbook publishing is transforming from a model of static textbooks to a modern model of *customizable textbooks*. Customization may involve reconfiguring content, combining textbooks, authoring one's own content, adding notes to content, and more. As such, publishing is moving away from a model of selling static textbooks, and toward a model of providing a *library of content* from which instructors can build a course. This Full Paper provides data for one digital-only publisher, zyBooks, on the prevalence and trends around reconfiguring and combining Computer Science and Engineering textbooks, instructor-authored sections, and instructor-added notes. The data show that for over 4,000 classes in 2020, over 85% of classes reconfigured their books, over 30% of classes combined two or more books with hundreds combining three or more, about 30% of books had instructor notes added, and about 65% of zyLabs-enabled zyBooks included instructor-created labs. The trend away from static textbooks and toward customizable content has substantial implications on how content is authored, requiring more modularity of content sections to support reconfiguration, and requiring more consistency across subjects to enable combining content. The trend also has substantial implications on book marketing, pricing, renewals, and more.

Keywords—computer science education, content customization, web-native textbooks, computer science engineering publishing

I. INTRODUCTION

This Research to Practice Full Paper presents data concerning customization of course content in engineering and computer science and discusses the implications for publishing. In the traditional Computer Science and Engineering (CSE) college textbook usage model, a class instructor requires students to acquire a textbook. That textbook comes in one form, even though instructors usually only cover a subset of available content, often covered in a different order than in the textbook. Instructors might require multiple such textbooks. Any additional notes or instructor-created content must be provided by other methods, like on a learning management system (or LMS, such as Canvas or Blackboard), discussion forum, or course webpage. Having to navigate multiple items (textbooks, LMS, forum, webpage), and jumping around within such items due to different coverage order, can hamper learning. While LMSs do allow instructors to link to textbook sections and thus to order content in the LMS, such an approach is still somewhat disconnected. Students prefer the convenience of all resources

located in one place, and well as the lower cost, of digital textbooks [1].

In contrast, modern digital publishing enables a different model, where content can be customized to a particular class. Figure 1 illustrates the contrast. With this approach, students are offered a customized textbook tailored specifically to their class. Instructors may:

- Reconfigure a textbook to include only the covered content, presented in the order covered
- Combine multiple textbooks into one textbook
- Create content to supplement textbook content
- Add notes to textbook content to expand, provide tips, etc.

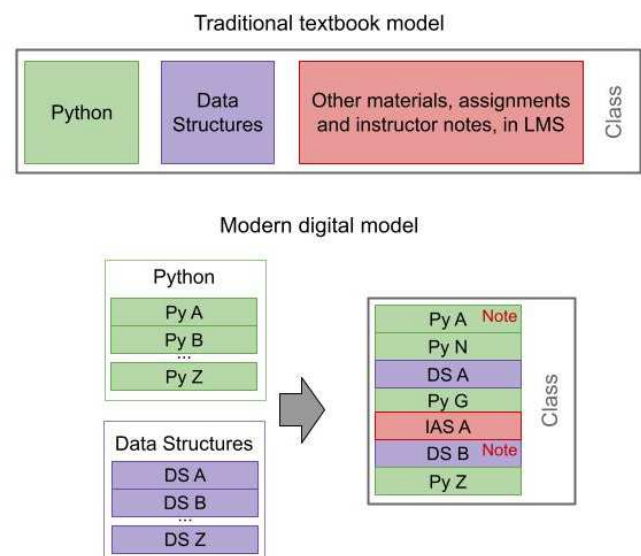


Fig. 1. The traditional textbook vs. the modern digital model. In the course textbook using the digital model, content from both the standard Python book and the standard Data Structures book are combined and supplemented with instructor-authored sections (IAS) and notes.

zyBooks is a web-native textbook platform that focuses on authoring primarily CSE books natively for the web. Each book is known as a zyBook and makes extensive use of animations and interactive learning questions with detailed explanations of right and wrong answers. zyBooks also utilize text, figures, and

tables, though less than traditional textbooks. In 2020, over 4,000 courses used zyBooks. The zyBooks catalog consists of typical textbooks, like "Programming in Python" or "Data Structures", each similar in topic coverage to traditional textbooks. When an instructor adopts a zyBook for a class, that class gets a unique instance of a zyBook with a unique URL, and the instructor can then customize that instance as desired. This paper summarizes data related to usage of content customization tools in the zyBooks platform. To our knowledge, no research has yet investigated the relationship between such customization and student learning, which is an important topic warranting additional future research. zyBooks is the first publisher to make such usage data available and this offers a novel analysis of such instructor and student behaviors.

II. RECONFIGURING A ZYBOOK

A CSE textbook's content typically consists of 10-20 chapters, with each chapter consisting of 5-15 sections. A section is the "atomic" unit of content, typically introducing a specific topic. Instructors usually inform students which sections a course will cover, and in what order. For example, a syllabus might state: "Week 1 covers sections 1.1, 1.2, 1.5, 7.1, 2.1, 2.2, and 2.3".

zyBooks allow reconfiguring of that content, illustrated in figure 2. Reconfiguring involves:

- Removing uncovered sections, so students see all content important for the course, yet are not overwhelmed with additional exposure to unused or irrelevant content. Removal may mean hiding some sections entirely, and/or moving some sections to a later chapter perhaps titled "Additional material" for interested students.
- Reordering covered sections, so students can progress through the content in the order covered in the course.

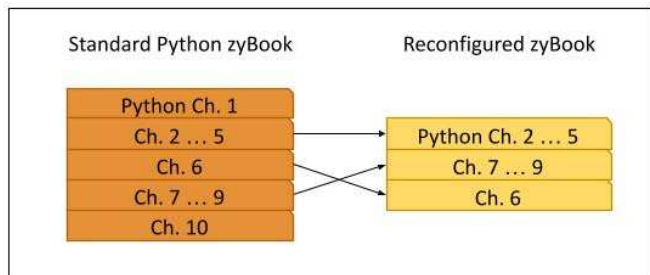


Fig 2. Depiction of a reconfigured zyBook.

In the reconfigured zyBook, two of the sections from the standard book (Ch. 1 and 10) are removed, and other sections are reordered.

The figures below provide data on zyBook reconfiguration. A zyBook is included in the analyses if at least 5 students were subscribed to that book.

Figure 3 shows how many zyBooks were reconfigured by instructors versus those without any reconfiguration, for each year since 2015. Every year, the vast majority of instructors reconfigure their zyBooks, and the proportion of those that choose to reconfigure rises substantially each year. In 2020, 3,903 zyBooks were reconfigured, compared to only 600 used in their nonreconfigured state.

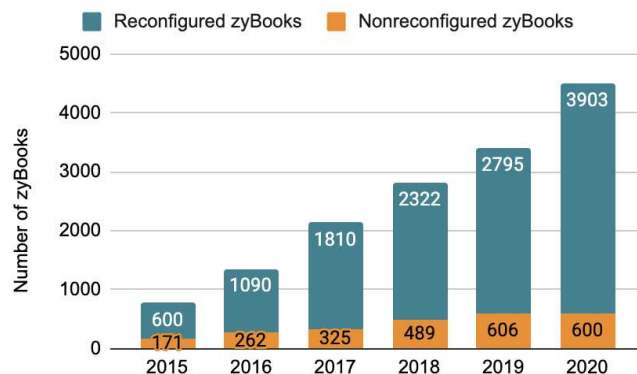


Fig 3. All zyBooks with reconfigured content per year

Figures 4 and 5 focus on one specific kind of reconfiguration, namely removing content sections from student view. In 2020, nearly 1,000 courses removed content. Of the 3,522 that did not, many of those may have moved non-required content to later chapters, titled "Additional material" or similar. Planned further explorations will examine the frequency with which instructors keep content, that they do not plan to use, visible to students.

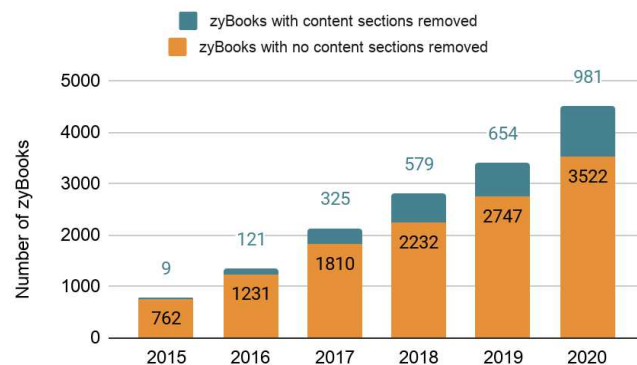


Fig 4. All zyBooks with content sections removed per year.

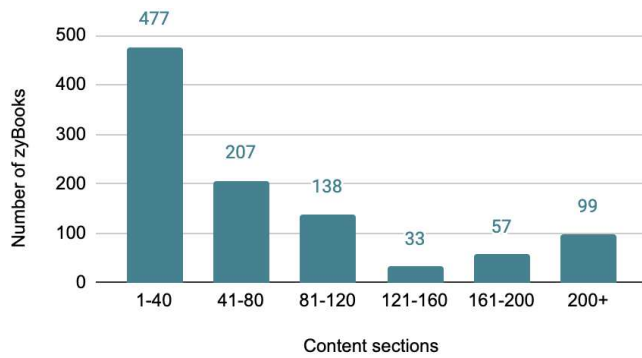


Fig 5. Histogram of number of removed sections per zyBook in 2020.

III. COMBINED ZYBOOKS -- HYBRIDS

Many instructors combine two or more catalog zyBooks to form their course zyBook, referred to as "hybrid" zyBooks. Hybrid books allow instructors to customize their approach to standard course topics and to teach unique courses that are at the intersection of many topics, illustrated in figure 6. To keep prices low, zyBooks prices hybrids only incrementally more than non-hybrids. For example, in 2020 a typical non-hybrid zyBook cost \$58, while adding a second catalog zyBook raised the total cost to only \$77.

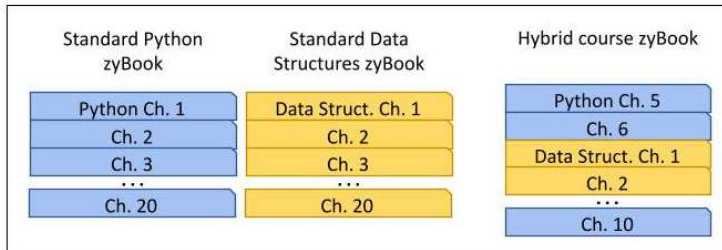


Fig 6. Depiction of a hybrid zyBook. In the hybrid course zyBook, sections from the standard Python zybook and sections from the standard Data Structures zyBook are combined.

Figure 7 shows the prevalence of hybrid zyBooks for each year since 2015. For the past several years, about one third of all course zyBooks were hybrids, with the ratio increasing slightly each year.

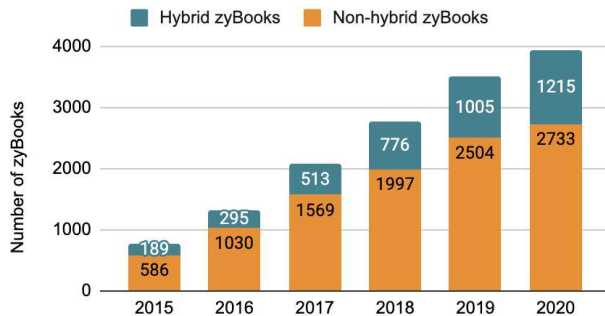


Fig 7. Hybrid and non-hybrid zyBooks per year.

Figure 8 provides a sense of how many catalog zyBooks ("subjects") were included in such hybrids, in 2020. Most

hybrids (71%) consisted of two subjects, while another 19% consisted of three subjects.

Interestingly, some courses combined five or more subjects. For example, one course on Data Analytics made use of eight catalog zyBooks: Computing Technology For All, Web Programming, Fundamentals of Data Analytics, Troubleshooting Basics, AP Computer Science Principles, Applied Statistics with Data Analytics (Python), and Spreadsheets Essentials. An emerging and interdisciplinary field such as Data Analytics provides the perfect opportunity to make use of hybrid zyBooks. Introductory courses also commonly used five or more subjects, where breadth was desired -- such as a course that covers a wide range of engineering topics like programming, digital design, electronic circuits, etc. Including background material is also a common motivation for combining subjects. As the typical number of topics covered in computer science courses continues to rise substantially [2], meaning a greater need for books that combine those topics together. Interdisciplinary courses in computer science and engineering have had great success improving student outcomes [3, 4].

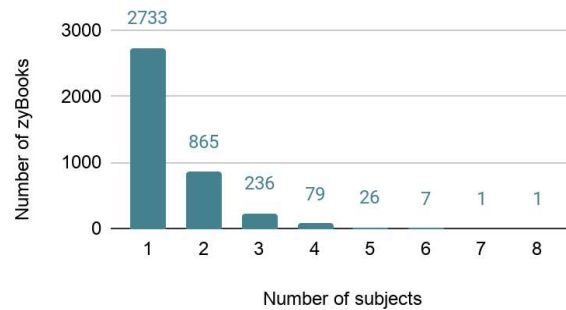


Fig 8. Histogram of number of subjects per zyBook in 2020.

IV. INSTRUCTOR-AUTHORED SECTIONS, LABS, AND INSTRUCTOR NOTES

A. Instructor-authored sections

Instructors are able to supplement zyBook content with their own authored content sections, illustrated in figure 9. Allowing such authoring enables a seamless learning experience for students, rather than needing to look in multiple places (e.g., course website, additional attached files) to digest all of the material.

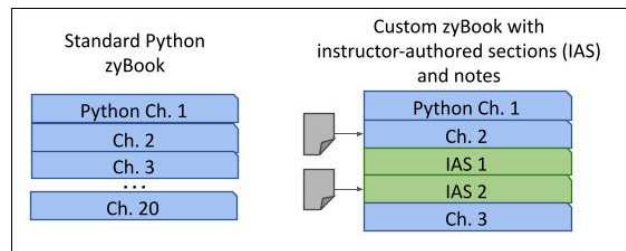


Fig 9. Depiction of a zyBook with instructor-authored sections (IAS) and instructor notes (described in the next section).

The capability for instructors to author their own sections was introduced in 2019, and already we see a large growth in use, with 229 zyBooks containing 1,574 instructor-authored sections in 2020. Some instructor-authored sections are similar to normal zyBook sections, teaching a topic thoroughly -- perhaps a topic not covered by the zyBook but desired by the instructor. Other sections are clever uses of content sections, such as a class syllabus followed by a syllabus quiz to ensure students read the syllabus, or announcements/discussion about a chapter's upcoming sections or programming assignments. One zyBook contained a total of 154 instructor-authored created sections.

Figure 10 below shows the number of instructor-authored sections per zyBook (if that zyBook included at least one instructor-authored section) in 2020.

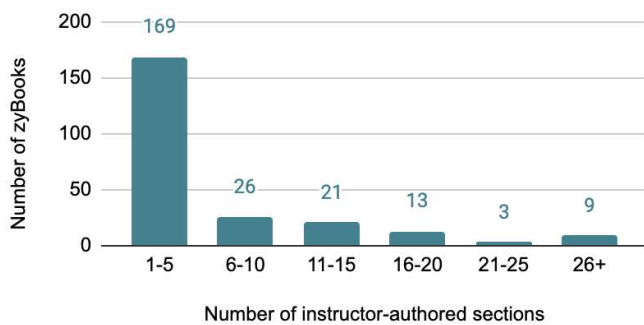


Fig 10. Histogram of number of instructor-authored sections per zyBook in 2020.

B. Instructor-created labs

zyBooks also allows instructors to author their own programming assignments ("labs"). The figure below shows the prevalence of instructors creating their own labs, versus using sample labs provided by zyBooks. In 2018, zyBooks introduced "zyBooks-maintained labs" (ZMLs), going beyond "samples" and instead actively maintaining/updating those labs each term. Those ZMLs seem popular, causing a plateau of the number of zyBooks with instructor-created labs, but nevertheless instructor-created labs remain popular.

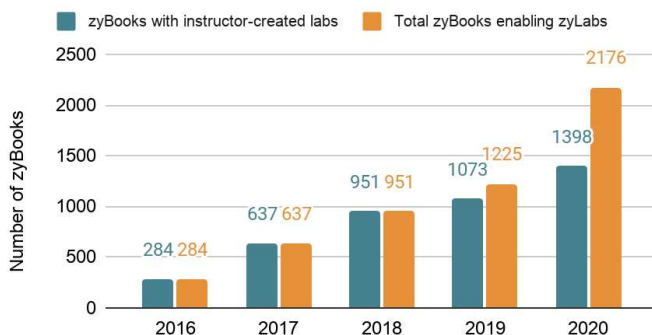


Fig 11. Number of total zyBooks with and without instructor-created labs per year. The orange bar represents the total number of zyBooks from that year that had zyLabs enabled, but no instructor-created labs.

C. Instructor notes

In addition, zyBooks enables instructors to attach notes throughout content sections (to any paragraph, for example), whether those sections were authored by zyBooks or instructors. A note appears just above the attached item, with a highlighted box entitled "A note from your instructor". This allows instructors to communicate relevant information, caveats, examples, instructions, etc. relating to specific content. Yet again, having this information linked directly to the content itself makes it easier for students to gather and use all of the information. If an instructor re-adopts a course zyBook for another term, the class notes are copied to that new course zyBook to the extent possible (but sometimes content is updated such that the note has no place to be attached in the new content).

Figure 12 below shows the prevalence of instructor notes in zyBooks. The percentage of course zyBooks that used at least one instructor note has increased gradually from approximately 15% in 2015 to nearly 31% in 2020. Figure 13 shows the average number of notes per zyBook, for course zyBooks that had at least one note.

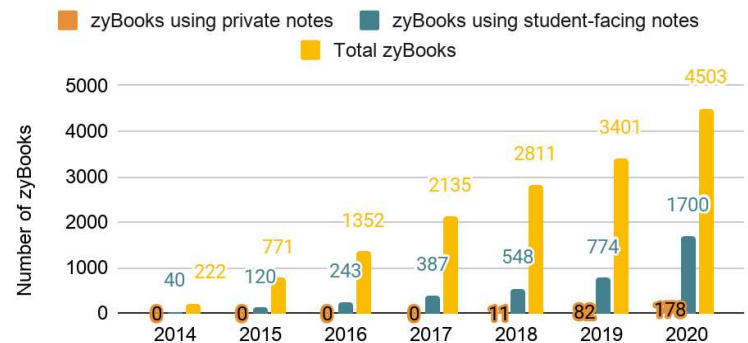


Fig. 12 Number of all zyBooks that used instructor notes per year. Private notes are only viewable by instructors and are less commonly utilized, while student-facing notes are seen by students using the zyBook.



Fig 13. Average number of notes per zyBook per year, for zyBooks that used at least one note.

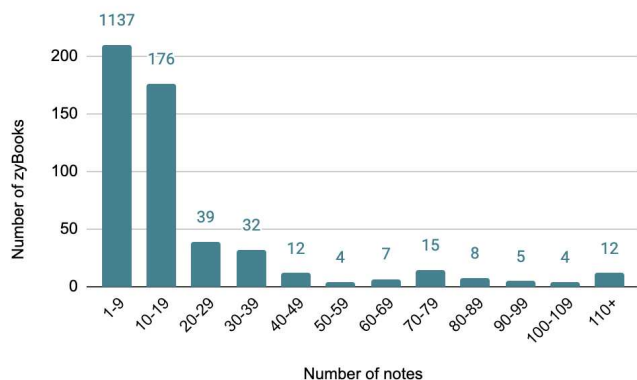


Fig 14. Histogram of number of notes per zyBook in 2020.

Figure 14 is a histogram showing the number of zyBooks that had 1-10 notes, 11-20 notes, etc. One can see that most instructors that add notes add just a few notes, but that some make extensive use of notes, adding 50 notes or more, as high as 120. Note: zyBooks help articles generally advise against such extensive annotation of content, because excessive notes can hamper the author's intended learning flow, and because the content is updated across terms, which might render some notes inconsistent with the updated content.

V. DATA FOR MATLAB AND JAVA ZYBOOKS

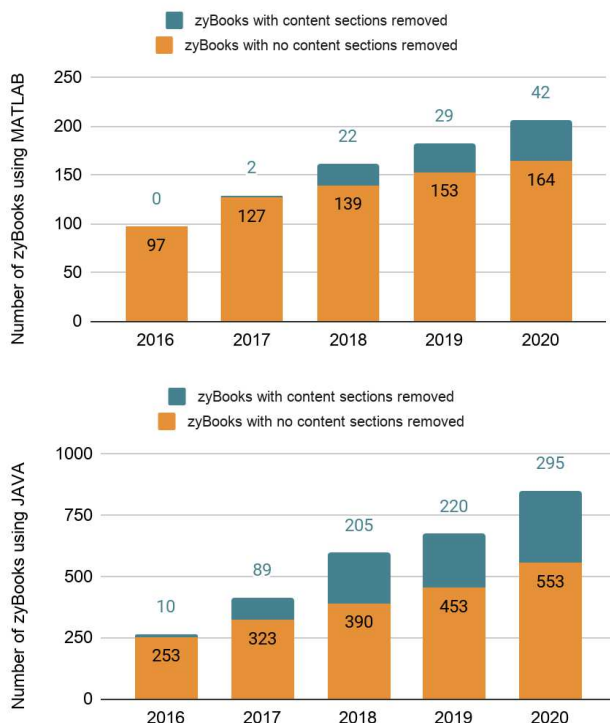


Fig 15. MATLAB (top) and JAVA (bottom) zyBooks with content sections removed per year. Slightly more JAVA zyBooks have removed content than other zyBook subjects.

In figures 15-19, we zoom in on the data for two particular zyBook subjects, MATLAB and JAVA. While the majority of trends are consistent with those for all zyBooks, we do observe

a couple key differences. In particular, slightly more JAVA zyBooks have removed content. This is perhaps due to the fact that a greater portion of JAVA zyBooks are hybrids, where some content is removed to make room for content from the other subjects. Another key difference we note is that while a greater portion of JAVA zyBooks were hybrids overall, a substantial portion of the hybrid MATLAB zyBooks are made up of up to 4 subjects.

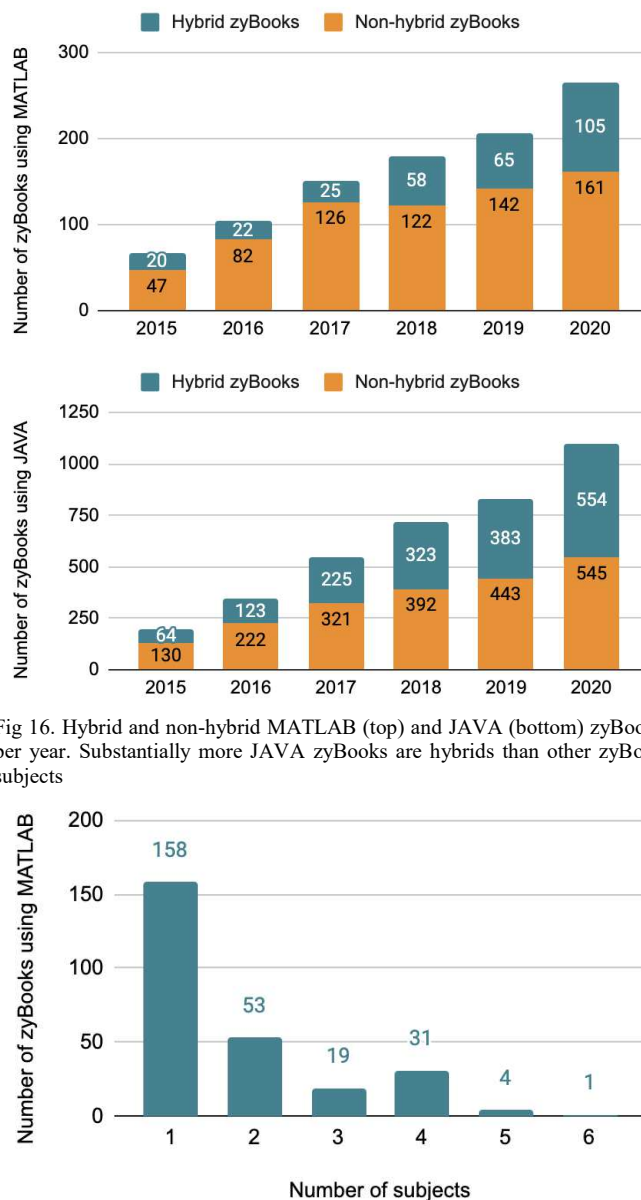


Fig 16. Hybrid and non-hybrid MATLAB (top) and JAVA (bottom) zyBooks per year. Substantially more JAVA zyBooks are hybrids than other zyBook subjects

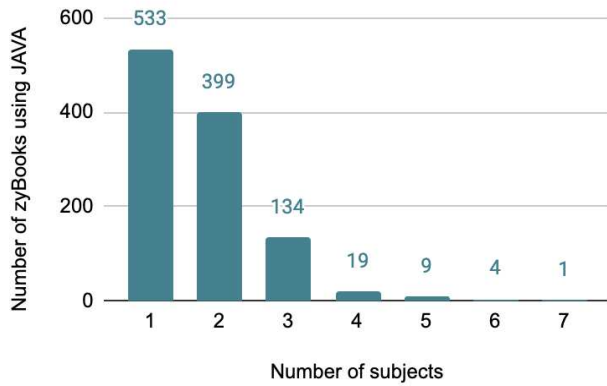


Fig 17. Histogram of number of subjects per MATLAB (top) and JAVA (bottom) zyBook in 2020. While a greater portion of JAVA zyBooks were hybrids overall, a substantial portion of the hybrid MATLAB zyBooks are made up of up to 4 subjects.

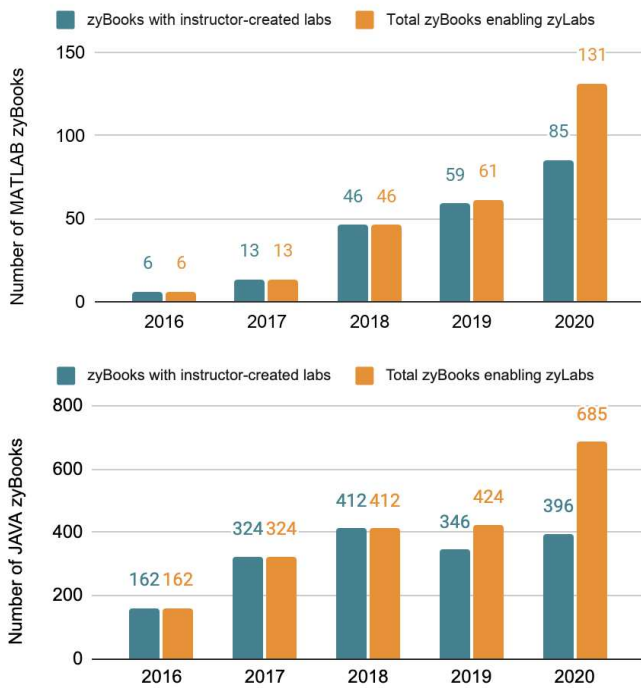


Fig 18. Number of MATLAB (top) and JAVA (bottom) zyBooks with and without instructor-created labs per year. The orange bar represents the total number of zyBooks from that year that had zyLabs enabled, but no instructor-created labs. The usage of labs is consistent across subjects.

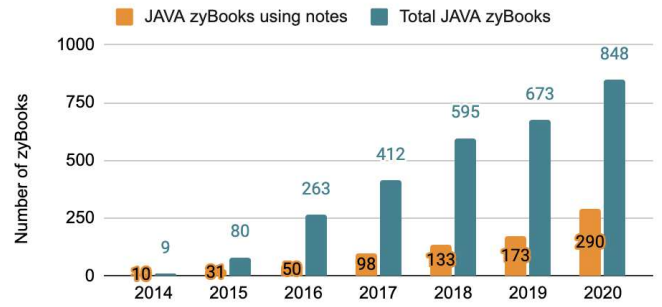
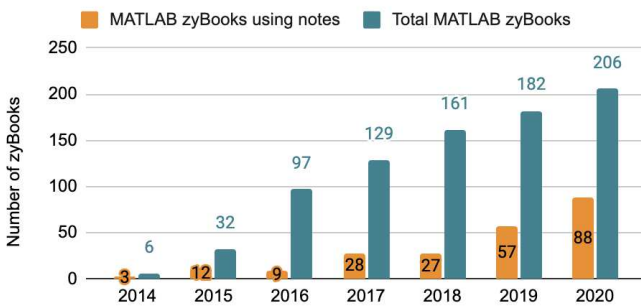


Fig 19. Number of MATLAB (top) and JAVA (bottom) zyBooks that used instructor notes per year. Private notes are only viewable by instructors and are less commonly utilized, while student-facing notes are seen by students using the zyBook. The usage of notes is consistent across subjects.

VI. DISCUSSION

A. Prevalence of customization

The data above show that many instructors use some form of Computer Science and Engineering course content customization when given the opportunity.

- Most instructors reconfigure content, with the percent of reconfigured zyBooks increasing from 78% in 2015 to 87% in 2020.
- About 30% of course zyBooks combine two or more catalog zyBooks, creating a hybrid.
- About 37% of course zyBooks incorporate notes from instructors.
- The new-in-2019 feature of instructor-authored sections is quickly growing in popularity. The feature of instructor-created labs, available since 2015, is popular, with nearly 65% of zyLab-enabled course zyBooks having such labs.

B. Key implications for publishers

For publishers, the implications of customization are substantial.

- Modularity: Previously, authors could assume that their content would be covered mostly in the order presented. Authors might think of a few different paths through the content and try to reduce dependencies to support those paths. In general, authors could assume that the content would still appear to students, and in the correct order. Today, instructors using digital content make heavy use of reconfiguration. Consequently, authors must focus on creating sections that are modular [5, 6], such that many more paths through the content are supported and different chapter grouping of sections can be formed.
- Consistency: Previously, publishers treated each textbook as an "island". Authors could choose any of various authoring styles in terms of section length, English usage, use of examples or figures, terminology, and more. Publishers focused on ensuring quality. Today, with instructors so frequently combining subjects, publishers need to start viewing textbooks not as islands, but rather as contributing to

a "library of content" from which instructors can build customized material for their course. The textbook becomes an initial grouping of content that eases discovery. Not only does this indicate the need for increased modularity, but also the need for a greater focus on consistency in authoring style, so that sections from different textbooks can be combined while yielding a reasonable learning experience for students (as opposed to having dramatic switches among styles from one section to the next).

C. Other implications for publishers

- **Marketing:** Publishers have long marketed textbooks by emphasizing the author. A textbook may be marketed as "Data Structures" by "Garcia and Jones", and publishers and instructors may refer just to "Garcia and Jones" in referring to the book. Given the trend towards textbooks contributing to a library of content and instructors creating hybrids from 3, 5, or even more books, emphasis on author names will naturally decrease. As instructors write and integrate their own sections into their digital textbooks, this trend becomes even more relevant (even if the section is denoted to students as instructor-authored). Additionally, modern digital content increasingly involves substantial contributions from experts within the publishing company, who assist authors. Author names are still important, but a notable rebalancing is occurring.
- **Pricing:** Historically, individual textbooks were priced individually, based on various factors such as the price of competitors. With the capability to combine content from multiple textbooks, pricing needs to be reconsidered in order to avoid unreasonably stacking costs for students purchasing course materials, and provide reasonable predictability of a hybrid product's price.

VII. CONCLUSION

Computer Science and Engineering college courses and instructors are embracing the switch from hard copy to digital textbooks at ever increasing rates. This transformation enables substantial personalization of content. It is becoming increasingly important to offer powerful tools for easy and seamless content customization [7]. Publishers need to provide a framework that allows for ease of course design and customization for instructors and a smooth effective learning experience for students. We've shown here that when such a framework is provided, instructors strongly take advantage of these capabilities and create unique courses that suit their particular needs. As the migration to digital textbooks progresses rapidly, it is also important to consider how modularity, consistency, and pricing should change within the publishing industry as we continue to explore and improve this vast frontier.

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