E-book Technology Facilitating University Education During COVID-19: Japanese Experience

La technologie du livre électronique pour faciliter l'enseignement universitaire pendant la COVID-19 : Expérience Japonaise

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Abstract

UNESCO reported in March 2020 that 84.5% of total enrolled students are affected in some way by COVID-19 pandemic with more than 166 country-wide closures of schools (UNESCO, 2020). Japan too imposed emergency remote teaching and learning at both the school and university level. In this study, we focus on a national university in Japan, and investigate how teaching and learning were facilitated during this pandemic period using an e-book platform, BookRoll. BookRoll was linked as an external tool to the university's learning management system. Such an endeavor also reinforced the Japanese national thrust regarding explorations of e-book-based technologies and using Artificial Intelligence (AI) in education. Teachers could upload reading materials, for instance their course notes, and associate an audio of their lecture. When students who registered in their courses accessed the learning materials, the system collected their interaction logs in a learning record store. Across the spring semesters from April to July 2020, the BookRoll system collected nearly 1.5 million reading interaction logs from more than 6,300 students across 243 courses in six domains with above 1,900 learners creating more than 78,000 reading logs weekly. While science and engineering courses mainly used the platform, law and language studies courses utilized the feature to upload audio tracks with reading materials. The interaction log analysis of the students with the content revealed that active learning actions, such as the use of annotations on text, were done more in humanities courses. Lastly, recommendations are created based on the analysis and the perception of the teachers about the emergency remote teaching and learning using the BookRoll system for orchestrating their course.

Résumé

L'UNESCO a signalé en mars 2020 que 84,5 % du total des étudiant·e·s inscrits sont affectés d'une manière ou d'une autre par la pandémie de COVID-19, avec plus de 166 fermetures d'écoles à la grandeur de ces pays (UNESCO, 2020). Le Japon a lui aussi imposé un enseignement et un apprentissage à distance d'urgence, tant au niveau des écoles que des universités. Dans cette étude, nous nous concentrons sur une université nationale du Japon, et nous examinons comment l'enseignement et l'apprentissage ont été facilités pendant cette période de pandémie en utilisant une plateforme de livres électroniques, soit la plateforme BookRoll. En tant qu'outil externe, BookRoll a été relié au système de gestion de l'apprentissage de l'université. Cette initiative a également renforcé la volonté nationale japonaise d'explorer les technologies basées sur les livres électroniques et d'utiliser l'intelligence artificielle (IA) dans l'enseignement. Les enseignant·e·s pouvaient télécharger du matériel de lecture, par exemple leurs notes de cours, et y associer un enregistrement audio de leur prestation. Pendant que les étudiant·e·s inscrits à leur cours accédaient au matériel d'apprentissage, le système collectait leurs interactions dans un registre d'apprentissage. Au cours des semestres du printemps, d'avril à juillet 2020, le système BookRoll a recueilli près de 1,5 million d'interactions concernant les lectures de plus de 6 300 étudiant·e·s dans 243 cours de 6 domaines, avec plus de 1 900 apprenant·e·s qui avaient créé plus de 78 000 entrées de journal, en mode lecture, par semaine. Bien que ce soit les cours de sciences et d'ingénierie qui ont principalement utilisé la plateforme, les cours de droit et d'études linguistiques l'ont utilisée pour y déposer des enregistrements audio associés à des documents à lire. L'analyse des interactions des étudiant·e·s avec le contenu a révélé que les actions d'apprentissage actif, telles que l'utilisation d'annotations sur le texte, étaient plus fréquentes dans les cours de sciences humaines. Enfin, des recommandations ont été formulées sur la base de l'analyse et de la perception des enseignant·e·s sur l'enseignement et l'apprentissage à distance d'urgence en utilisant le système BookRoll pour orchestrer leur cours.

Mots clés : e-Book ; BookRoll ; Analyse de l'apprentissage ; Enseignement supérieur ; Enseignement et apprentissage d'urgence en ligne ; COVID-19

Introduction

According to recent studies (Crawford et al., 2020; Hodges et al., 2020; Reynolds & Chu, 2020), the COVID-19 pandemic forced teachers and students to transition to emergency online education without prior preparation or guidelines. While higher education institutions might have remote teaching facilities such as their own Learning Management System (LMS) or infrastructure to support the design and creation of the teaching learning materials used in the course, still faculties rushed to convert curriculum to an online environment, and online

pedagogy had to be overlooked (Crawford et al., 2020). Teachers and students were participating in emergency remote teaching and learning from their residence often with many constraints.

Recent Works Related to Teaching and Learning During COVID-19

At the time of this study in September 2020, after the end of the academic spring semester in Japan, some forums called for special issue proposals and discussions related to education during COVID-19 (Bakker & Wagner, 2020; Erduran, 2020; Reynolds & Chu, 2020; Tomlinson et al., 2020). Initial studies focused on teachers' reflections on instructional practices due to the sudden change in orchestrating their individual class work. For instance, Nuere and de Miguel (2020) reported on how two Spanish universities migrated to online classes by the initiatives of individual course instructors, while having various logistics constraints and lack of technical knowhow. After the semester ended, others reported regarding the medium of communication such as Zoom and its effect on attitudes and perceptions of learners (Serhan, 2020). It found, in the context of one American university course which migrated from face-to-face classes to synchronous online sessions in March 2020, that while students acknowledged the flexibility and use of multimedia during the Zoom classes, they did not prefer the online experience due to the many distractions while learning from home, technical issues using the video conferencing application, and a perception of a lower quality of interaction with peers and teachers. Some studies focused on learning technology utilization during the pandemic at the institutional level (Lagi, 2020). It was found that there may be some shortage of funds to rapidly migrate to online learning and to train teachers on the aspects of orchestrating remote and emergency learning. Studies also focused on the transformations of educational practice due to the pandemic in specific domains such as science education (Erduran, 2020) or medical education (Tomlinson et al., 2020). In medical education, for neurosurgery training, the use of simulation and virtual reality technologies were highlighted to continue the education for doctors. These works were found in the research article repositories across Web of Science, Scopus, and Google Scholar and are illustrative examples of the discourses related to emergency remote teaching and learning. This highlights the need of a socio-technical approach to understand and support the crisis.

Multimedia use in general (Krippel et al., 2010) is studied from the perspective of the designed content and its receiving audience, the students. For instance, in the context of higher education, lecture captures (Caglayan & Ustunluoglu, 2020) are the audio-visual contents where the instructor's prior in-class recorded lectures are shared as course materials in subsequent offerings. Caglayan and Ustunluoglu (2020) investigated the use of lecture capture technologies in a Turkish university across nine different faculties and found this approach was useful for students; however, the usage patterns varied according to faculty, level, year of study, and student's grade, and therefore further research is needed to understand how such systems can be adopted effectively in practice. Banerjee's (2020) literature review highlighted that most students assume that lecture capture is helpful for learning, whereas most staff consider that lecture capture takes a toll on attendance. Other studies focusing on audio books were conducted more

from a perspective of language learning (Best, 2020; Tusmagambet, 2020). Best (2020) synthesized literature to highlight audio book popularity in a first language learning context and mentions that most work focuses on listening in relation to reading, but that more research is needed on the intrinsic benefits of listening and listening for enjoyment. Tusmagambet (2020) reported findings of a mixed methods study indicating significant improvement of language fluency using audio books in a second language class with silent reading activity, however, this study found no significant difference in motivation of reading compared to only using e-books without audio.

The context of this study involves e-book-based content which can have associated audio tracks. In such context, investigations like the lecture capture system are relevant to understand usage and engagement with the e-book platform and its effect on cohorts of students and teachers for adoption. Given the pandemic situation, it is still early to have an account of findings on how semester-long classes were organised. Also, it would be time consuming, by traditional data collection methods like surveys and interviews with stakeholders, to gather relevant data about course activities. However, this work aims to provide an initial narrative driven by educational log data concerning what resources were shared and how students from different domains utilized them during the pandemic.

Considering the general theme of EDUsummIT2019 "Learners and learning contexts: New alignments for the digital age," this research looks closely at the context of a university level education in Japan during the COVID-19 pandemic. It fits the intersection of two thematic working groups: TWG1 - Technology developments: how human computer interactions change with technological innovation and TWG6 - Putting learning back into learning analytics: optimizing learning through analyzing the data (Fisser & Phillips, 2020). The e-book-based learning platform, BookRoll, focuses on integrating the technological innovations in the field of AI in education with interaction data collected from the platform. This work presents a descriptive context of the appropriation of this technology and its perceived usefulness during the pandemic period.

Research Objectives

As a part of the academic media centre associated with the university, the research team spearheaded the implementation and support of a university wide use of an e-book-based learning system. The framework was built to foster research on educational big data, maintaining the quality of a production system, and ensuring learner's privacy by collecting interaction logs pseudonymously. This research context included the following aspects:

1. BookRoll, an e-book-based learning platform brings together capabilities of standardized data logging and enables data-driven services to support the teachers and students. It is not just an e-book reader.

2. After an initial teacher's survey (Majumdar et al., 2020) during the school closedown, the current version of BookRoll included functions to let the teachers upload audio content

and associate it with the reading material. To our knowledge, this is the first study to analyze e-book interaction data with associated audio content collected from a variety of different university courses.

3. While such a large-scale study regarding a systematic university-wide implementation of the e-book system itself is rare, this specific context is also an example of emergency remote teaching (Hodges et al., 2020) where the sudden migration was facilitated by the e-book platform and many university teachers voluntarily adopted it.

The current work investigates the following research questions:

1. What are the characteristics of the uploaded reading and audio materials across courses from different domains which were used during this emergency remote teaching?

2. What are the learning behaviors of the learners across the semester during this emergency remote teaching?

3. What are the perceptions of the teachers regarding conducting their course with e-book-based activities during this emergency remote teaching?

Background

Technical Foundation: Learning Evidence Analytics Framework

The Learning Evidence Analytics Framework (LEAF) is the technology framework that drives this research to develop the infrastructure for big data analytics in education (Ogata et al., 2019). It includes BookRoll, the e-book platform (Ogata et al., 2015). Teachers can upload learning materials to BookRoll in PDF format and students can access them on a wide range of devices through a standard web browser. The platform then records the interactions of browsing and annotating on those materials as log data in the learning record store (LRS). Figure 1 shows the reader's interface and functions in BookRoll. Based on the study findings during the initial period of the pandemic (Majumdar et al., 2020), an audio upload function was developed to associate audio clips with each learning material. With this function, teachers can easily upload their spoken lecture or tutorial audio associated with those materials. The students can control the audio, which plays automatically when the material is accessed. The student's activity logs from the LRS are processed and then visualized on a learning dashboard LAViEW (Majumdar et al., 2019). Both instructors and students can access the dashboard directly from the LMS. Teachers can access the learning behaviors of their registered students on each uploaded material. Multiple panels represent the information visually, such as the percentage of the material completed, number of annotations, time spent on each page, and quiz answered on a content page. Learners can see their own data in each of the panels.

Figure 1

Technology Foundation for Learning Analytics Enhanced e-Book-Based Learning System
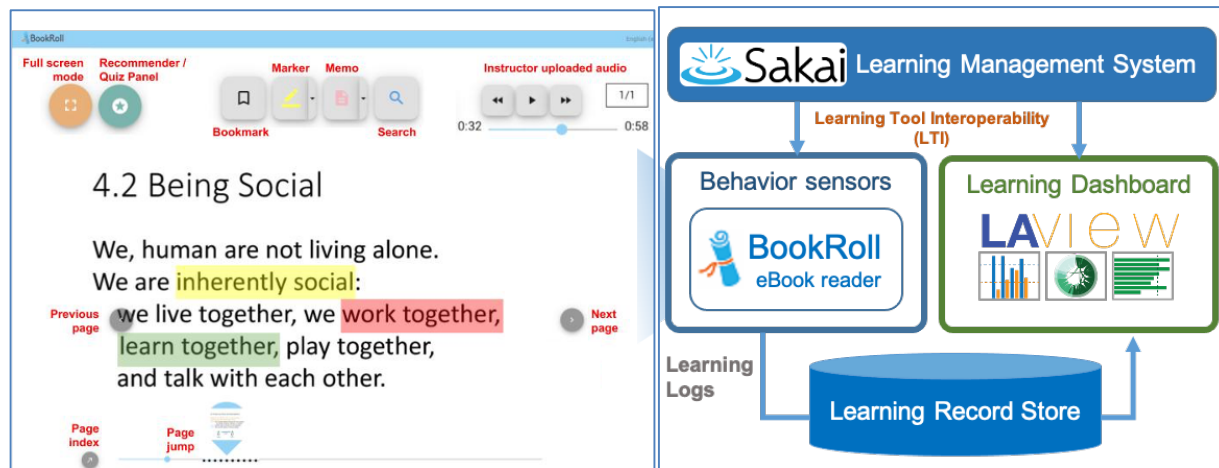
a. Learner Interface of Book Roll   b. Architecture of the LA Platform

Learning Affordances and Data Logged

Learners can access all the reading content shared in BookRoll through their registered LMS course. When they open the system for the first time, BookRoll provides the users with the details of the data being logged and requests authorization to log their reading behaviors. The reading actions recorded in the study are listed in Table 1.

The *open and close* operations note when a learner accesses a particular content or closes it. Thus, these actions are indicative of the learner's intent to access specific knowledge content shared in a particular course. *Navigation* actions relate to changing pages, either going to the next or previous page in a particular content while the reader engages in or browses through it. Readers can use the page slider at the bottom of the screen (refer to Figure 1a.) to jump directly to a particular page or click on a bookmarked page. A full text search is also possible, and readers can click directly on the searched page. Apart from *next* and *previous*, longer jumps using the slider, bookmarked pages, or searched content can indicate intended jumps to locate specific content. Annotation features in BookRoll include adding markers, bookmarks, or typed or handwritten memos through gesture or digital pen inputs. Learners can make annotations during the reading process or as part of an activity associated with the content (e.g., highlighting during skimming and noting questions in memo while partaking in an active reading strategy). Each annotation can be updated or deleted. Such actions can indicate reflective actions during learners' self-regulated learning activities (Winne, 2017).

In the current version of BookRoll, learners can control (play or pause) content associated audio. When the audio ends, an automatic log of AUDIO_END is recorded. An in-content recommendation panel feature can be accessed by teachers to share external content links and multiple choice or memo-based quizzes with the learners. Embedded links in the text is also navigable directly. Such teacher-curated external resources give learners the affordance to

explore further knowledge contents. An in-content quiz feature aims to help students reflect on the knowledge components. The system logs when the learner opens or closes the recommendation panel, clicks on the embedded text links, or answers the question in the pop-up quiz. During content creation actions, the system saves when the teacher registers, adds, or modifies new content.

Table 1

Distribution of the Types of Interaction Logs

		Interactions	Hours spent	Users	Courses
Open & close	OPEN	127,400	7,268	6,267	229
	CLOSE	9,481	77	2,908	204
Navigation	NEXT	838,574	28,833	5,876	230
	PREV	258,834	11,534	4,753	205
	PAGE_JUMP	34,867	1,479	3,613	207
	BOOKMARK_JUMP	1,249	60	115	59
	SEARCH_JUMP	1,137	42	203	64
Annotation	ADD MARKER	33,760	504	1,436	177
	ADD MEMO	4,220	197	1,043	164
	ADD BOOKMARK	1,478	52	508	124
	ADD_HW_MEMO	173	1	59	34
Update annotation	DELETE MARKER	2,442	65	606	131
	CHANGE MEMO	2,111	102	354	102
	DELETE BOOKMARK	1,221	44	868	158
	MEMO_TEXT_CHANGE_HISTORY	588	15	136	55
	DELETE_MEMO	507	133	370	103
	UNDO_HW_MEMO	49	1	11	8
	CLEAR_HW_MEMO	19	0	10	8
Audio interaction	AUDIO_START	147,724	4,983	2,985	115
	AUDIO_PAUSE	79,111	5,836	2,577	102
	AUDIO_END	24,493	1,628	2,332	96
Recomendation & search	OPEN_RECOMMENDATION	1,484	11	294	71
	LINK_CLICK	1,223	145	257	53
	SEARCH	1,156	29	306	87
	CLICK_RECOMMENDATION	501	29	97	8
	QUIZ_ANSWER_CORRECT	487	6	172	9
	QUIZ_ANSWER	320	1	137	9
	CLOSE_RECOMMENDATION	2	0	2	2
Teacher action	REGIST CONTENTS	1,324	125	126	164
	ADD_RECOMMENDATION	133	1	10	19
	DELETE_RECOMMENDATION	2	0	1	1
Grand Total		1,576,070	63,202	6,379	243

The collected data is processed in the LEAF infrastructure to provide various data-driven services such as smart dictionaries (Lecailliez et al., 2020), AI-driven content recommendation systems (Takii et al., 2020), and learning dashboards (Majumdar et al., 2019). The dashboard was also used for conducting specific teaching-learning activities (Chen et al., 2020) and assisted to monitor reading behaviours during the different phases of the activities.

Theoretical Standpoint of Current Analysis

Interactions in e-Learning Context

Moore's interaction model defines interactions in distance education, which proposes three interaction categories: student–student, student–teacher, and student–content (Moore, 1989). Student-student interaction refers to interaction between individual students or among students working in groups. Student-teacher interaction aims to stimulate or maintain students' interest in the content, motivation to learn, and self-direction. Student-content interaction refers to students' interaction with the content that results in a change in their understanding, perspective, or cognitive structure (Moore, 1989). However, recent works have highlighted the learner-content interaction as the weakest link in interaction research in the context of distance education (Xiao, 2017).

Engagement in Online and e-Book-Based Learning

Ashwin and McVitty (2015) proposed student engagement having a nested nature based on its object of focus which can be the formation of understanding, formation of curricula, or formation of communities. In the context of e-books, students engage to form an understanding with that shared content. Recent work analyzing Britain's university students' perceptions about engagements with e-book-based learning proposed recommendations for institutes' academic libraries to provide more options for targeted searching and to facilitate a "bite-size" approach to reading by the students (Casselden & Pears, 2020). In this work, we utilize learner-content interaction analysis to understand learner engagement during the emergency remote learning.

Research Methods

Context and Data Collected

The current study focuses on a national university in Japan and its academic offerings during the 2020 Spring semester. Normally, the spring semester classes runs from April 9 to July 20 and the final exams and feedback were from July 23 to August 3. Due to the pandemic, the online classes commenced on May 6 and ended on July 20, then final exam continued until August 5. The spring semester was conducted remotely completely online. Courses were offered from 31 different graduate schools during the spring semester in the LMS and from them, 243 courses used BookRoll to upload and share their learning materials. The distribution of the domains of the courses are provided in Figure 2.
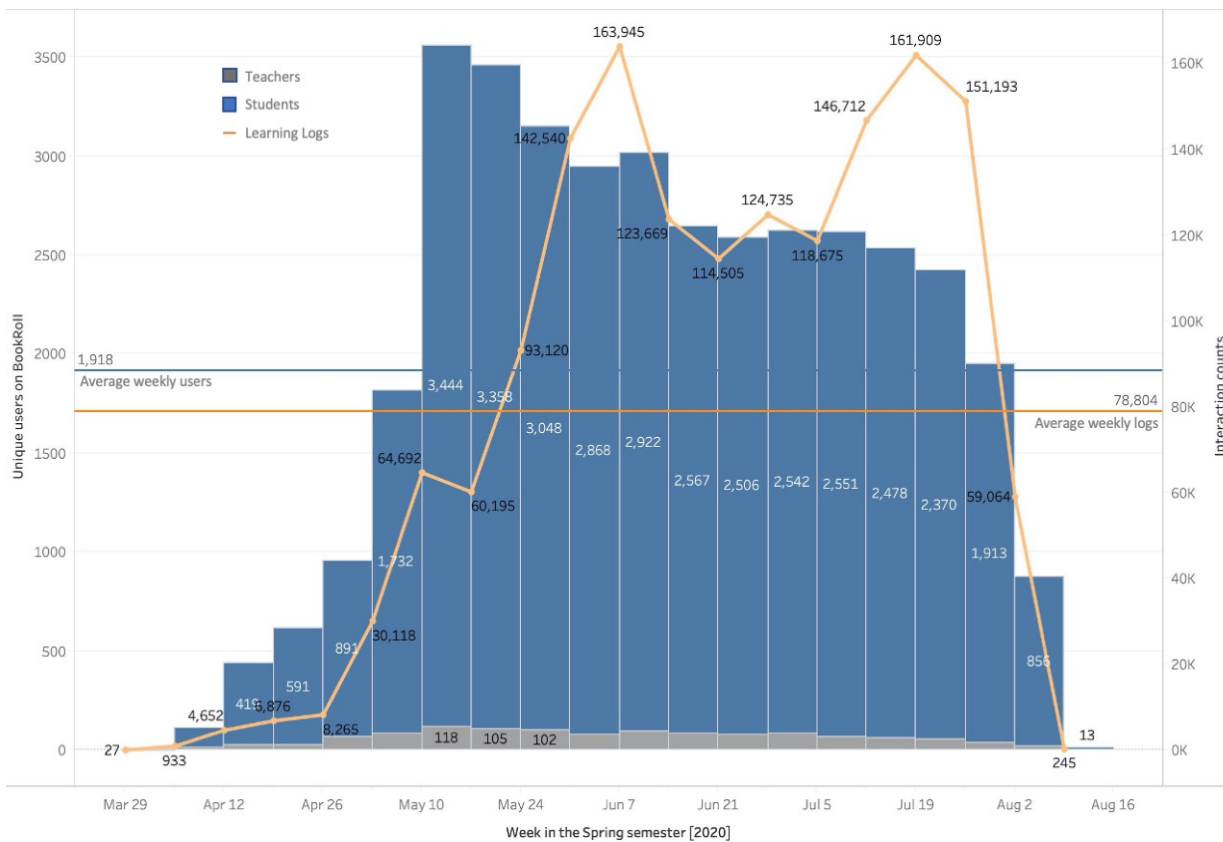
Figure 2

The Distribution of the Courses During the Spring Semester of 2020 (n=243)
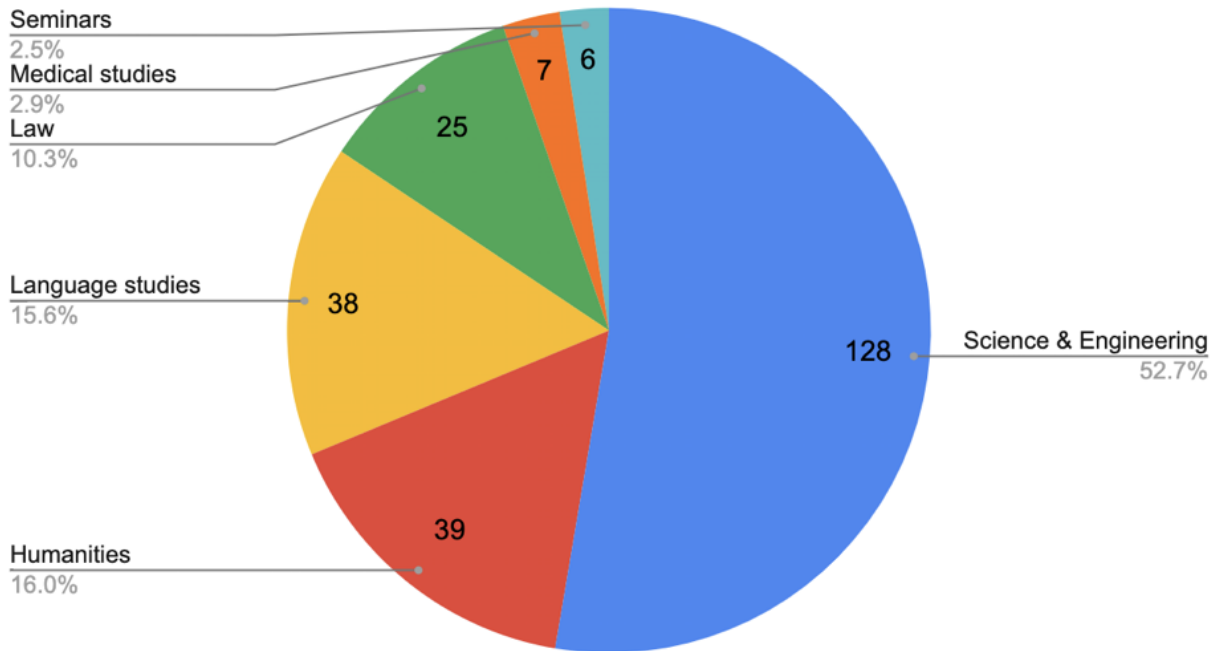
A total of 1,886 reading materials were viewed by the students. Additionally, 2,111 audio files were uploaded and associated with 641 reading materials (34% of the total reading materials viewed). The audio materials were part of 115 courses (47.3% of the total courses using BookRoll) with a total run time of more than 433 hours. For this study, we analyzed the interaction logs collected during the period of April 1 through August 9 (130 days). This period included the initial time where the teachers uploaded and registered their course content and a full week after the completion of final examinations. Each action that lasted more than 3 seconds but less than 10,000 seconds was considered. This duration cut-off was implemented so that random interactions and long idle times were eliminated. Figure 3 gives the timeline distribution for the number of unique users online and weekly interaction count during the period of observation (April 1 to August 9, 2020). On average, there were 1,918 users online each week generating 78,804 interaction logs.

A total of 1,576,070 interactions from 6,379 users (6,135 students and 244 teachers) were analyzed. The data log contained teachers' course content registration actions and learner interactions during content access in the BookRoll platform. The distribution of the interaction log types is provided in Table 1.

Figure 3

Collected Logs and Unique Learners in the System

Analysis Method

The analysis is focused on understanding the features of the course contents that were shared by the teachers and the interaction pattern of the students with that content (a visual overview is presented in Figure 4).

Based on the course name in the LMS, the graduate school offering the course was identified and mapped to the subject domain. Courses were from six main domains: science and engineering, humanities, language studies, law, medical studies, and seminar courses (proportions of all courses were presented in Figure 2). The distribution of the content with respect to its features such as number of pages of the reading materials, whether there were associated audio materials, and the length of the uploaded audio was calculated for each of the six domains. The characteristics of the learner's usage of the system was then investigated based on the logged data for the different course content types and domains.

To understand the temporal relationship of the learner interactions, action logs were processed to find temporal trends both within an active day, for instance the duration of activity within the university's synchronized online learning period, and the time outside of school. The temporal trends were also checked across the period of the pandemic. Lastly, the teacher's

perception of orchestrating their course using BookRoll was analyzed through an end of semester survey completed by the teachers.

Figure 4

Analysis Overview
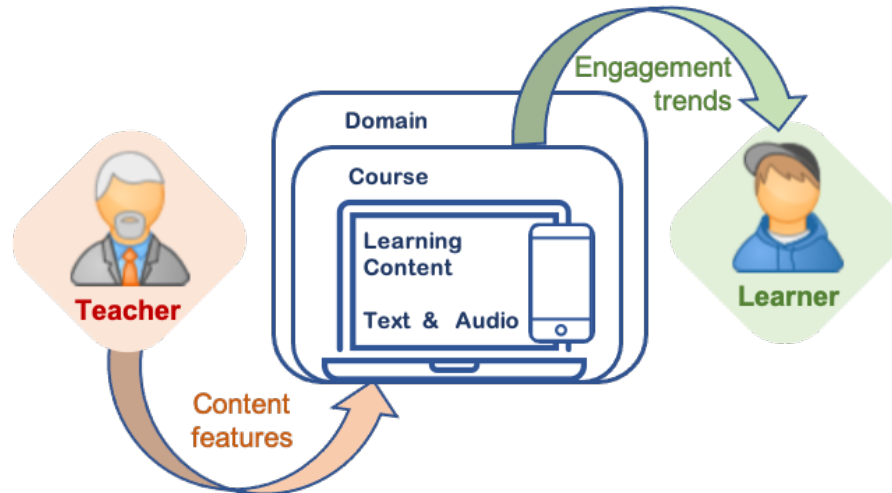
Results

The findings are reported in three parts corresponding to the research questions: 1) the features of the contents uploaded by the teachers, 2) the interaction patterns of the students with the contents, and 3) the perceptions of the teachers.

Learning Content Shared by Teachers

Figure 5 provides the distribution of the content divided according to with or without associated audio. Both the science and engineering 28.5% (n=286) and humanities 36.3% (n=144) domains had associated audio. Law and language studies courses had more content with audio, 51% (n=126) and 53% (n=132) respectively. Medical sciences and seminar courses had less audio content, 7% (n=2) and 9% (n=7) respectively. The average total number of pages for the content with audio was 15, whereas those without audio was 18 pages.

Table 2 gives the distribution of the audio content across courses from different domains. It indicates the percentage of the courses in that domain which had audio contents, the number of reading materials which had the audio track associated, the total number of audio tracks uploaded in each domain, the average count of the audio tracks per content per course in each domain, the average duration of the tracks, and median and total duration. It is observed that the science and engineering domain had 48 courses that included audio materials with 37.5% of the total courses in that domain. Whereas in law, 80% of total law courses (n=20) associated audio with their uploaded content. Among medical studies and seminar courses, only one course uploaded the audio. Excluding seminars and medical studies (due to a smaller number of samples for comparison), the distribution was not statistically different across the domains (F=1.01,

p=0.391). However, audio tracks associated per content in a course was highest for humanities and language studies with an average of four tracks per content item.

Figure 5

Distribution of Reading Content with and without Associated Audio Across Courses from Different Domains
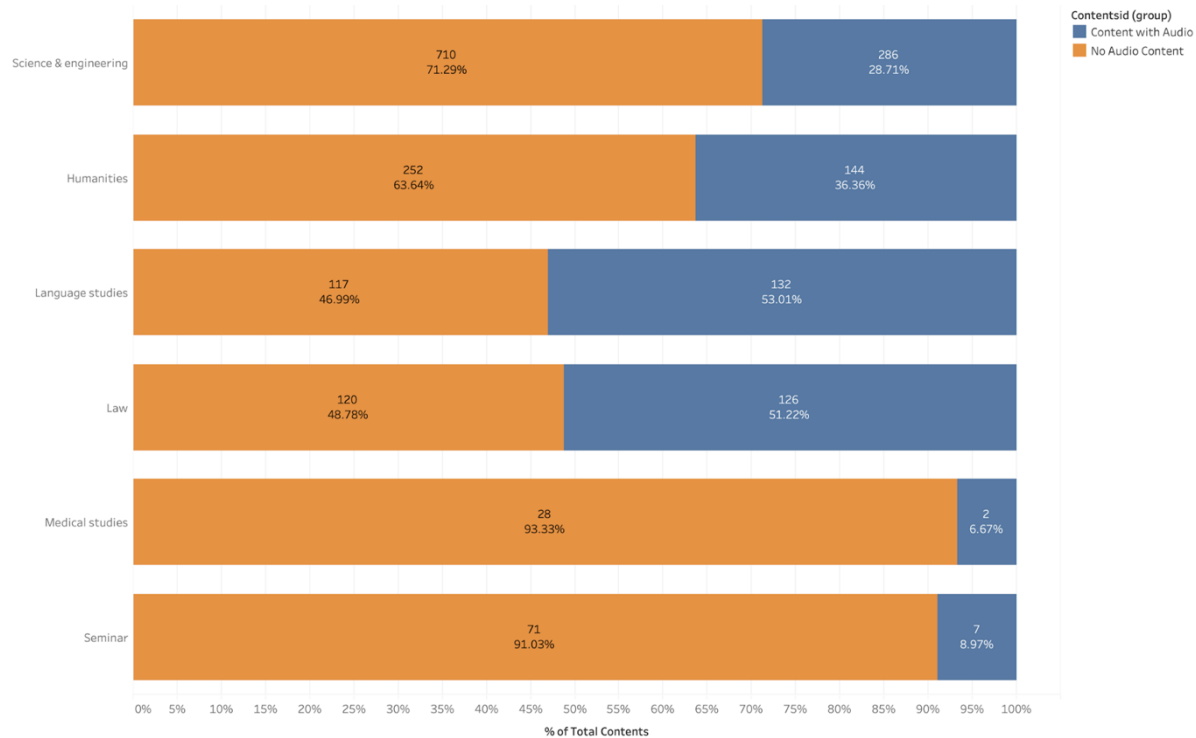
Considering the duration of audio tracks, law had more than 143 hours with an average duration around 33.5 minutes. The distribution of the median audio track duration of courses in each domain revealed that the difference between the courses was significant (H(3) = 9.97 and p= 0.019). Dunn's post-hoc comparison highlighted that law courses had longer median duration of audio tracks (27.8 minutes) than all other domains and there was no pair-wise difference for the rest (refer to the median duration column in Table 2). This indicated that the content in law courses were more like lecture captures but with a longer duration. Other domains had audio content with a shorter duration; for instance, language studies courses had an average of 5.5 minutes (median 3.9 minutes) for the audio tracks. In that context, many instructors had uploaded tracks for listening activities along with the content.

Table 2

*Distribution of the Audio-Based Contents Across Different Domains*

Domain	Courses (% of that domain)	Contents with audio track	Total Audio tracks	Audio Track per content per course. mean (s.d.)	Average Duration (minutes)	Median Duration (minutes)	Total Duration (hours)
Law	20 (80.0%)	122	286	2.4 (1.2)	33.5	27.8	143.6
Science & Engineering	48 (37.5%)	171	681	3.5 (3.3)	14.5	7.7	141.7
Humanities	24 (61.5%)	115	519	4.0 (4.1)	13.1	6.8	95.7
Language studies	26 (68.4%)	114	584	3.9 (4.0)	5.5	3.9	46.7
Seminars	1 (16.6%)	6	20	3	9.5	7.2	3.2
Medical studies	1 (14.2%)	2	21	10	6.0	4.6	2.1
Grand Total	120	530	2111	3.5 (3.4)	14.2	6.8	433.0

Learner Engagement

Variation in Content with and without Audio

Figure 6 presents the engagement of the learners for the different nature of the content (with and without audio materials) across different domains of the courses. Each point represents a content item, and the distribution shows the computed average minutes spent on the contents per active day per learner accessing that content. The median of each type of content in a domain is marked by the number of minutes. The overall domain's median and average is marked by the yellow band. For the science and engineering courses median time per learner per day is 42 minutes for content with audio and 90 minutes for content without audio. For the humanities course the median engagement was 136 minutes for content with audio and 167 without audio. For humanities and science and engineering courses the trend showed higher engagement with contents without audio. However, the trend related to the median time spent reversed for language studies and law courses. The contents with audio had more median engagement with audio (language studies had 120 minutes and law had 227 minutes) than without (language studies was 45 minutes and law was 86 minutes). While the number of content items for medical studies and seminars was lower than in other domains, it was observed in those domains as well that students spent more time on content associated with audio.
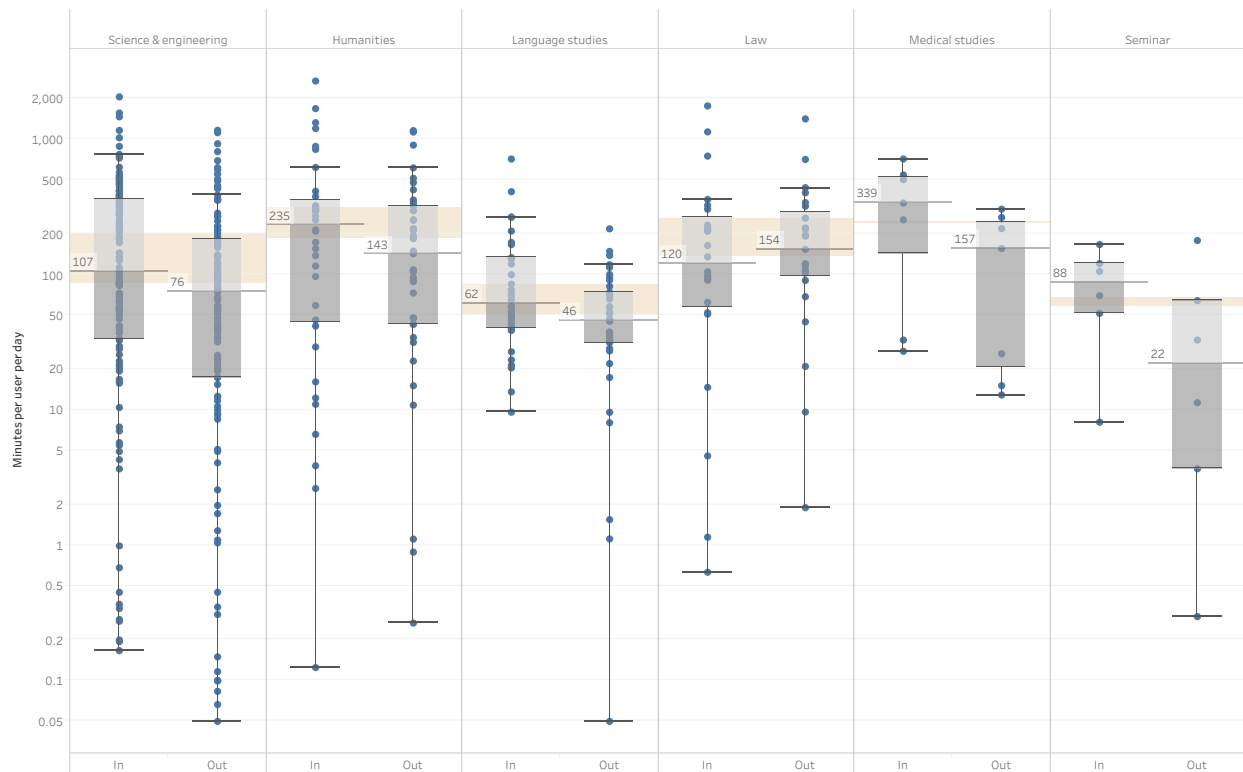
Figure 6

Learner Engagement with Reading Content with and without Associated Audio
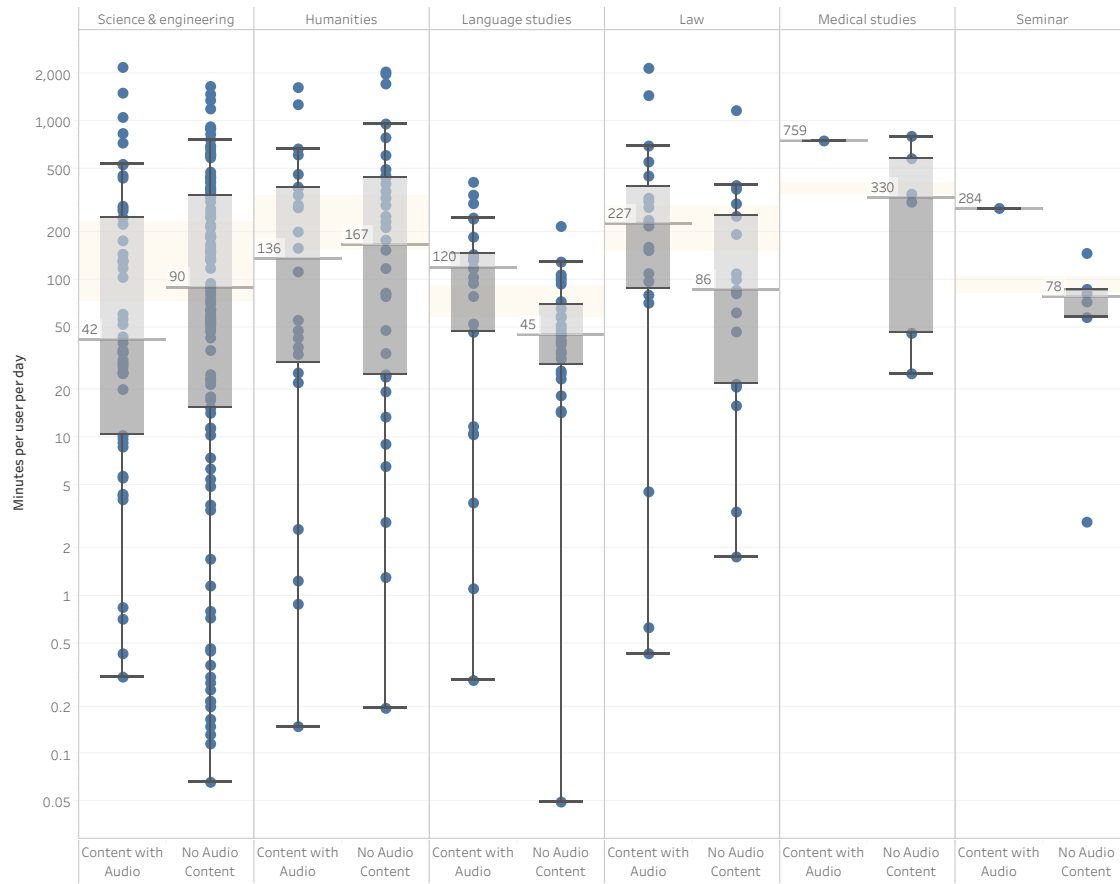
Variation During Synchronized Class Time and Outside

Figure 7 presents the learning behaviors within a day; the analysis includes the period of the university's allotted time where some courses had synchronous online classes (weekdays between 9 am to 6 pm) and learning activity outside that period (weekdays from 6 pm to 9 am and weekends). Each point represents a course in a particular domain and the distribution shows the computed average minutes spent in that course per active day per learner accessing different contents in BookRoll. The domain's overall median and mean is highlighted by the yellow band and the median value for in-class and out-of-class hours are marked respectively. Medical studies courses had the highest median time spent by the students on BookRoll, with nearly 5.5 hours during the allotted school hours followed by humanities courses with around 4 hours. Science and engineering courses had a median value of 1.7 hours, whereas language learning courses had nearly one hour of engagement logged per working day per student.

For out-of-school hours, law and medical studies courses had nearly 2.5 hours of median engagement followed by humanities courses which logged 2.3 hours and science and engineering courses having 1.3 hours. Language studies courses and seminars had 46 minutes and 22 minutes respectively.

Figure 7

Learner Engagement with Reading Content Within and Outside School Hours

## Longitudinal Reading Behaviors across the Semester

Longitudinal behaviors of the learners were analyzed across the semester with respect to the operations they performed in BookRoll. In Figure 8, the left tabular representation reports the total distributions of the operations categories by count of interactions, hours spent, total unique users recorded in those operations, and the number of unique courses in which they were recorded. The right bar charts represent the average values across the months per distinct learners per active day. Both the average interaction counts and the time spent per interaction is reported.

The open and close actions are indicative of the access to the materials on BookRoll. The time associated with it is corresponding to that spent on the first page of the content. It indicates an increase in the usage of the materials uploaded on BookRoll as the semester progresses. The navigation action in the e-book to browse the material also increased as the semester progressed. The computed average reading rate across all learners was 9.5 pages per day. Creating annotations and updating them are considered active learning behaviors (Winne, 2017). Across the period, a daily average annotation action was 8.1 (SD = 11.7) and for updating was 2.8 (SD = 4.1). Similarly, the access to recommended materials (external online resources, quizzes) on BookRoll can also be considered a part of active learning based on the designed content and the learning tasks. In the period of analysis, daily average access to recommendation and search per learner was 2.2 (SD = 1.4). Listening to the audio track associated with the content can also be

active learning if there is an activity associated with it, for instance language studies used short clips for listening-based vocabulary learning activities. In case the audio and text content in the e-book had lecture notes, the trend of accessing it increased just before the mid-term and final-term evaluations. Over the period of this analysis, the average daily audio interaction was 11.7 (SD = 9.6).

Figure 8

Distribution of the Logs in Different Interaction Categories, Count of Interactions and Duration of Engagement per Learner per Day in a Particular Month
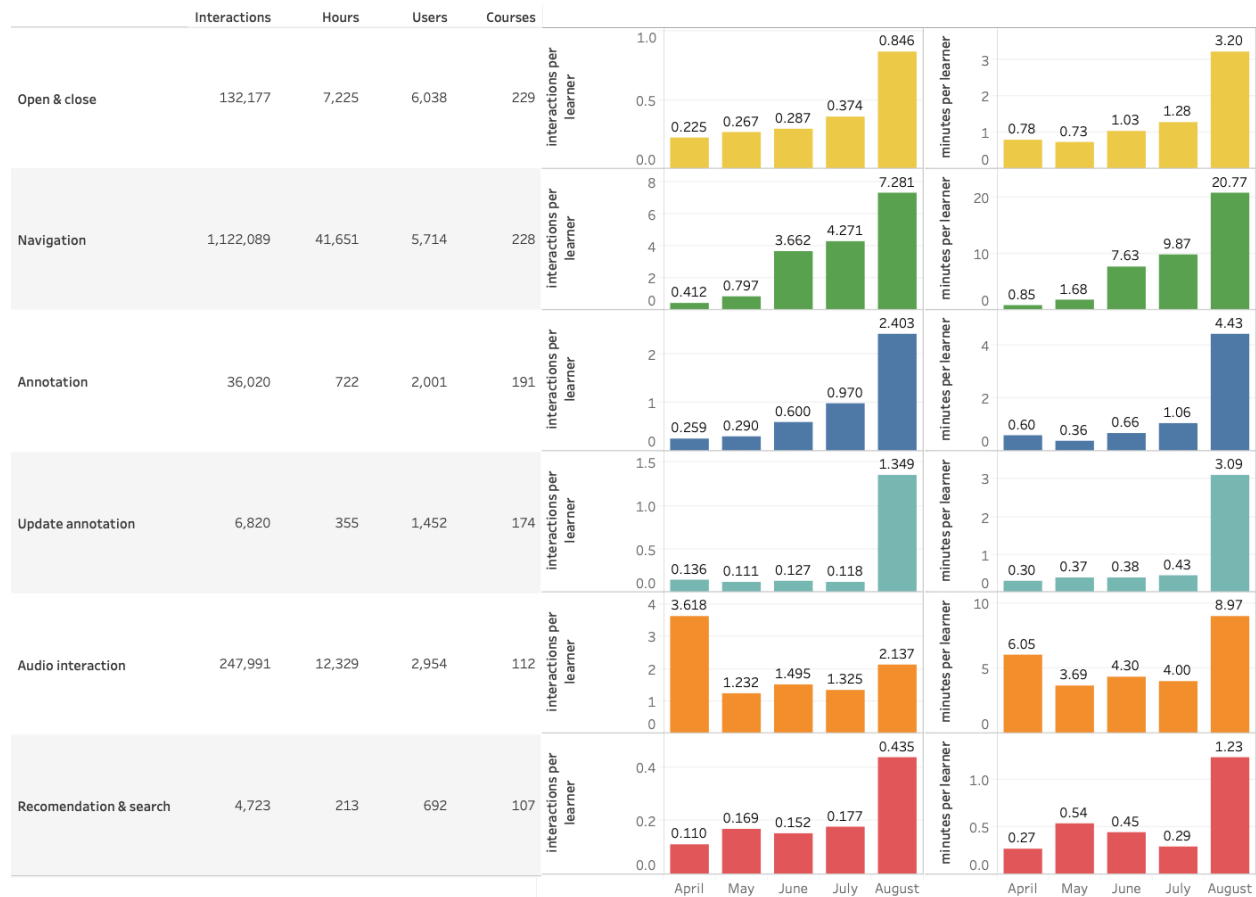

This analysis prompted us to look at the specific active learning operations dealing with annotations, updating them, and searching or interacting with the content in the recommendation panel. As the detailed qualitative nature of the audio material associated with the e-book content was not analyzed, for instance whether it was lecture speech or listening based assignments, listening actions were omitted at this stage of analysis. Figure 9 below provides the variation of the active learning operations performed by the learners across different domains and type of reading content, one with associated audio and the others without audio. On average, 50% of the content uploaded had active learning operations performed by the students. For science and engineering courses, annotation activities were proportionally higher, 82% of the total active engagement actions, with reading content which did not have associated audio. For language

studies, 88% of the total active learning interactions on content having audio involved annotations. Humanities courses having content with audio had 47% of active learning interactions in the recommendation and search.

Figure 9

Distribution of Annotation Behavior in Domains with Different Content Type
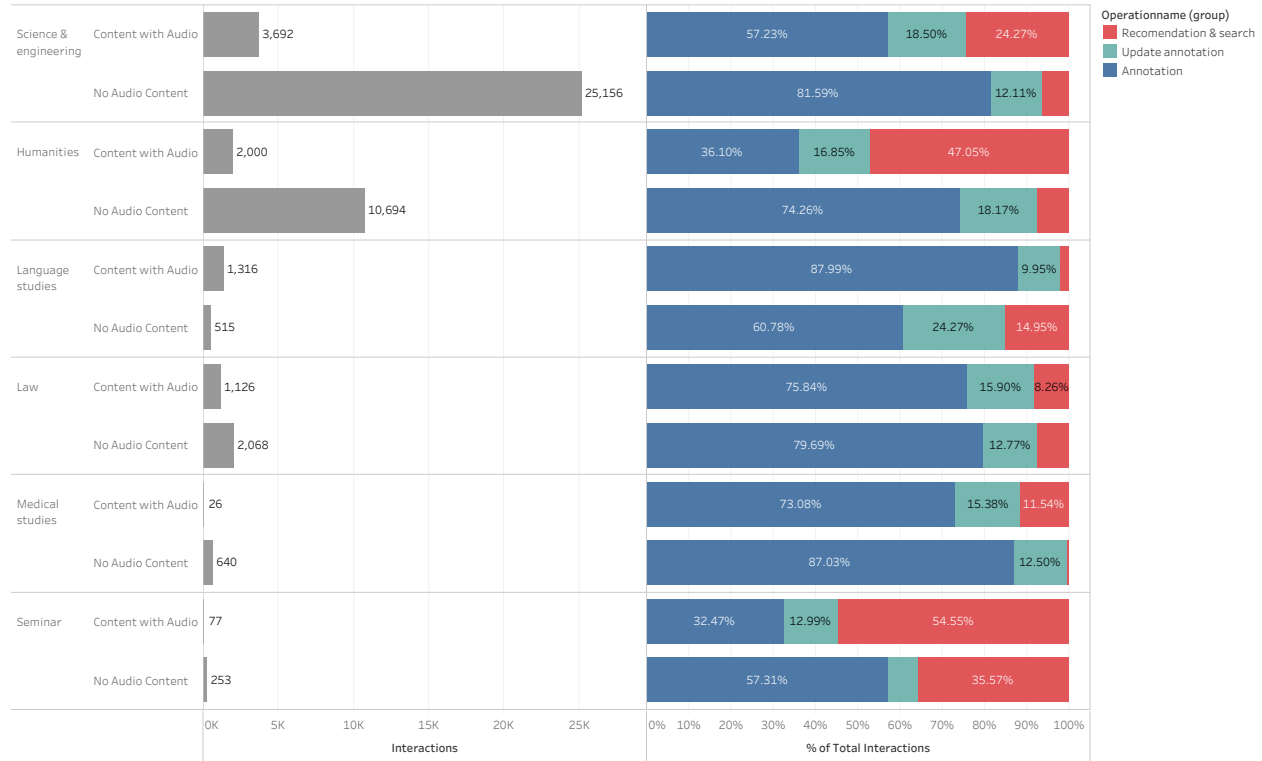
Reflections of the Teacher

After analysis of the results, the analysis was presented via online presentation to interested teachers on August 18, 2020. Nearly 30 teachers attended the session. A survey was open for the teachers who wanted to provide some feedback. Ten instructors responded to the survey regarding their experience of orchestrating the course with the online e-book platform. The teachers who responded belonged to different domains related to science and technology (7 teachers), humanities (1 teacher), and language studies (2 teacher). Most of them had classes once a week, one twice a week, and two thrice a week. Five of the teachers had a synchronous online class and two had asynchronous distribution of material for the course. The response to in-course use, its usefulness, and ease of use of BookRoll and LAViEW Analysis tool for the teachers and their students is summarized in Table 3.

The teachers also provided justification and descriptive feedback for some of their responses. Regarding their students' understanding of the course content, the teachers had an overall positive impression that the online mode was as good as their face-to-face class. Some mentioned that this was possible as there were weekly assignments given to the students and they

had more opportunities to practice and solve problems. These assignments were evaluated and regular feedback helped to improve student understanding. One teacher noted that understanding was relatively better based on the quality of the submissions that were received this year than the previous ones where only lectures were done. Another teacher observed that for a regular online test the average score was more than 80%. One teacher also acknowledged that understanding would depend on individual students and cannot be commented unconditionally. Eight teachers had course assignment and report submissions for the final course evaluation and two other teachers choose an open book online test. BookRoll's perceived usefulness and ease of use was because teachers could easily upload their previously prepared lecture notes as pdf reading materials and upload their recorded audio.

Table 3

Teacher Survey Responses (n=10)

Item	Response
How often did you use BookRoll (BR)?	More than 10 times in the course (60%), 5 times or more (20%), 3 times or more (20%)
Was BR useful for your students' learning?	Very useful (30%), Useful (60%), Somewhat useful (10%)
Was BR useful for managing your course?	Very useful (50%), Useful (50%)
Was BR easy to operate?	Very easy (20%), Easy (50%), Neither easy nor difficult (19%)
How often did you use the Analysis Tool (AT)?	1 or 2 times (40%), Around 5 times (20%), Around 3 times (20%), More than 8 times (10%), Never used (10%)
Was AT useful for managing your course?	Very Useful (10%), Useful (50%), Somewhat useful (30%), Did not use (10%)
Was AT easy to operate?	Very easy (10%), Easy (40%), Neither easy nor difficult (40%), Did not use (10%)

The fact that the material is not downloadable and had a tracking function for student activity was useful for one teacher to know how much students could learn from the self-study material. Teachers also mentioned the inconvenience of uploading multiple reading materials and that the role of a teaching assistant as one helping to create and upload supplementary materials was not defined. The quiz function associated with the BookRoll panel only had multiple choice options and did not provide the option of elaborate answers. As well, the quality of some uploaded images in the material did not match their expectations and occasionally there were issues with the audio playback. Regarding the LAViEW dashboard, the teachers mentioned it was helpful to look at students' activities at a glance and that would help for future revision of their materials.

Discussion

Recommendations Based on Findings from the Data

The analysis of the logs of the BookRoll system indicated continuous usage by instructors and learners during the spring semester that was conducted online due to the COVID-19 pandemic (see Figure 3). On average, the learner read 9.5 pages per day. There were 9.8 marking actions and 2.4 memos were created. Across the domains, humanities and medical studies course learners had higher average engagement in terms of duration of BookRoll interactions with nearly two hours on active days. As the semester progressed, the content access increased and the duration of engagement per action also increased. However, for the interactions with the audio, there was more engagement in the beginning, then dropped in the middle before rising again at the end (see Figure 8). Interaction levels may be because learners firstly received recorded lectures, then later switched to synchronous online mode, and later again referred to the materials before the end of the semester evaluative components.

The usage peaked twice in the beginning of June and end of July. These periods corresponded to the preparation period for mid-term and end-term examinations. While there was an average amount of traffic of more than 1,900 uses per user, the activities increased during the term examination period. This was anticipated and taken care of by the network support team. At an institutional level, it is important to consider the traffic and allot network resources accordingly to maintain the online teaching learning experience.

Analysis of the uploaded content items by the teachers revealed that the science and engineering courses mainly used BookRoll to share course reading content (n= 996, 52.8% of total uploaded contents). Given the option to upload audio, there was a fair proportion of content which had associated audio (n=697, 35% of total reading content). Law and language studies courses utilized the function the most with nearly 80% and 68% of their courses associating audio tracks with the reading materials respectively. Around 50% of the contents related to those courses had at least one associate audio. Further the law courses had an average audio content length of around 33 minutes which was longer than the ones in the science and engineering and language studies courses which averaged 13 minutes. We found that the instructors from the law faculty mainly used a recorded lecture audio and shared it directly with the content. This also explains why there was marginally more learner engagement in law courses with the content outside the university's class timing (see Figure 7). Language studies courses uploaded listening-based activities as short audio tracks. Also, a higher use of annotation for the language studies courses with audio content (see Figure 9) was observed with marginally higher engagement during synchronous class times (see Figure 7). The use of the recommendation panel was seen mostly utilized in humanities courses when the content was along with the associated audio (see Figure 9). The recommendation panel can have short multiple-choice quizzes or links to share external content. Both of those features can be used to design active learning tasks which the students engage in while reading the material. For the humanities courses it was reported that the
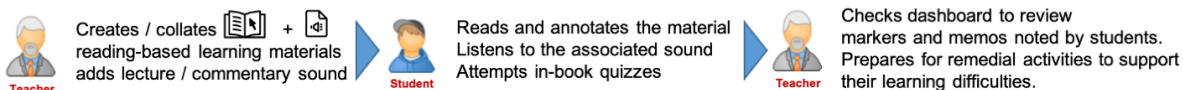
synchronous timing had more median engagement (see Figure 7). Such short activities could also be used during synchronous online class where the teacher can directly provide reflection spots within the reading material.

The teachers' feedback confirmed that both BookRoll and LAViEW Analysis tools were easy to use, and some used them regularly during their online class periods. The technology barrier was low, and the teachers could easily utilize their previously created materials to start using the platform, which was essential for university level teaching (Banerjee, 2020).

Based on the findings from interaction analysis and teachers' feedback, we propose a workflow for teachers while using reading-based learning contents associated with audio tracks in Figure 10.

Figure 10

Workflow of Teachers to use the LEAF Platform for Remote Online Teaching

Creates / collates reading-based learning materials adds lecture / commentary sound — **Teacher**

Reads and annotates the material
Listens to the associated sound
Attempts in-book quizzes — **Student**

Checks dashboard to review markers and memos noted by students. Prepares for remedial activities to support their learning difficulties. — **Teacher**

- Content without audio tracks associated can be complemented with annotation based activities for higher engagement. Such trends were seen in humanities, science and engineering courses.

- Content with short audio clips (3 to 4 minutes duration)
  - Having activities associated with highlighting and writing memos can be used in synchronous classes as seen in language studies courses.
  - Associating in-content recommendations (external resources) or quiz also had more engagement as seen in humanities course.

- Content with long audio clip (greater than 30 minutes duration)
  - Should be designed keeping in mind students access at their own pace often asynchronous to class time as seen in law courses.

- Teacher can check the reading engagement and attemtps of the in-content task in the analysis dashboard and revise their materials or instructions for students appropiately.

- Teachers can think of delivering open-book assessments using the in-content quizes.

Implications from the Perspective of EDUsummIT Agenda

While the general theme of EDUsummIT2019 was *Learners and learning contexts: New alignments for the digital age*, this work looks closely at the context of a university level education in a developed country like Japan during the period of COVID-19 pandemic. This research fits the intersection of two thematic working groups: TWG1 - *Technology developments: how human computer interactions change with technological innovation* and TWG6 - *Putting learning back into learning analytics: optimizing learning through analyzing the data.* The discussed e-book-based learning platform, BookRoll focuses on integrating the technological innovations in the field of AI in education with interaction data collected from the platform. This work presents a descriptive context of the appropriation of this technology and its perceived usefulness during the pandemic.

E-book technology has the following advantages: it takes less bandwidth to distribute learning materials than video-based learning activities, teachers can directly use their previously created content with the students and provide trackable in-content formative evaluations such as reflective questions or annotation-based activities. Authoring and updating video-based content is relatively more difficult than the text-based resources and using the tools to appropriately generate the content often requires support (Kellogg, 2013). Additionally, to maintain a video streaming service is more server resource intensive.

From the perspective of learning analytics research, the work contributes to TWG6 by putting learning back into learning analytics: optimizing learning through analyzing the data. For instance, extracting a knowledge model is one of the challenges and doing it from video is more complex and often requires manual tagging and building the ontology of concepts. In the case of e-book content, natural language processing based approaches can be applied directly (Flanagan et al., 2019) to create a knowledge model which assists in determining the learners' states of understanding and further supports their learning. The data collected from this study can be further utilized for that modeling purpose.

Limitations and Future Analysis

The current study focused on the 243 semester-long university courses which ran online during the spring semester of 2020. Furthermore, a strict measure for inclusion of logs was done to eliminate any frivolous actions, considering only actions which were sustained more than three seconds. This was based on previous work done on analysis of e-Book data (Akçapınar et al., 2019) where the reading materials shared with students were the only lecture slides. However, the reading materials varied in the current analysis and in some cases the threshold of three seconds might have eliminated actions that were intentional by the student during the learning episode. Given the nature of the interaction logs in the system and the limited instructional design available for different courses, the analysis can provide an overview of the aggregated learners' behavior and its variation across the period. A part of this information, for instance, the total learners having activity on a specific content, their count of annotations, and time spent on each page of the content are also provided to the instructor in the learning analytics dashboard. While it informs them about their course activity on specific content at an aggregate level, if a specific learning episode needs to be analyzed, the filtering criteria of the logs and its processing should be matched with the instructional design context (an example in Majumdar et al., 2020). Hence further analysis and reflection is required to understand the observed variations in the different domains of courses.

Another issue in this aggregate descriptive analysis is the operational context of the courses, such as how many times per week the online classes were organized or the schedule for uploading and updating the content, was not considered. During the pandemic period, the online class setting often changed from synchronous to asynchronous and therefore the analysis only

considered the logs in the allotted class timing as being synchronous interactions. Similarly, the research team did not have the information related to BookRoll activities that the instructors provide in the course, i.e., whether weekly assignments were provided in the LMS or in any other channel as there were less interactions in quiz function of BookRoll. Such information is useful to check the differences in student-content engagement patterns and would be considered for future inferential analysis.

The LEAF platform is under development and its features are continuously improving. The audio playback related issues and image quality of the uploaded figures which were noted by the teachers in their feedback regarding BookRoll is improved in the next version of the tool. Given the data logging capability in LEAF, future studies can compare the re-run of a course in a specific domain to further gain evidence of effective online teaching learning practices in that domain.

Conclusion

This study fills a knowledge gap by 1) analyzing a university-wide usage of an e-book-based learning system across a semester during the pandemic period, 2) focusing on learner-content interactions in the different domains of subjects and indicated temporal trends of learning interactions as recorded by the system, and 3) providing an easy transition to emergency online learning where teachers can use their previous teaching materials and associated audio lectures to conduct their semester coursework. Results can inform instructors from different subject domains and instructional designers about students' engagement statistics across the semester during emergency online learning. Based on the findings in this paper, they can decide to design content and learning tasks with a mix of reading and listening materials considering different engagement in synchronous and asynchronous modes. To design, teach, and support online learning with reading and audio materials, the effectiveness of this large-scale implementation project can encourage policy makers to adopt e-book-based technologies for providing an active learning experience at a comparatively lower bandwidth than that of video-based solutions.

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