Preview Analytics of ePUB3 eBook-based Flipped Classes Using a Big Data Approach

Tina Pingting Tsai[1], Jyhjong Lin[2], Jiali Hou[3], Yihsiu Chen[3], Chingsheng Hsu[2]

[1] Center for General Education, National Taipei University of Education, Taiwan
[2] Department of Information Management, Ming Chuan University, Taiwan
[3] Department of Information Management, National Dong Hwa University, Taiwan
tinatsai85@gmail.com, jlin@mail.mcu.edu.tw, alexhou@gms.ndhu.edu.tw,
mi04crazy@gmail.com, cshsu@mail.mcu.edu.tw

Abstract

Flipped learning has been commonly used to provide students with learning contents inside/outside classrooms. It encourages students to preview learning contents before their classes. Thereafter, learning activities are taken in classes with instructions or help from the teacher. An important issue in the success of flipped learning is the effectiveness of students' preview because it affects the subsequent learning activities in their classes. Fortunately, for ePUB3 eBooks used in flipped classes, the embedded *track* and *test* functions can be used to track the accesses and tests taken on these eBooks. As such, the teacher can capture the effectiveness of students' preview by checking their pre-class accesses and tests, and hence take adequate actions for subsequent class activities. In this paper, we present an analytics approach investigating the effectiveness of students' preview. Their accesses and tests on ePUB3 eBooks are tracked, recorded, and analysed using a big data BOOCs (eBook Open Online Courses) platform. The approach is applied to a 3-class course at a university in Taiwan with 71 first-year students enrolled. As the results illustrate, the approach is useful for supporting teachers to take adequate actions in classes. Students' preview effectiveness is gradually enhanced in later classes.

Keywords: Flipped learning, Preview analytics, ePUB3 eBook, Big data BOOCs platform

1 Introduction

In e-Learning, many Learning Management Systems (LMS) [1-2] have been presented, such as Moodle [3], ScholarLMS [4], and Zuvio [5] for sustaining the controllable process of learning activities. In general, these platforms provide a sound solution to guide the progress of learning activities. They, however, do not address the delivery of learning contents for providing students with suitable ways of reading these contents. For this, we presented earlier in [6] some discussion about the spectacular delivery of learning contents using ePUB3 techniques [7]. Afterwards, we applied these delivery methods in flipped learning [8-12] to present an ePUB3 eBook-based flipped learning approach [13] for academic classes. In these classes, students were encouraged to preview learning contents in ePUB3 eBooks before the classes. Then, student-centric activities were set during these classes with instructions or help from teachers.

However, according to our experience in these flipped classes, an important issue has not been discussed well yet. That is, how adequate learning activities can be provided based on the effectiveness of students' preview to sustain an effective flipped class. In our view, this issue is important and should not be neglected. As it can help teachers to take adequate actions in the class for those students who do not have an effective preview, these students' difficulties in participating in this class can thus be reduced. Consequently, this can enhance their preview effectiveness for later classes to ease their difficulties in participating in these classes.

Therefore, in this paper, we explore this issue by introducing an analytics approach investigating the preview effectiveness in an ePUB3 eBook-based flipped class with the following considerations:

(1) As ePUB3 eBooks are used in this flipped class, students' pre-class accesses and tests on these eBooks are tracked using their embedded *track* and *test* functions.

(2) For capturing the effectiveness of students' preview, the tracked volume of students' accesses (i.e., access actions) and tests (i.e., test results) are captured, recorded, and analysed using a big data analytics platform.

(3) Based on the effectiveness of students' preview, adequate actions can be taken to sustain the effectiveness of this flipped class. Afterwards, such preview effectiveness can enhance the effectiveness of these students' previews for later flipped classes.

*Corresponding Author: Tina Pingting Tsai; E-mail: tinatsai85@gmail.com
DOI: 10.3966/160792642019122007011

Therefore, our discussion focuses on the preview analytics where *track* and *test* functions in ePUB3 eBooks are used to track students' pre-class accesses and tests. A big data BOOCs (eBook Open Online Courses) platform is employed to record and analyse these tracked data to capture the effectiveness of these students' preview. In particular, it is noticed that many *accessible modalities* can be embedded in the *textual pages* of ePUB3 eBooks such as *picture*,*video*,*pullable note*, *referential link*, *guided reading, automatic repetition*, *exercise*, and *discussion*. The *track* function is thus associated with these *textual pages* and *accessible modalities* for tracking all accesses on them.

This paper is organized as follows. Section 2 discusses the possible analysed conditions of students' previews tracked by the *track* and *test* functions in ePUB3 eBooks. The big data BOOCs platform used to record and analyse these tracked data is then illustrated in Section 3. Finally, Section 4 presents the conclusions.

2 The Preview Analytics Approach

As shown in Figure 1, our approach focuses on the effectiveness of students' preview in an ePUB3 eBook-based flipped class [13]. As an extensive part of class work, students' pre-class accesses and tests on their ePUB3 eBooks are tracked and analysed using a big data analytics platform. This supports the teacher to take adequate actions for subsequent class activities.

2.1 Tracking of Preview Accesses and Tests

As stated above, students' pre-class accesses and tests on their previewed eBooks are tracked by the embedded *track* and *test* functions in these eBooks. The tracked access actions and test results are formatted into specific types of messages (e.g., JSON or XML). As an example, Table 1 shows a set of JSON messages derived from the tracked accesses on a page of an eBook. These messages are then subscribed and screened under pre-set criteria by a cleaning mechanism (e.g., ETL: Extract, Transform, Load) to transform them into meaningful artifacts (e.g., credible access actions and test results). For instance, any two consecutive clicks on a page are screened as a credible reading if their interval is between 3-50 seconds. Also, any test results from a test on a page are screened as a credible assessment if they are turned in within 10 minutes after the test page is opened.

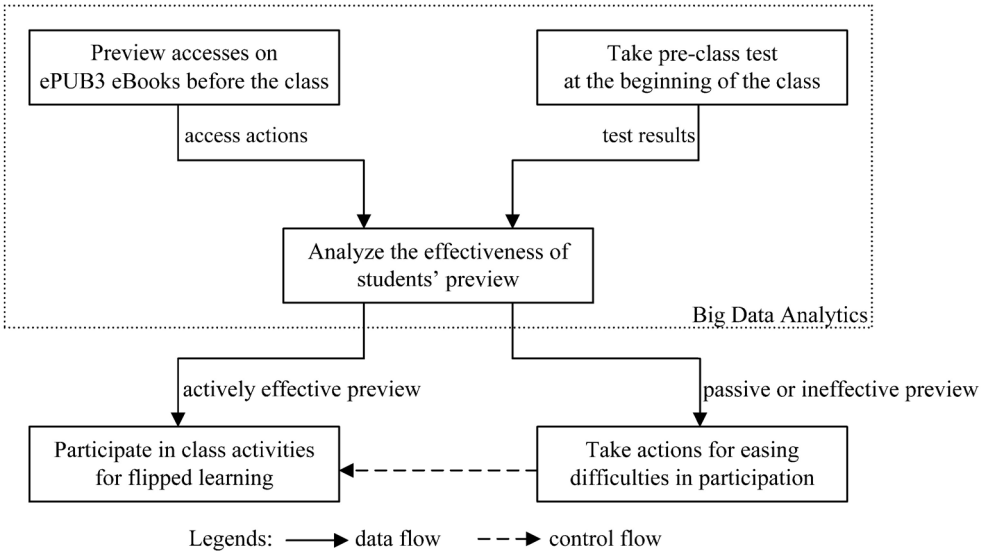


Figure 1. The preview analytics approach for ePUB3 eBook-based flipped classes

For example, after being subscribed in terms of the intervals between any two consecutive clicks, the JSON messages in Table 1 can be transformed into respective intervals: (#open, #1), (#1, -#2), (#2, #3), (#3, #4), (#4, #5), (#5, #6), and (#6, #change). Then, after being screened under the first criterion described above, some of these intervals are retained as meaningful ones: (#1, #2), (#2, #3), (#4, #5), (#5, #6) because their intervals are between 3 – 50 seconds; as an instance, (#1, #2) is a 6091- millisecond time interval between the respective reading times, 1521081188251 and 1521081194342 (milliseconds since 01/01//1970). These meaningful intervals can then be analysed in an accumulated manner for deriving the conditions of students' accesses on this page, e.g., the accumulated time a student spent reading this page.

2.2 The Effectiveness of Students' Preview

To our knowledge [14], a feasible way to measure the effectiveness of students' preview for a class is to identify the conditions of their pre-class accesses on the previewed eBooks and their tests about these eBook contents. This is because pre-class accesses can identify their acquaintance with these eBooks and tests

Table 1. JSON messages derived from the tracked accesses on a page of an eBook

access action for opening page 1	access actions for clicking on page 1

{ #open
"_id": "35c5cf71-b30c-4e6c-a47cd3b0396291ee",
"_rev": "2-ad149d462bda4a25aa6248f5a1d52366",
"className": "Script Writing",
"studentId": "06374036",
"bookNo": "co_20180312170904",
"bookName": "Script Design and Writing",
"flag": "openPage",
"readingTime": 1521081187336,
"openPages":
{
"spineItemPageIndex": 0,
"spineItemPageCount": 1,
"idref": "page0001.xhtml",
"spineItemIndex": 1,
},
}
access action for changing pages from 1 to 2
{ #change
……..
"flag": "changePage",
"readingTime": 1521081134571,
"changePages":
{
"spineItemPageIndex": 0,
"spineItemPageCount": 1,
"idref": "page0001.xhtml",
"spineItemIndex": 1,
},
{
"spineItemPageIndex": 0,
"spineItemPageCount": 1,
"idref": "page0002.xhtml",
"spineItemIndex": 2,
},
}
	{ #1
	……..
	"flag": "clickPage",
	"readingTime": 1521081188251,
	……..
	}
	{ #2
	……..
	"flag": "startMedia",
	"readingTime": 1521081194342,
	……..
	}
	{ #3
	……..
	"flag": "suspendMedia",
	"readingTime": 1521081199663,
	……..
	}
	{ #4
	……..
	"flag": "clickPage",
	"readingTime": 1521081120194,
	……..
	}
	{ #5
	……..
	"flag": "resumeMedia",
	"readingTime": 1521081128369,
	……..
	}
	{ #6
	……..
	"flag": "stopMedia",
	"readingTime": 1521081133480,
	……..
	}

can identify to what degree they possess preparative knowledge about these contents. All of these are important for ensuring they can participate in the subsequent class activities without difficulties. Therefore, in terms of a student's accesses (i.e., access time) and tests (i.e., test score), his/her preview effectiveness may be clustered into one of the following conditions for further learning analytics [15-18]:

(1) The student's preview is actively effective on a specific part in an eBook if he/she has accessed it and learned this part well. In general, this condition exists if (a) he/she has taken active access actions on this part, e.g., viewing textual pages or watching embedded videos over the required time thresholds; and (b) he/she has attained suitable effective test results on this part, e.g., exceeding the designated score, such as whole class's average score on the test. It should be noted that for ensuring the activeness of his/her accesses, the teacher needs to set up required thresholds for any determinants applicable to these accesses. For example, accessing a textual page is said to be active if his/her accumulated access time is within 1 to 5 minutes (*duration*). In addition, accessing an embedded video is active if his/her accumulated access time is at least 3 minutes (*minimum*).

(2) The student's preview is passively effective on a specific part of an eBook if he/she has not yet accessed much but already learned this part well. In general, this condition exists if (a) he/she has taken passive access actions on this part (i.e., not reaching required thresholds of applicable determinants); and (b) he/she has attained suitable test results for this part.

(3) The student's preview is actively ineffective on a specific part in an eBook if he/she has accessed it but not yet learned this part well. In general, this condition exists if (a) he/she has taken active access actions on this part (i.e., reaching required thresholds of applicable determinants); and (b) he/she has not attained suitable test results for this part.

(4) The student's preview is passively ineffective on a specific part in an eBook if he/she has not yet accessed or learned this part well. In general, this condition exists if from (a) he/she has taken passive

access actions on this part (i.e., not reaching required thresholds of applicable determinants); and (b) he/she has not attained suitable test results on this part.

2.3 Actions Based on the Preview Effectiveness

With the possible conditions of students' preview effectiveness set, it is time to explore the causes of these conditions and then attribute these causes to possible weaknesses in these students. As one might conceive, these weaknesses may help the teacher to take adequate actions on subsequent learning activities for alleviating them. For example, a supplemental study and test may be required for those students with a passively ineffective preview to build and verify their preparative knowledge before their engagement in subsequent class activities.

(1) For a student with actively effective preview on a specific part in an eBook, this implies that (a) the student has actively read the contents of this part; and (b) he/she possesses the preparative knowledge of the contents of this part. In this condition, the student can participate in subsequent class activities without difficulties. The teacher may thus place him/her a more student-centric activity for enhancing his/her knowledge innovation/construction abilities such as participating in an *inquiry-/project-/problem-based* constructive discussion. Further, considering his/her active preview, the teacher may issue some praise or reward to encourage his/her continued active previews for later classes.

(2) For a student with passively effective preview on a specific part in an eBook, this implies that (a) the student has not actively read the contents of this part; but (b) he/she possesses the preparative knowledge about the contents of this part. In this condition, the student can participate in subsequent class activities without difficulties. However, since he/she has not actively read the contents of this part, the teacher may consider designating him/her to read some essential points in this part for enhancing his/her acquaintance with the contents. Note that for such a designation, the teacher may consider tracking his/her reading by using the embedded *track* function to supervise the conditions of his/her reading (e.g., whether his/her clicks on reading pages are credible). Further, considering his/her passive preview, the teacher may issue a reminder or punishment to incite his/her increased reading in the previews of later classes.

(3) For a student with actively ineffective preview on a specific part in an eBook, this implies that (a) the student has actively read the contents of this part; but (b) he/she does not possess the preparative knowledge about the contents of this part. In this condition, the student is not expected to participate in subsequent class activities without difficulties, although he/she has actively read the learning contents. Therefore, the teacher may consider designating a supplemental study and test on some essential points in this part for enhancing and verifying his/her preparative knowledge about the contents. Note that for such a designation, the teacher may consider tracking his/her study and test by using the embedded *track* and *test* functions to supervise the conditions of his/her study and test (e.g., whether his/her clicks on study and test pages are credible). Further, considering his/her active preview, the teacher may give some praise or reward to encourage his/her continued active previews in later classes.

(4) For a student with passively ineffective preview on a specific part in an eBook, this implies that (a) the student has not actively read the contents of this part; and (b) he/she does not possess the preparative knowledge about the contents of this part. In this condition, this student would have difficulty to participate in the subsequent class activities and, even worse, he/she is not acquainted with the learning contents. Therefore, the teacher may consider placing him/her in an instructive lecture and test for building and verifying his/her preparative knowledge about the learning contents. Note that for such an instruction, the teacher may consider tracking his/her lecture and test by the *track* and *test* functions to supervise the conditions of his/her lecture and test (e.g., whether his/her clicks on lecture and test pages are credible). Then, considering his/her passive preview, the teacher may issue some warning or punishment to incite his/her increased reading in the previews of later classes.

3 The Big Data BOOCs Platform

In this section, we present the big data BOOCs platform and its practical use in identifying the conditions of students' previews.

3.1 The Big Data BOOCs Architecture

As a flipped class matures to a higher level of effectiveness, the teacher often needs to maintain a very large repository of data representing valuable knowledge about the class. While such knowledge concerns all aspects of the class, the aspect of effectiveness of students' previews is focused on herein because it affects the subsequent learning activities to sustain the effectiveness of this class. In addition, as ePUB3 eBooks are used in the class, the effectiveness of students' preview can be captured by checking their pre-class accesses and tests on these eBooks to identify the conditions of their previews. Therefore, a suitable architecture for tracking, recording, and analysing these students' accesses and tests is needed such that the teacher can identify the effectiveness of students' previews.

To address this need, as shown in Figure 2, a big data BOOCs architecture is employed with the characteristics:

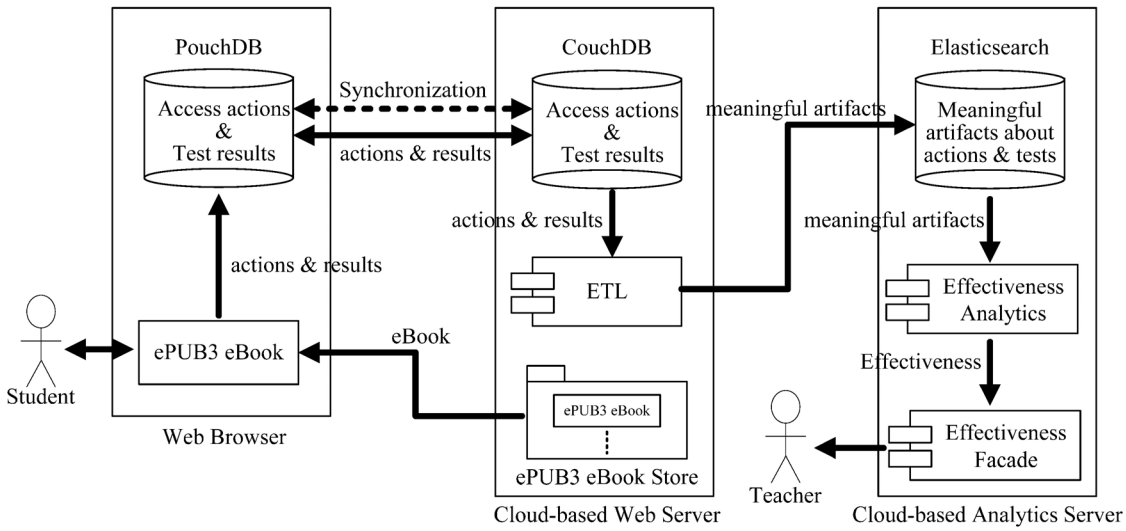


Figure 2. The big data BOOCs architecture

(1) In a flipped class, a number of students will result in a very large number of preview accesses and tests on their ePUB3 eBooks (e.g., the actions taken on the textual pages or embedded videos and the results of answering on the test pages). To deal with this, the architecture employs suitable mechanisms for supporting the necessary big data analytics [19] that include collaborative ETL (Extract, Transform, Load), Data Storage (NoSQL databases), Online Analytics, and Visual Façade.

(2) A distributed environment is used for distributing these mechanisms into respective repositories. Their executive servers are built on IaaS cloud services to attain high performance and scalability [20-21]. More specifically, a pair of PouchDB and CouchDB [22] is used to track and store students' pre-class accesses and tests on their ePUB3 eBooks. In particular, these two NoSQL databases synchronize these tracked accesses and tests between their residual Web Browser and Cloud-based Web Server for maintaining better reliability. ETL is then used to subscribe and screen these accesses and tests under pre-set criteria to transform them into meaningful artifacts (e.g., credible access actions and test results). Then, these artifacts are transmitted into an Elasticsearch engine [23] for supporting the desired effectiveness analytics of students' previews by an analytics component. Finally, the analysed effectiveness information is displayed in a visual manner by a Façade component.

(3) For tracking students' pre-class accesses and tests on their previewed eBooks, the embedded *track* and *test* functions in these eBooks are used, respectively, for sensing the actions taking on the textual pages or embedded modalities and the results of answering on the test pages. These sensed access actions and test results are formatted into respective JSON messages as those shown in Table 1 and then stored synchronously in the pair of PouchDB and CouchDB databases.

3.2 Constructed BOOCs Platform and Its Practical Use

A prototype of the big data BOOCs platform has been constructed for illustrating its usefulness for identifying the conditions of students' preview. In practice, it has also been applied to a 3-class 'Script Writing' course at the Center for General Education of a university in Taiwan. During Spring semester of 2018, 71 first-year students enrolled in this course and attended its three classes (addressing story design, script design, and script writing. Further, two eBooks, as shown in Figure 3 and Figure 4 were used in these three classes. The first eBook was used in the 1st class and the second eBook was used in the 2nd and 3rd classes. Each class was conducted with the following flipped learning activities:

(1) A preview of the eBook before the class. This was engaged in by students within a week prior to the class for building their preparative knowledge about the contents of this eBook.

(2) A pre-class test at the beginning of the class. This was taken within 10 minutes by all students for verifying their preparative knowledge about the learning contents. Based on students' preview accesses and tests, their preview can be identified as effective or ineffective according to the conditions of their access actions and test results.

(3) A group discussion for effective students after the pre- class test. Those students with an effective preview took 45 minutes to construct their knowledge about the subject of the class. Afterwards, they presented the conclusion of their discussion in the 6th activity shown below.

(4) A supplemental study, test, or lecture for ineffective students after the pre-class test. This was carried out in 15 minutes by those students with an ineffective preview to build and verify their preparative knowledge about the learning contents.

Figure 3. Image from the first ePUB3 eBook used in the "Script Writing" course

Figure 4. Image from the second ePUB3 eBook used in the "Script Writing"course

(5) A group discussion for ineffective students after the above supplemental activites. Following the above supplemental activites by those students with an ineffective preview, this took 30 minutes. It should be also noted that since these students took 15 minutes on their supplemental activites, they therefore had only 30 minutes for their discussion. After that, they presented the conclusion of their discussion in the 6th activity shown below.

(6) A group presentation at the end of the class. At the end of the class, all students took 20 minutes to present the conclusion of their discussion described in the 3rd or 5th activity above. This served to verify their learning effectiveness on the subject of the class.

Figures 5 through 7 illustrate the tracked volume of these students' previews on the textual pages of the first eBook for their 1st class.

(1) Figure 5 illustrates the tracked volume of an individual student's preview on these pages and the tracked average volume of the whole class's previewing of these pages. Note that these tracked data are measured as accumulated seconds of previewing each of these pages.

(2) Figure 6 illustrates the tracked results of one student's test over these pages (i.e., about the four subjects on these pages) at the beginning of the class and the tracked average results of the whole class's taking this test. In this case, these tracked data are measured as the number of correct answers.

(3) Figure 7 illustrates the identified condition of each student in the whole class's preview on these pages. In this case, the condition of each student's preview is identified using the cluster analysis technique:

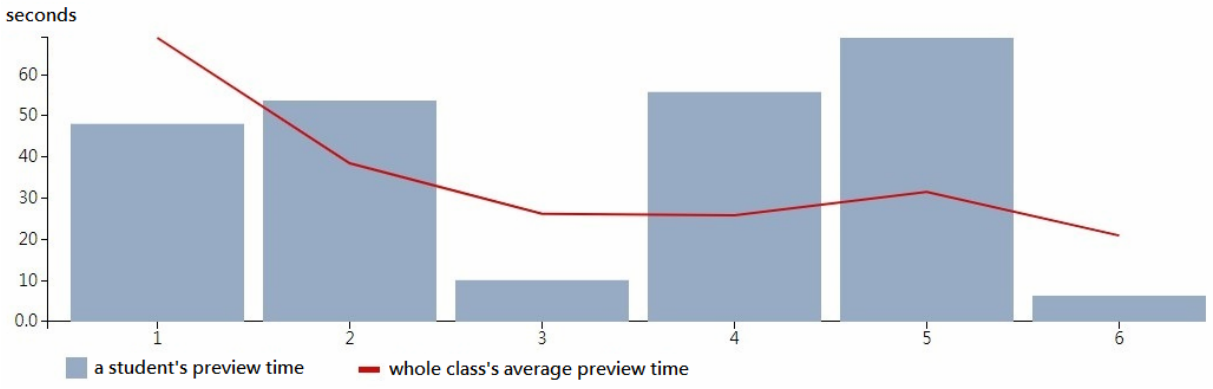


Figure 5. Tracked volume of individual students' and the whole class average preview for the 1st class

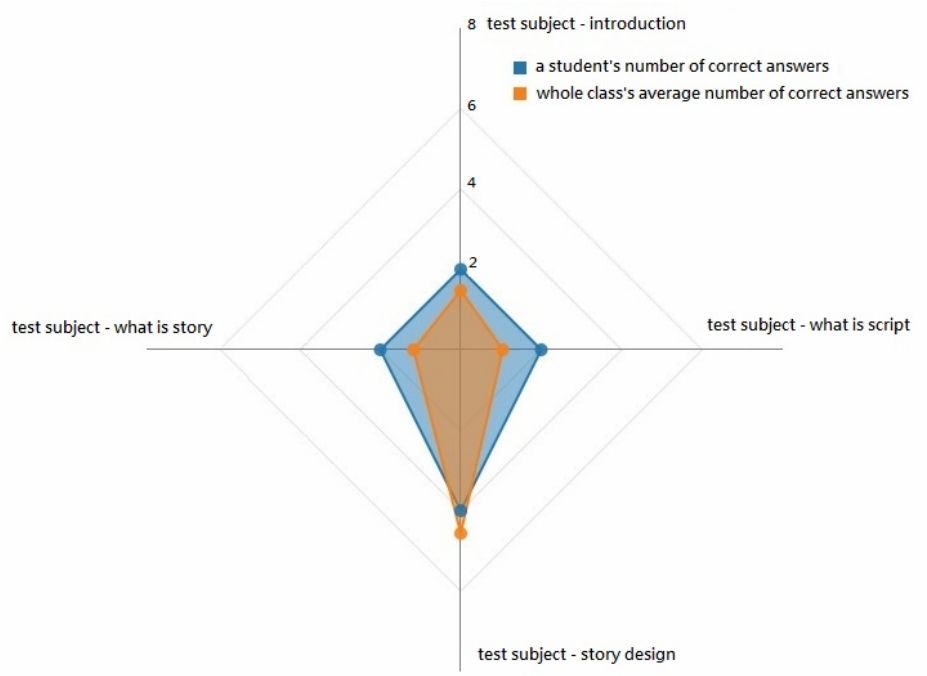


Figure 6. Tracked (average) test results of one student's (the whole class average) in the 1st class

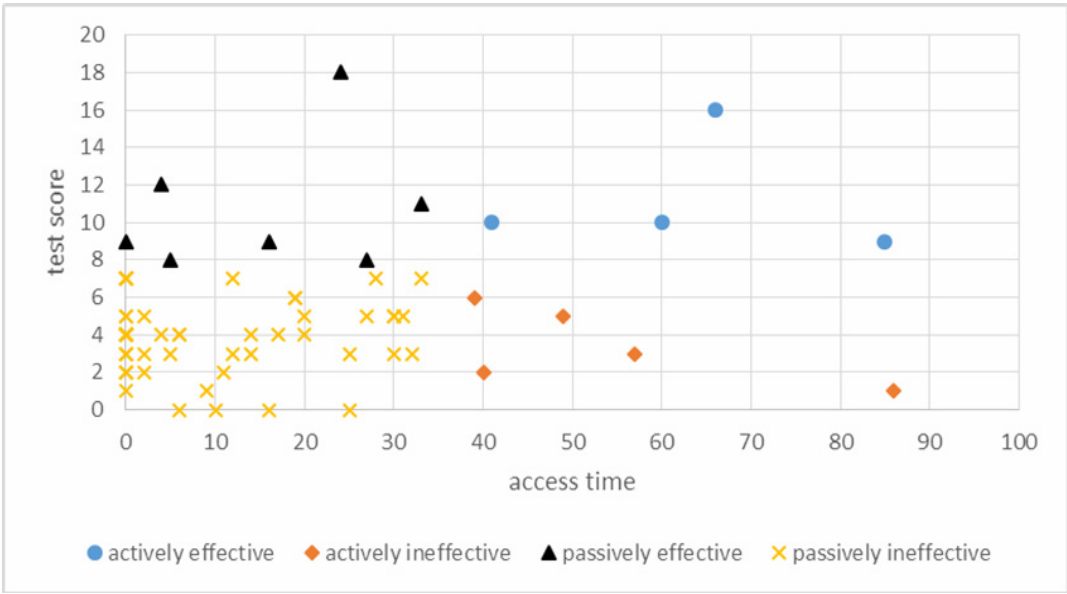


Figure 7. Identified condition(s) of each student's preview for the 1st class

(1) Considering the tracked data for the whole class regarding students' accesses and tests, the *k*-means algorithm [24] is adopted for clustering students' conditions. It is noted that *k*-means is a clustering technique which partitions *n* objects into *k* clusters with the time complexity of $O(nkt)$, where *n* is the total number of objects, *k* is the number of clusters, and *t* is the number of iterations. Here, *k* is set to 2 and the clustering process terminates its iterations once no more changes occur in cluster centers.

(2) The results from clustering students' accesses and tests are respectively shown in Table 2 and Table 3 (see the first row in each for the 1st class illustrated below). As shown in Table 2, 9 students are clustered as active and 62 others are passive for their accesses. Table 3 shows that 11 students are clustered as effective and 60 others are ineffective for their tests. Therfore, considering these two kinds of clusters, the condition of each student can be identified and delineated as one of the four conditions: actively effective, actively ineffective, passively effective, and passively ineffective. It is noted that since we use *k*-means to delineate students into effective or ineffective clusters, some students are allocated into ineffective ones. However, this represents only that these students are 'relatively ineffective' for their tests compared to other students in the effective clusters. It does not necessarily mean these students have poor test results.

Table 2. Clustering by k-means for students' accesses

Class	Passive Cluster		Active Cluster		# of iterations	Distance between centers
	Center	# of cases	Center	# of cases		
1st class	10	62	58	9	4	48.014
2nd class	5	43	18	28	5	12.888
3rd class	3	23	13	48	6	10.412

Table 3. Clustering by k-means for students' tests

Class	Ineffective Cluster		Effective Cluster		# of iterations	Distance between centers
	Center	# of cases	Center	# of cases		
1st class	4	60	11	11	4	7.059
2nd class	3	58	8	13	2	4.573
3rd class	2	60	5	11	2	3.580

3.3 Identified Conditions of Preview Effectiveness

In summary, with the above the tracked volumes of all students' previews on the textual pages of their first eBook, the conditions of their preview effectiveness are identified as follows.

(1) 7% (5) of these students have an actively ineffective preview of these pages. This implies that they actively read these pages but do not possess the preparative knowledge about these pages. In this condition, the teacher places them first in a supplemental study on the subjects of these pages - what is script and what is story – for enhancing their comprehension about these pages. A supplemental test is then set for verifying their preparative knowledge about these pages before they join subsequent class activities.

(2) 77% (55) of these students have a passively ineffective preview of these pages. This implies that they did not actively read these pages and also do not possess the preparative knowledge from these pages. In this condition, the teacher places them first in an instructive lecture for building their preparative knowledge about these pages. A supplemental test is then set for verifying their preparative knowledge about these pages before they join subsequent class activities. Further, considering their passive preview, the teacher gives them a score punishment to incite increased reading in the previews of later classes.

(3) 16% (11) of these students have an actively or passively effective preview on these pages. This implies that they possess the preparative knowledge about these pages. In this condition, the teacher places them directly an *inquiry-based* group discussion for constructing their knowledge about the critical subject of these pages - story design. Further, for those students with a passive preview, the teacher gives them a score punishment to incite increased reading in the previews of later classes.

3.4 Enhancement of Students' Preview Effectiveness

In our analytics approach, the conditions of students' preview are identified for helping the teacher to set adequate actions for these students to alleviate their possible difficulties in joining subsequent class activities. In particular, for those students with active reading in their preview, the teacher gives a score reward to encourage their continued active reading in the previews of later classes. In contrast, for those students with passive reading, the teacher gives a score punishment to incite increased reading in the previews of later classes. Finally, for those students with an ineffective preview, the teacher sets such supplemental activities as a study, test, and lecture for building and

verifying their preparative knowledge about the learning contents. Meanwhile, their actions are tracked for supervising the conditions of their participatin in these activities.

After the 1st class of the 'Script Writing' course, our approach was also applied to the 2nd and 3rd classes of this course. The identified effectiveness conditions of all students' previewing the second eBook for these two classes can be respectively seen in Figure 8 and Figure 9 (see the second and third rows of Table 2 and Table 3 for their sourced clustering results). Figure 10 summarizes the ratios of these four conditions in these three classes.

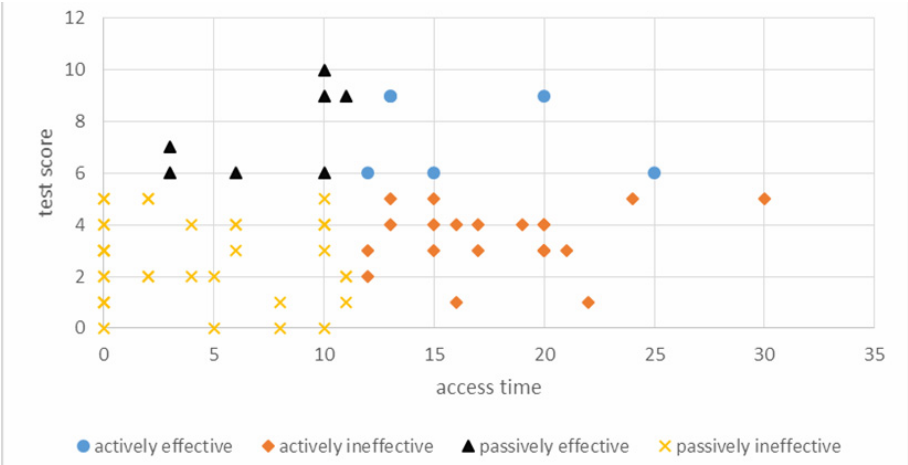


Figure 8. Identified condition(s) of each student's preview for the 2nd class

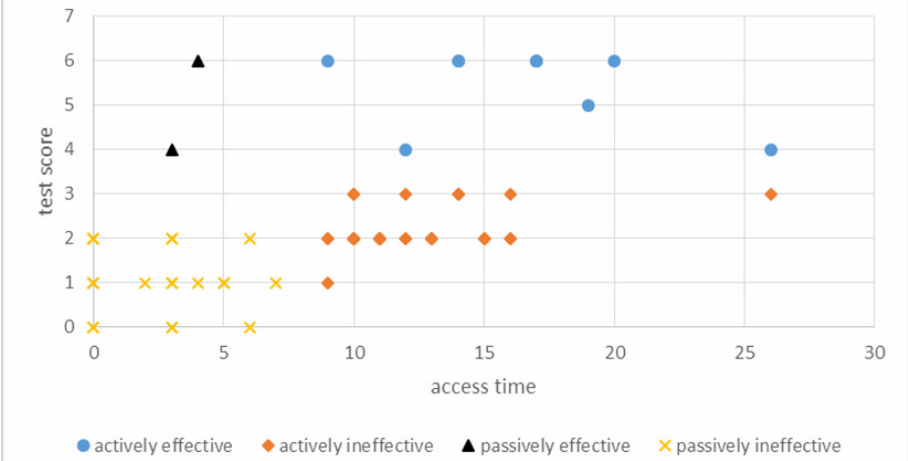


Figure 9. Identified condition(s) of each student's preview for the 3rd class

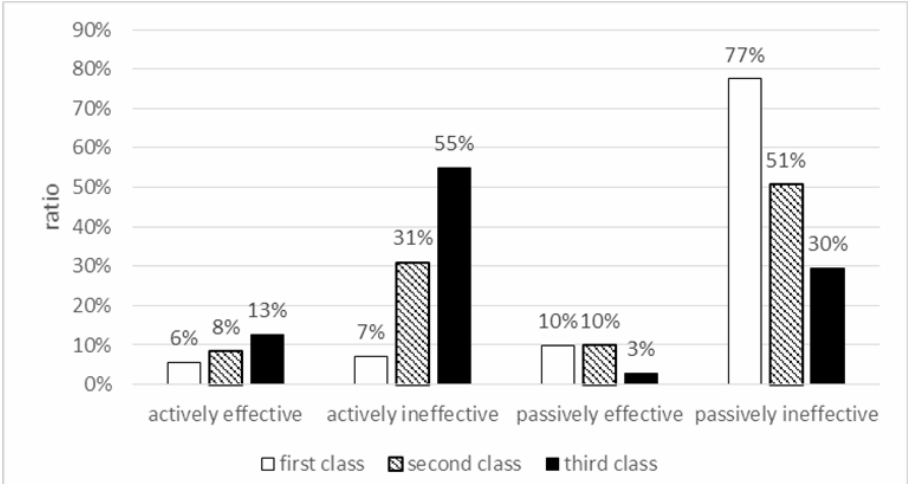


Figure 10. Ratios of students' preview conditions in the three classes

As one may conceive from Figure 10, the conditions of these students' preview effectiveness have been gradually enhanced. For instance, the number (ratio) of students with an actively effective preview consecutively increased throughout the three classes from 4 (6%) to 6 (8%) to 9 (13%). In contrast, the number (ratio) of students with a passively ineffective preview decreased from 55 (77%) to 36 (51%) to 21 (30%). The usefulness of our approach can thus be concluded.

In addition, the variations of all students' conditions across the three classes are further analyzed as follows.

(1) Considering the variations of students' conditions on their accesses as shown in Table 4 and Table 5, a McNemar test [25] is conducted with its results shown in Table 6. It can be found from Table 6 that the ratio of active students in the 2nd class is significantly greater than that in the 1st class since the *Z* value is negative and the one-tail p-value is very small. The same situation also occurs from the 2nd to the 3rd class. Based on this McNemar test, the results imply that students have been motivated to be more active in their reading for the previews of later classes.

Table 4. Contingency table of students' accesses for the 1st and 2nd classes

1st class \ 2nd class	active	passive	sum
active	4	5	9
passive	24	38	62
sum	28	43	71

Table 5. Contingency table of students' accesses for the 2nd and 3rd classes

2nd class \ 3rd class	active	passive	sum
active	20	8	28
passive	28	15	43
sum	48	23	71

Table 6. McNemar test for students' accesses

	1st class vs. 2nd class	2nd class vs. 3rd class
Ratio of active students (former)	0.12676	0.39437
Ratio of active students (afterward)	0.39437	0.67606
Z	–3.52821	–3.33333
Two-tail p-value	0.00042	0.00086
One-tail p-value	0.00021	0.00043

(2) Considering also the variations of students' conditions on their tests as shown in Table 7 and Table 8, the results of another McNemar test are shown in Table 9. It can be found from Table 9 that the ratios of effective students in the 1st and 2nd classes are not significantly different since the two-tail p-value is very large. The same situation also occurs from the 2nd to the 3rd class. Based on this McNemar test, these results imply that effective students have been encouraged to maintain their effective conditions (i.e., sustain their good test scores) throughout the three classes.

Table 7. Contingency table of students' test results for the 1st and 2nd classes

1st class \ 2nd class	effective	ineffective	sum
effective	3	8	11
ineffective	10	50	60
sum	13	58	71

Table 8. Contingency table of students' test results for the 2nd and 3rd classes

2nd class \ 3rd class	effective	ineffective	sum
effective	5	8	13
ineffective	6	52	58
sum	11	60	71

Table 9. McNemar test for students' tests

	1st class vs. 2nd class	2nd class vs. 3rd class
Ratio of ineffective students (former)	0.15493	0.18310
Ratio of ineffective students (afterward)	0.18310	0.15493
Z	-0.47140	0.53452
Two-tail p-value	0.63735	0.59298
One-tail p-value	0.31868	0.29649

4 Conclusion

In this paper, we discuss an important issue about the success of ePUB3 eBook-based flipped classes: the provision of adequate learning activities based on the effectiveness of students' previews. In particular, *track* and *test* functions in ePUB3 eBooks are used to track students' pre-class accesses and tests and the big data BOOCs platform is employed to record and analyze these tracked data to capture the effectiveness of these students' previews. Cconsidering both the accesses and tests, the preview effectiveness of these students can be delineated into four possible conditions: (1) actively effective; (2) actively ineffective; (3) passively effective; and (4) passively ineffective. These conditions can then be explored to capture the possible weaknesses in students. As such, the teacher can take adequate actions on subsequent learning activities to enhance students' learning effects by alleviating these weaknesses (e.g., a supplemental study and test for those students with an actively ineffective preview).

A prototype of the big data BOOCs platform has been constructed and applied to a 3-class 'Script Writing' course at the Center for General Education of a university in Taiwan. Among the 71 students who enrolled in this course and attended its three classes, the tracked volumes and results of their previews and

tests and the identified conditions of their previews have been respectively illustrated for presenting the usefulness of this approach to preview effectiveness. Further, applying this information to the 3 classes allowed the teacher to take adequate actions on these students; their preview effectiveness was gradually enhanced. Thus, the validity and usefulness of our approach can be concluded.

In future work, we will continue to explore the application of our approach on the effectiveness analytics of other learning activities in eBook-based flipped classes such as discussions, exercises, and projects. Further, in addition to the flipped classes, we will also try to apply our approach of effectiveness analytics in other types of eBook-based classes such as face-to-face driver, rotation, and online driver ones. The usefulness of our approach on these effectiveness analytics will then be further discussed.

References

[1] D. E. Stone, J. G. Zheng, Learning Management Systems in a Changing Environment, in: V. X. Wang, *Handbook of Research on Education and Technology in a Changing Society*, IGI Global, 2014, pp. 756-767.

[2] N. H. Lin, J. C. Hung, H. P. Chang, T. K. Shih, A Cross Domain Framework for SCORM Based on Web Service Architecture, *Journal of Internet Technology*, Vol. 9, No. 1, pp. 35-50, January, 2008.

[3] Moodle, https://moodle.org/, October, 2018.

[4] ScholarLMS, https://www.scholarlms. com/, October, 2018.

[5] Zuvio, http://www.zuvio.com.tw/, October, 2018.

[6] L. C. Lin, T. P. Tsai, J. J. Lin, Some Useful ePUB3-based Contents Delivery Functions, *5th International Conference on Information and Education Technology*, Tokyo, Japan, 2017, pp. 49-52.

[7] ePUB3 Overview, http://www.idpf.org/epub/30/spec/, October, 2011.

[8] S. C. Chang, G. J. Hwang, Impacts of an Augmented Reality-based Flipped Learning Guiding Approach on Students' Scientific Project Performance and Perceptions, *Computers & Education*, Vol. 125, pp. 226-239, June, 2018.

[9] G. J. Hwang, M. R. Chen, H. Y. Sung, M. H. Lin, Effects of Integrating a Concept Mapping-based Summarization Strategy into Flipped Learning on Students' Reading Performances and Perceptions in Chinese Courses, *British Journal of Educational Technology*, Vol. 50, No.5, pp. 2703-2719, September, 2018.

[10] J. Lee, H. Choi, Rethinking the Flipped Learning Pre-class: Its Influence on the Success of Flipped Learning and Related Factors, *British Journal of Education Technology*, Vol. 50, No. 2, pp. 934-945, March, 2019.

[11] C. J. Lin, G. J. Hwang, Q. K. Fu, J. F. Chen, A Flipped Contextual Game-based Learning Approach to Enhancing EFL Students' English Business Writing Performance and Reflective Behaviors, *Educational Technology & Society*, Vol. 21, No. 3, pp. 117-131, July, 2018.

[12] Z. Zainuddin, Students' Learning Performance and Perceived Motivation in Gamified Flipped-Class Instruction, *Computers & Education*, Vol. 126, pp. 75-88, November, 2018.

[13] T. P. Tsai, J. J. Lin, L. C. Lin, A Flip Blended Learning Approach for ePUB3 eBook-based Course Design and Implementation, *Eurasia Journal of Mathematics, Science and Technology Education*, Vol. 14, No. 1, pp. 123-144, January, 2018.

[14] T. P. Tsai, L. C. Lin, J. J. Lin, A Study on the Preview Effectiveness of Learning Contents in ePUB3 eBook-based Flip Blended Learning Models, *International Journal of Mobile and Blended Learning*, Vol. 11, No. 2, pp. 50-67, April-June, 2019.

[15] S. Bharara, S. Sabitha, A. Bansal, Application of Learning Analytics using Clustering Data Mining for Students' Disposition Analysis, *Education and Information Technologies*, Vol. 23, No. 2, pp. 957-984, March, 2018.

[16] A. M. Navarro, P. Moreno-Ger, Comparison of Clustering Algorithms for Learning Analytics with Educational Datasets, *International Journal of Interactive Multimedia and Artificial Intelligence*, Vol. 5, No. 2, pp. 9-16, September, 2018.

[17] M. A. Rentroia-Bonito, D. Gonçalves, J. A. Jorge, Clustering Students Based on Motivation to Learn: A Blended Learning Approach, *International Journal of Mobile and Blended Learning*, Vol. 7, No. 3, pp. 18-39, July-September, 2015.

[18] P. Veeramuthu, R. Periyasamy, V. Sugasini, Analysis of Student Result using Clustering Techniques, *International Journal of Computer Science and Information Technologies*, Vol. 5, No. 4, pp. 5092-5094, July-August, 2014.

[19] A. Vera-Baquero, R. Colomo-Palacios, O. Molloy, Business Process Analytics Using a Big Data Approach, *IEEE IT Professional*, Vol. 15, No. 6, pp. 29-35, November-December, 2013.

[20] B. Hayes, Cloud Computing, *Communications of the ACM*, Vol. 51, No. 7, pp. 9-11, July, 2008.

[21] M. Y. Luo, Design and Implementation of an Education Cloud, *Journal of Internet Technology*, Vol. 15, No. 2, pp. 229-240, March, 2014.

[22] CouchDB, http://couchdb.apache.org/, October, 2018.

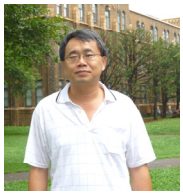
[23] Elasticsearch, https://www.elastic.co/cn/products/elasticsearch, October, 2018.

[24] J. A. Hartigan, M. A. Wong, Algorithm AS 136: A k-Means Clustering Algorithm, *Journal of the Royal Statistical Society*, Series C., Vol. 28, No. 1, pp. 100-108, January, 1979.

[25] M. L. Berenson, D. M. Levine, K. A. Szabat, *Basic Business Statistics: Concepts and Applications (GE)*, 13th ed., Pearson Prentice Hall, 2015.

Biographies

Tina Pingting Tsai is an associate professor of the Center for General Education at National Taipei University of Education in Taiwan. She received her Ph.D. degree in 2010 from the Chinese Literature Department at National Central University, Taiwan. Her research interests include Chinese Education, e-Learning, Chinese Literature, and Marketing Planning.



Jyhjong Lin is a full professor of the Information Management Department at Ming Chuan University in Taiwan. He received his Ph.D. degree in 1995 from the Computer Science Engineering Department at University of Texas at Arlington in USA. His research interests include Software Engineering, System Architecture and Development, and e-Learning.

Jiali Hou is currently an associate professor in the Department of Information Management of National Dong Hwa University, Taiwan. He received the Ph.D. degree from National Central University, Taiwan. Hou's primary research interests include e-Learning, Information Security, Data Mining, IoT, Big Data, Business Intelligence and Enterprise Resource Planning.

Yihsiu Chen is a Ph.D. student of the Information Management Department at National Dong Hwa University, Taiwan. She received her M.S. degree in 2011 from Ming Chuan University, Taiwan. She has more than 8 years working experience in software industry. Her expertise includes Project Management, SA/SD, eBook and e-Learning System.

Chingsheng Hsu got his Ph.D. degree from the Information Management Institute, National Central University, Taiwan, in 2005. Currently, he is an associate professor of the Information Management Department, Ming Chuan University. His research interests include Blockchain Technology, Data Mining and Big Data, Digital Watermarking and Information Hiding, and e-Learning.