

Analytics of Open-Book Exams with Interaction Traces in a Humanities Course

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Abstract: Open book exams (OBE) have been a mandated part of each course structure at some universities. Also during the COVID19 emergency remote teaching situation, OBE would be an option for many instructors over a proctored examination. In this study we investigate a *Critical Analysis of Literature and Cinema* course which had offered open book exam components for more than 11 years in a face-to-face classroom mode. However, this time the OBE was conducted online using BookRoll, a learning analytics enhanced eBook platform. 89 Students accessed *Hayavadana*, an Indian play uploaded on BookRoll during the exam. They attempted a critical reading task to identify performative elements and cultural references in the text by highlighting them with yellow and red markers respectively and writing a reflective memo about the identified items in BookRoll. We analyzed learner's interaction logs gathered in the learning record store linked to BookRoll during the OBE and investigated the relations between their critical reading behaviors to the OBE achievement. Further, selecting two distinct achievement groups we conducted process mining to identify distinct reading behaviors of the high and low performers and give examples of their generated reflective memos. This study aims to initiate further discussion related to the application of learning analytics in humanities courses and probed into the behaviors of the students during the OBE.

Keywords: Learning analytics, open book exam, humanities course, BookRoll, critical reading activity, process mining, Hayavadana

1. Background and Motivation

From the humanities education standpoint, developing critical reading skills is crucial. Critical reading is an active, in-depth reading of a text that calls forth a deeper engagement with the text. Such an activity requires cognitive tasks such as comprehending, analyzing, evaluating, interpreting and synthesizing. Critical reading enables the reader to read not only the explicit meanings but the layered and the implicit meanings as well. One of the essential values of Humanities is identified as critical thinking (Holm et.al., 2015). Especially so in the case of courses that deal with cultural texts including narrative arts. While understanding subjective experiences embedded in the texts is important, deciphering the layered meanings in them is equally significant. In that context, a pertinent way to assess the student is not only to ask them to remember and reflect on the text but provide an open book exam (OBE) where the text is provided during the process of reflection itself. Analysis of students' behavior during OBE to understand their critical reading behaviors given a focused evaluative activity has the potential to thereafter design learning scaffolds. However limited scholarship investigates this process. It would not only require a meaningful reading task but also some technical affordance to trace the learners' behaviors. BookRoll, an ebook reader linked in the learning and evidence analytics framework fitted as an appropriate technology choice. The current study looks at an actual implementation of an OBE in the BookRoll environment and collects interaction traces of students who attempted the task. In such an authentic learning assessment setting, we investigate the following two research questions:

1. What are the relations between the reading behaviors and achievements of the learners in an OBE with critical reading tasks?

2. What are the differences between the high and low performing students during an OBE with a critical reading task to identify cultural references and performative elements based on their interaction patterns and outputs during attempting the task?

The article is organized in the following sections. Section 2 looks at the related works and provides the foundation of the study. Section 3 illustrates the course context of the OBE and the research methods. Section 4 presents the results of the analysis. Section 5 ends with a discussion and conclusion of the study.

2. Related Work and Foundation of the Study

2.1 Open Book Exams (OBE)

OBE, in a broad sense, allows the students to open either or all of their study material, text book, class notes and other reference material. Chan (2009) points out OB exams are less demanding on memory as it is no longer necessary for students to cram a lot of facts, figures and numbers, provides a chance for students to acquire the knowledge during the preparation process itself, enhances information retrieval skills of students and enhances the comprehension and synthesizing skills of students. OBE are often designed to call forth higher cognitive levels and to promote study and teaching methods that would improve understanding (Eilertsen & Valdermo 2000). Earlier researchers compared open-book and closed-book exams (Theophilides & Koutselini 2000; Block, 2012). They found that students preparing for an open-book examination tend to consult various sources and interrelate the information acquired and while taking the exam, they work creatively and probe deeply into the knowledge gained. In one study, OBE was conducted online and the effect of training on the OBE was investigated; the effect of training was found to have positive outcomes where the ones who were trained scored higher (Rakes, 2008). While as a concept OB exams are not new, very few institutions have been using them on a regular basis. The university where the current study was conducted has been one of the very few institutions to implement OBE across disciplines for more than 35 years (Improbable Achievements, 1990). These exams provide a range of flexibilities wherein these exams can be fully or partially open book. The situation that rose due to the Covid 19 pandemic made many universities explore employing OBE. In an online, remote exam scenario OBE is a favorable way of administering assessment as it can minimize use of unfair means while attempting an exam. In one such study during the emergency remote teaching due to COVID-19, researchers investigated the effect of OBE (Ashri & Sahoo, 2021).

2.2 Learning Evidence Analytics Framework (LEAF)

Learning Evidence Analytics Framework (LEAF) is an overarching technology framework to collect evidence of learning and teaching from the logs generated in a technology-enhanced learning environment (Ogata et al. 2018). In this instantiation of the framework, the instructor coordinated the course on the university's Learning Management System (LMS), Moodle. BookRoll, an e-book reader, was linked to LMS via Learning Tools Interoperability (LTI) protocol and used to upload the reading contents like lecture slides, reference articles and reading assignments in PDF format for students to access. Tools like BookRoll can be considered as a learning behavior sensor as it can log student's reading and annotation interactions in a Learning Record Store (LRS) as standard eXperience API (xAPI) statements. Figure 1 presents the technical architecture based on LEAF that is used in our study and the user's reading interface in BookRoll which supports annotation functions such as highlighting with different colors, adding memos and bookmarks in the content. As long as there is an internet connection, students can read their books anytime from a web browser on their personal computer or smartphones. Student's reading activity log from the LRS is then provided to the dashboard database and visualized for both the instructors and students appropriately.

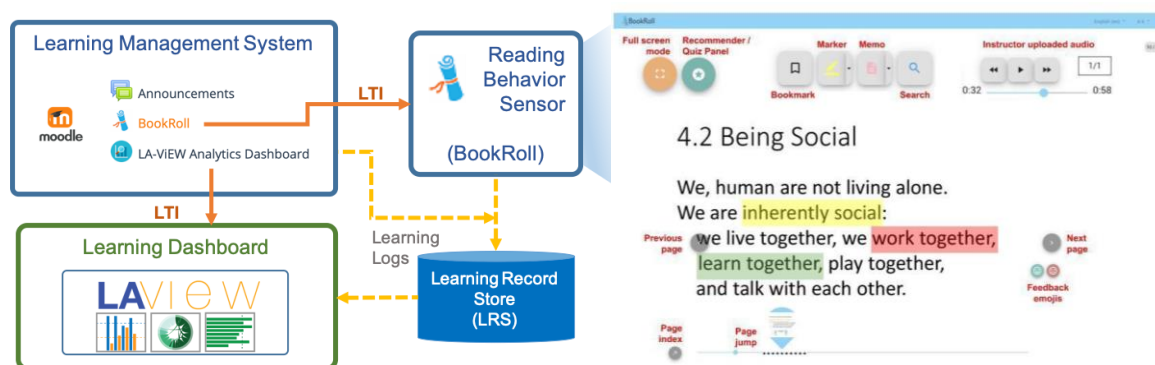


Figure 1. Learning and Evidence Analytics Framework (LEAF) and BookRoll interface.

3. Study Context and Method

3.1 Context and Participants

This particular study furthers the ongoing research on reading analytics of learners in a Humanities education context at the undergraduate level (Majumdar et.al. 2020, 2021). Critical Analysis of Literature and Cinema (CALC) is an elective course offered by the Humanities and Social Sciences Department in a private University in India. The course CALC encompasses the following objectives; inculcate in students a critical insight required to interpret a work of literature and cinema, enable the students to perceive the subtle nuances of such works and to develop critical judgment, and to introduce different forms, terminologies and trends prevalent in such artistic ventures to enable them to place a work of art in the proper context. Reading tasks, film viewing tasks, and critical analysis activities are integral parts of this course. Within this context, it is mandatory to keep a portion of the evaluative components as open book. The class was scheduled for 3 hours each week, split across three sessions. Students met for a total of fifteen weeks. In addition to these classroom interactions, students were given take-home readings and film viewings. The classes had to be conducted in an online mode for the entire semester due to the Pandemic Covid 19 situation. The exams and other assignments were conducted using the LMS. In this particular case one of the evaluative components was carried out using Bookroll.

We followed a purposive sampling and selected the students enrolled in the course (n=89, 77 males, 12 females) as participants. They were pursuing their undergraduate program in engineering and sciences in the university. The class included students in the age group of 19 to 23 years and were enrolled in their second, third or fourth year of study in the university. At the time of the research, they had been introduced to approximately 0 to 3 humanities courses as electives. For the open-book exam the students could access BookRoll from their course Moodle. The details of the exam and instructions are as follows.

An overall phenomenographic research approach (Jan Larsson & Inger Holmström, 2007) guided the research questions to focus on a single activity undertaken by the students enrolled in the course, the OBE in this case. The team of researchers including the course instructor then interpreted the different approaches that emerged from the interaction logs during that episode of the exam.

3.2 Open-Book Exam: Instructions and Example of Critical Reading Task Given

The instructor chose an Indian play titled Hayavadana (Karnad, 1972), originally written in Kannada and then translated into English by the playwright himself. The content was uploaded on BookRoll and the students were given access to the content 3 days before the actual open book evaluative component. The designed task involved students going through the first act of the play to first identify and highlight cultural references (red highlight) and performative elements (yellow highlight) and then to write a memo each on both these elements in the text designated. The activity was designed around these two factors as the play is deeply steeped in the cultural milieu of traditional Indian theatre. Also, Hayavadana being a densely multi-layered text, the instructor had identified these two tasks to be significant in the context of deciphering layered meanings of the text in a critical reading scenario. Instructions for the

one hour OBE were given to the students posted on the LMS followed by announcing them to do it during the online synchronous class (Fig 2a.). An example of the highlighted cultural reference and the performative element is also shown below (Fig 2b.). We have selected 2 of the pages which the students have spent most of the time (see section 4.1)

Figure 2a. Instructions 2b. Examples of Cultural References and Performative Elements in a Page.

3.3 Data Collection and Analysis

The data extracted for this study included the reading logs in BookRoll during the open book exam period. Of the total 89 students enrolled in this course, 84 accessed BookRoll to answer the open book exam. 15071 logs were captured during the activity. For this study, we considered the 14838 action logs of opening, navigating through its pages and annotating its content. The instructor evaluated and scored the answers out of 10 marks, 1 mark each for marking and 4 marks each for the memo. The interactions and score distribution are presented in Table 1.

Table 1. Distribution of the Students' Action and Score during the Open-Book Exam

	Time (min)	Completion (%)	Events (counts)	Red Markers	Yellow Markers	Memo	Bookmark	Score
Mean	59.798	42.45	188.845	29.2	44.9	2.1	0.2	7.43
Std. Dev	22.752	19.28	59.504	14.1	26.6	1.0	0.5	1.52
Minimum	28	21	79	3	3	0	0	0
Maximum	135	95	344	69	118	6	2	9.5

In our earlier work we characterised critical reading behavior of the learners (Majumdar et al. 2021). In the current study with a new batch of students the critical reading based activity was conducted as an OBE and had a time constraint. Hence we aim to investigate more about the process of attempting the highlight and memo based tasks. To answer RQ1 the interaction log was collected and processed to get the interaction counts of each annotation action and its correlations to the outcome score as computed by JASP (JASP Team, 2019). Then DISCO (Fluxicon, 2021) was used to find the prominent interaction process for the cohort while they attempted the OBE. To answer RQ2, and understand the difference between students who were at different performance levels, we separated the group into high and low groups based on the score provided after the instructor evaluated all the highlights and the reflective notes. Based on the performance distribution of the whole class, the students who scored 8 (out of 10) or above were considered as high performers (n=33) and those who scored 7 or below were low performers (n=26). The choice to leave the mid performers (n=25) was to consider a clear distinction of the performance groups.

4. Results and Interpretations

4.1 Correlation between Student's Reading Behaviors and Achievement in OBE

In the given dataset, the correlation between the student reading behaviors in navigating, annotating, editing annotations and the achievement as measured by the OBE score is analyzed and presented in Table 2. Count of number of interactions and the total duration of each of Navigation behavior (actions consisting of NEXT, PREV, PAGE_JUMP and BOOKMARK_JUMP), Annotation behavior (actions consisting of ADD_MARKER, ADD_MEMO and ADD_BOOKMARK) and Editing behavior (actions consisting of CHANGE MEMO, DELETE_MEMO or DLETE_MARKER) is computed. Considering the significance level at $p=0,05$, the achievement score was positively correlated to the duration of editing behavior. The count of the editing behavior was positively related to its duration and also to the count of navigation. The count and the duration of the annotation behavior are negatively correlated, whereas the annotation count is positively correlated to the time spent on navigation. Navigation behavior's count and duration are also negatively correlated.

Table 2. Correlation between Interaction Behaviors and Achievement in OBE ($n=84$ students)

		Count of interactions (_c)			Duration of interactions (_d)		
	OBE Score	Navigation	Annotation	Editing	Navigation	Annotation	Editing
OBE Score	—						
Navigation_c	0.035	—					
Annotation_c	0.061	-0.111	—				
Editing_c	0.211	0.341**	0.105	—			
Navigation_d	0.038	-0.248*	0.265*	0.002	—		
Annotation_d	0.019	0.104	-0.392***	-0.08	-0.073	—	
Editing_d	0.23*	-0.03	0.055	0.248*	0.027	-0.07	—

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

4.2 Interaction Patterns during the Open-Book Examination

To answer the OBE, three subtasks for the students would be i. reading the allotted pages for understanding the text and its nuances, ii. identifying cultural references and performative elements in those pages as markers and iii. writing one memo each on both the marked elements. It typically would involve comprehension, synthesis and reflexive tasks. Through process mining from the interaction logs as shown in Fig 4, the process of the interaction behaviors emerged. The process mining overview has each interaction logged as a state, represented as a node in the graph and the sequence (transition of one action to another) as the edge of the graph. The information in the node also provides the number of individuals that did the specific action. For instance 84 students opened the text. The information in the edge presents the average time between the transition to the next action and how many students had the specific transition pattern. For instance, after opening the text and reading the content for an average of 14.3seconds, 9 students used the slider to navigate to another page. The edge width and the color intensity is proportional to the mean duration.

Considering the states from the diagram for all the students' ($n=84$) interactions during OBE, it shows that while all the participants used NEXT and PREVIOUS action to navigate, few of them used JUMPs either by using slider ($n=30$, 35%) or by using the BookMark that they added ($n=4$, 5%). For annotations all of them did yellow and red markers but only $n=81$, 96% of them added memos. As for modifying annotations, around 60% deleted the yellow ($n=51$) or Red markers ($n=49$) at some point of time. As for memos 70 (83%) students changed them and 23(27%) students deleted.

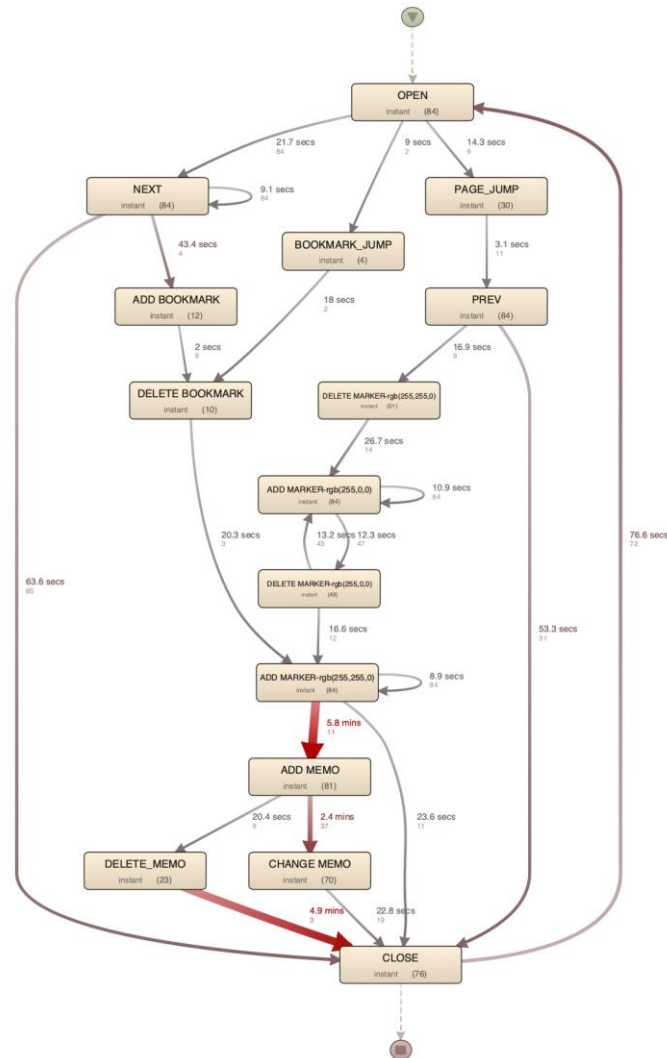


Figure 3. Overall Interaction Sequence during OBE (n=84).

As for the information regarding the average time spent on each interaction, first we checked the actions which were repeated. Consecutive clicking NEXT, adding Markers (both yellow and red) are seen for all the participants. On average consecutive NEXTs were clicked after 9.1 seconds. Adding red markers and yellow markers were after 10.9 and 8.9 seconds respectively. Adding and deleting red markers consequently were seen in more than 50% students with around 12.75 seconds as mean interval. Adding the memo was 5.8 mins for 13% students. 44% of students changed the memo after 2.4 minutes.

4.3 Differences in Interaction Patterns and Outcomes of High and Low Performers.

To answer RQ2, the interaction process of both the high and low groups were mined. The criteria of selecting an activity (interaction state) node in the process was set to 50%, that is at least 50% of the group members had it. The top 30% prominent paths (links) were selected. We present the interaction behaviors of the two performance groups and examples of the reflective memo submitted.

4.3.1 Low Performers Interaction Patterns and Artefact Created

For the low performing group the interaction sequence had three initiating actions related to navigating or adding red or yellow markers (see Fig 5). The adding memo action had an average duration of 3.8 minutes. It was also seen that 55.7% of all the actions happened in pages 9 to 11 of the content.

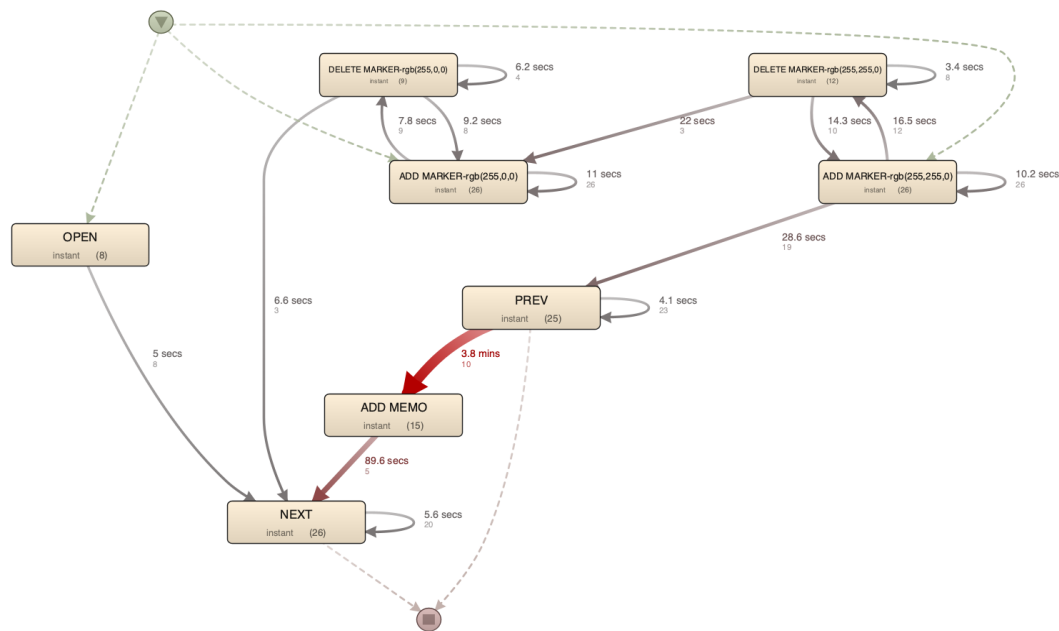


Figure 4. Interaction Pattern of Low Performing Group (n=26).

Low performers mostly highlighted the easily identifiable markers. More importantly, their memos mentioned the obvious points of cultural references and performative elements. Memos lacked synthesis of various references in different pages of the text and how they cumulatively add up overall. One example memo reads like this: (Student_id: 1538, score 5.5/10) “*Cultural: The Cultural reference to Lava Kusha, Rama Laxmana and Krishna Balrama and signifies the strength in the bond between the two friends and shows it as unbreakable. Performative: The first line of the play sets up the stage for the play. Most other performative elements describe the movements, emotions or actions of the actors.*”

In the above example, the student has pointed out the reference to the text of *Ramayana*; but falls short of dealing with other significant references to the nuances discussed in section 5.1. What one can note from the memo is only a limited and largely surface-level understanding of the text. There seems to be a lack of deeper engagement with the text while attempting the task. The total time spent on the critical reading task in the BookRoll environment was 32 minutes before writing the memo and the pattern of interactions also highlights no time spent in modifying or revisiting the memos.

4.3.2 High Performers Interaction Patterns and Artefacts Created.

For the high performing group the prominent initiating states were either navigation or adding a red marker (see Fig 6). 50.6% of activities happened in pages 8-10. Revisiting and editing memos was a significant action for the high performers which was not present for the low performers.

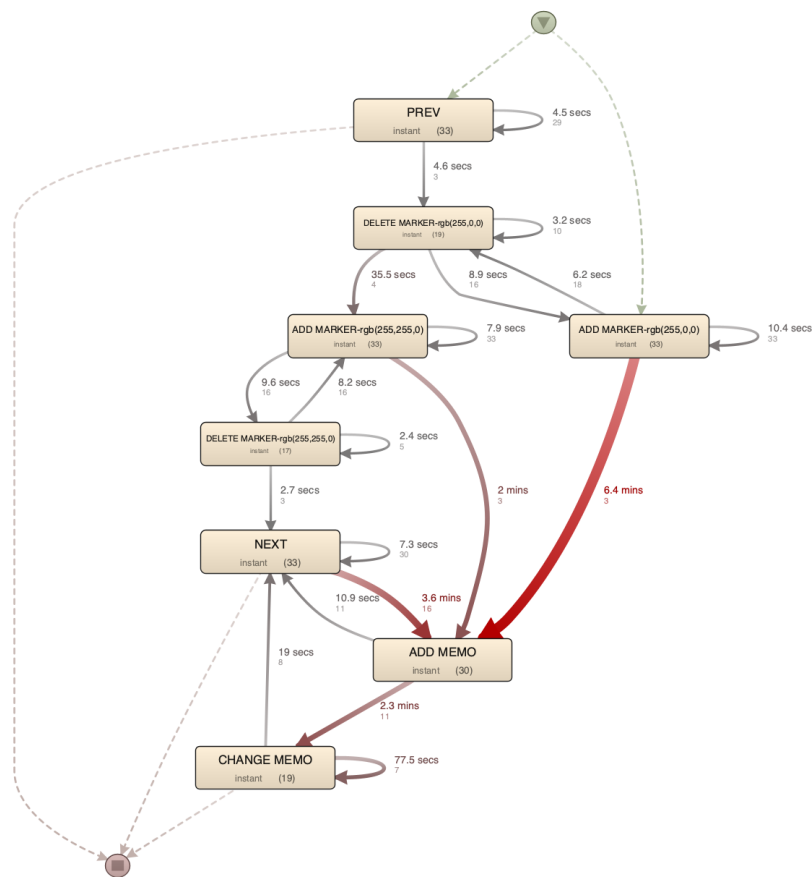


Figure 5. Interaction Pattern of High Performing Group (n=33).

Here is a sample memo by a high performer (student_id: 389, score: 9.5/10) on performative elements: the memo at the very beginning captures the use of masks, music and the significance of these; simultaneously it makes a note of how displaying such vivid imagery keeps the audience's interest. The student is not only capturing the essentials, but is able to move beyond the text and make sense of the intention of the playwright in specific: *"Masks and Music are very instrumental elements of any play, since plays are an inherently different form of literature compared to written works, in the sense that plays involve a lot of dramatization and display vivid imagery to keep the audience entertained and engrossed in them. Here, the music is used by the narrator as an external narrative element to beautifully portray events happening in the story and to provide exposition that keeps the audience always engrossed."* Further, the student is able to reflect upon the use of songs in this specific context as well as other contexts: *"On closer inspection, we can notice that these songs occur intermittently between the play to rejuvenate and renew the audience's interest as well as provide a means of a cultural form of enjoyment through music's universal appeal to humans."* Pausing for a while, the memo highlights the narrative function of the songs: *"Also, this particular song sung by the female chorus is actually foreshadowing what will happen to Padmini, Devadatta, and Kapila later in the story."* Then reflective task is continued as the student adds observations on the point about masks and costumes used in the play: *Along with striking audio imagery provided by music, plays also provide striking visual imagery through the use of masks for actors and eye catching costumes.* Before completing the memo, the student now is able to reflect upon the aesthetic and narrative/ dramatic functions of the use of masks: *"These masks come in myriad designs, each one perfectly describing the nature and behavior of the character wearing it. For example, here we have Devadatta wearing a pale white mask to reflect his soft, gentle nature and build, and we see Kapila wearing a dark black mask which perfectly reflects his strength and might."*

This memo by a high performer is a carefully observed, comprehended, revisited, and synthesized reading of the text; it also exhibits his/her ability to articulate the ideas cogently. The interaction process in this particular case indicates the student revisited, modified and added memos at various points in the timeline. Reflective reading, conceptual clarity and finesse in the articulation are

evinced in the performance of this particular performer who spent 54 minutes in BookRoll and updated the 2 memos 5 times in total before submitting it.

5. Discussions and Conclusions

5.1 Identifying Cultural Reference and Performative Elements during OBE.

Hayavadana, the play is deeply rooted in the Indian cultural milieu, and since a typical student in this study context probably had enough exposure to Indian culture, cultural references are easier to identify. The first few pages have several references and beliefs common to Indian society- irrespective of one's religious affiliation. References to 'Lord Ganesha', 'Vighneshwara, the destroyer of obstacles', 'husband of Riddhi and Siddhi', 'Goddess Kali' etc. are easy to identify as cultural references for the target audience in this case. Also, there are references to various myths and folk tales from India, the 'Princess of Karnataka', 'Gandharva', 'Goddess of Chitrakoot', reference to places of pilgrimage for the Hindus etc. some of which require a knowledge of the rich mythological texts from India. Regarding performative elements, the play Hayavadana draws from contemporary theatrical conventions and also harks back upon Indian theatrical roots, especially from the Yakshagana form of folk theatre which is new for most of the students. Easier choices to highlight in this context are the frequent stage directions in the play. The highlights on Bookroll indeed confirm it; points such as 'The stage is empty except for a chair...', 'The Bhagavata sings verses in praise of Ganesha', 'The actor goes out' etc. are heavily highlighted while the more nuanced references to the theatrical conventions are identified by very few students. Reference to the audience, actors addressing the audience directly at times, and use of other such metatheatrical conventions such as the use of masks, dolls, half curtains etc. are identified and highlighted by a smaller number of students among the high performers.

5.2 Contributions of the Current Finding and Implications for Technology Design

The reading logs of interactions in BookRoll system and the processed data from the learning analytics dashboard were used to investigate two specific research questions about the relationship of reading behavior to OBE achievement and about the differences in the interaction behaviors and artefact created by the high and low achievement groups. We found that the total duration of the editing action was significantly correlated to the score for this specific time. In previous work (Majumdar 2021), four different reader's profiles emerged during an in-course non-evaluative critical reading activity: Effortful, Strategic, Wanderer and Check-outs. From that perspective most of the reading attempts during the OBE would be either Effortful or Strategic. The current study further analysed interaction sequences during an OBE session about which we did not find any prior literature. Such an analysis was afforded by the LEAF technology framework that logged the students' interactions and limited previously. We differentiated high and low group interaction patterns (compare Fig 5 and 6) and artefacts generated during OBE. High performers had significant reflective states such as changing the memos, cycles of deleting and recreating the markers in their overall interaction process. Such behaviors were limited in the case of low performers. It confirms the initial correlation of editing duration and the achievement in the OBE.

5.2 Limitations and Future Work

The current study investigated the relationship of reading behaviors and achievement in OBE from interaction log data and students' artefacts probably for the first time. However there are certain limitations that require further attention. The overall process of attempting the OBE is captured through log data which does not capture the prior conceptual understanding of the students, their motivation or any of their prior dispositions. These might have implications of how the student is engaging in the task and their behaviors. Further studies are required to investigate differences in student's online reading behavior of the same text prior to exam and during exam.

The BookRoll portal not only enabled tracing the student's reading behavior, but also assisted the instructor to easily upload the reading materials and instructions and the student to answer in the

same portal. The instructor could check the students answers provided in the memos directly in the Analysis tool and export the list for the whole class for grading. While this enabled the workflow of conducting the OBE smoother during the COVID19 emergency remote teaching, further technical support can also be developed to automatically evaluate the OBE task given in the current context. Highlighting through markers and writing memo actions of learners can potentially be used to give them feedback. During the data analysis process, the instructor highlighted the portions of the text for reference. Currently we are preparing to present the instructor's highlighted part in the analysis dashboard for the learners to check.

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