Liu, C.-C. et al. (Eds.) (2014). Proceedings of the 22nd International Conference on Computers in Education. Japan: Asia-Pacific Society for Computers in Education

Learning Analytics Data Items on Digital Textbooks

Yasuhisa Tamura[a*]
[a]*Sophia University, Japan*
*ytamura@sophia.ac.jp

Abstract: This paper proposes a set of data items to be collected in Digital Textbooks working on desktop/ laptop/ tablet PCs. Based on conventional LMS-based learning activity analytics, various types of data were proposed to use. In addition, modern tablet PC-based learning has advantage to collect more detailed learner's data with use of equipped sensors and material manipulation logging. This proposal is under discussion in IDPF EDUPUB community, which aims to specify ePub3-based Digital Textbook format and functions.

Keywords: Learning analytics, e-Textbooks, Learners' behavior, Analysis, Sensors, EDUPUB

1. Introduction

This article focuses on combination of two modern issues: Learning Analytics and Digital Textbooks. Some background information of these issues are introduced below.

Learning analytics (LA) has become a major area in learning science and learning technology research. From the end of 1990s, LMS (Learning Management System) based learning environments have emerged. Since then, many types of learning activities logs have been collected in these LMSs and analyzed. These data come from instruction-based activities, e.g. class participations, material views, and answers to quizzes. Also they include active learning-based ones, e.g. enrollments, utterances, interim and final products of group activities.

For LA researches, there are a series of International Conferences on Learning Analytics and Knowledge. These proceedings are available: Long et al. (2011), Dawson et al. (2012), Suthers et al. (2013) and Pistilli et al. (2014). As a general survey, Shum (2012) classifies 5 types of LA activities: (1) analysis dashboard of LMS or VLE, (2) predictive analysis, (3) adaptive learning analytics, (4) social network analysis, and (5) discourse analysis. Especially for active learning and collaborative learning, Shum and Ferguson (2012) shows some LA goal and future issues of these activities. Up to date discussion and information are available on Google Groups on Learning Analytics (2014).

As described below, the author intends to establish a basic and standard collection of data items to use LA activities with use of Digital Textbooks. This collection should include data items that are utilized in previous researches. In order to clarify these data items, the author investigated some of previous published papers and listed up the used data items. The summary is shown in Table 1 and Table 2. Table 1 shows 17 papers to focus on classroom and individual learning. Also, Table 2 shows 13 papers to focus on collaborative and active learning. These data items are referred in the proposal in Section 2.

Digital textbooks, also known as e-textbooks, are now investigated and planned to implement at several countries all over the world. KERIS (2014) in Korea started investigation and experiment in 2008, and lead to finish implementation throughout the country until the end of 2015. Also China, Singapore, Philippines, India and other Asian countries are proceeding investigation and experimental introduction. In Europe, England, France, Germany, Spain and other countries are under investigation and experiment. In United States of America, some states including California, Washington and Utah are planning to deliver open textbooks or complementary devices.

Table 1. Data items and Objectives of Learning Analytics Researches (classroom and individual learning).

Reference	Data Items	Goal of Analysis
Arnold and Pistilli (2012)	Posting of a traffic signal indicator on a student's LMS home page, E-mail messages or reminders, Text messages, Referral to academic advisor or academic resource center, Face to face meetings with the instructor	Relationship between items and achievement
Barber and Sharkey (2012)	Prior credits earned, Discussion post count/week, Late assignments, Orientation participation, Count of messages to instructor, Inactive time since last course	Prediction of class achievement
Clow (2013)	Visit, Registration, and contribution ratio of MOOCs	Drop rate analysis of MOOCs learners
Graf et al. (2011)	Templates, patterns, learning object, database connections of materials	Judgment of material difficulty
Holman et al. (2013)	Grade, Class standing, and badges of quizzes	Self prediction of achievement
Kizilcec et al. (2013)	Visiting, Enrollment, and assessment numbers in MOOCs courses	Number transition of MOOCs learners
Lonn et al. (2012)	Grade information every few weeks	Assistance necessity from mentors
Martin et al. (2013)	Answers of each sub-quiz	Visualization of learning process
Monroy et al. (2013)	Teacher's usage of teaching unit parts (overview, essentials, engage, explore, explain, evaluate, intervention, acceleration)	Heat map of unit parts usage
Niemann et al. (2012)	Learning object usage in a web portal	Similarity of learning objects
Pardos et al. (2013)	Quizzes and scaffolding help	Relationship between Scaffolding help and achievement
Raca and Dillenbourg (2013)	Video captured actions of learners	Learner behavior during classrooms
Santos et al. (2012)	Date and time range of learners	Visualization of learning status
Sao Pedro et al. (2012)	Quiz answers	Transition of problem solving skills
Tempelaar et al. (2013)	Achievements in various learning areas	Skill analysis (Self-belief, learning focus, planning, management, persistence)
Verbert and Duval (2011)	Dataset and functions of recommender system	Comparison of Recommender systems
Wolff and Zdrahal (2013)	Precision and recall of learning units	Comparison of TMA (Tutor-marked assessment) and VLE (Virtual learning environment)

Table 2. Data items and Objectives of Learning Analytics Researches (Collaborative and active learning).

Reference	Data Items	Goal of Analysis
Ahn (2013)	Emails received, Emails sent, Friends, Friend Lists, Links, Member pages, Networks, Notes, Photos, Status messages, Videos, Wall posts	Factor analysis of media literacy (Negotiation, Networking, Judgment, Play, Multitasking, Appropriation, Transmedia navigation)
Cambridge and Perez-Lopez (2012)	Discussion post, blog, their narratives,	Analysis of discourse style to activate learner groups
Camilleri et al. (2013)	Pleases and numbers of utterances in virtual space	Behavior analysis
Cobo et al. (2012)	Reading and writing activities during online discussions	Clustering of learners
Ferguson and Shum (2011)	Keywords in text chat	Chat type (evaluation, explanation, reasoning, justification, perspective)
Koulocheri and Xenos (2013)	Bookmarks, blog posts, topics and files uploaded, bookmarks, comments on bookmarks/blog posts/topics/files in group	Visualization of member relationships
De Liddo et al. (2011)	Response type of utterances (respond, about, example, solution, support)	Relationship analysis of learners
Schneider et al. (2013)	Eye-tracking data	Estimation of collaborative learning skills
Schreurs et al. (2013)	Person, type of tie, topic	Visualization of learner relationship network
Shum and Crick (2012)	Quiz achievement and various activities	Relationship between individual learning achievement and meta-skills
Siadaty et al. (2012)	Vocabulary in shared Wiki and bookmark	Collaborative skills analysis of corporate learners
Suthers and Rosen (2011)	Chat, Discussion, File sharing	Multiple level visualization (Process, Domain, Event, Action, Mediation, Relationship, Tie)
Tempelaar et al. (2013)	Achievements in various learning areas	Analysis of necessary skills (Self-belief, learning focus, planning, management, persistence)

In Japan, MEXT (Ministry of Education, Culture, Sports, Science and Technology) (2011) published a roadmap called "The Vision for ICT in Education", which were planning to introduce digital textbooks countrywide until 2020. Also, an experimental project was deployed from 2011 to 2013. It was a joint project between MEXT and MIC (Ministry of Internal Affairs and Communication) to introduce ICT and digital learning materials to selected 20 schools. Final report of this project (in Japanese) is available through MEXT (2014). At the same time, MEXT and MIC started experimental development projects of Digital Textbooks in 2013. In these projects, MEXT is focusing ePub3, while MIC is HTML5. These projects will continue in 2014.

On the other hand, various standardization organizations and communities are trying to specify standard file formats and specifications for Digital Textbooks. These projects and their timelines are shown in Figure 1. IEEE (2014) initiated Actionable Data Book Project in 2011, and published some research papers. Also, CEN (European Committee for Standardization) (2014) and IMS Global Learning Consortium (2014) began eTernity Project and ICE Project in 2012 and 2013, respectively.

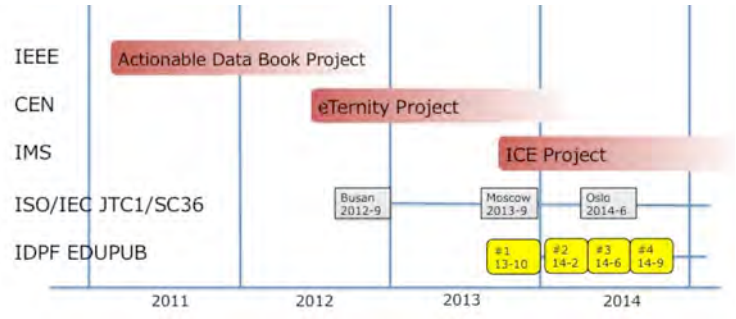

Figure 1. Standardization projects for Digital Textbooks

Among them, ISO/IEC JTC1/SC36 (2014), a subcommittee of ISO dedicated to e-learning technical specifications, started e-Textbook Project in September 2012 meeting at Busan, Korea. It is investigating related standardization activities, issued a set of questionnaires of Digital Textbooks to standardization communities, and arranged future issues in a document in 2014 meeting.

The latest and the most active one is called EDUPUB project. It is lead by IDPF (International Digital Publishing Forum) (2014), which specified ePub3 format for Digital Books. The first workshop of EDUPUB was held in October 2013 at Boston, USA, while the second in February 2014 at Salt Lake City, USA. The third workshop was held in June 2014 at Oslo, Norway, and the fourth is scheduled in September 2014 at Tokyo, Japan. Through these workshops, these outlines below are discussed.

- Core file format is ePub3.
- In order to add textbooks specific structural semantics, Pearson and Benesse staffs proposed their textbook and material descriptive tags. It is under online discussion.
- In order to attach learner note into the textbooks, "Open Annotation in ePub" specification is under discussion.
- For quiz data format, IMS QTI (2014) (Question and Test Interoperability) specification is a major candidate.
- For calling scheme of outer applications or resources, IMS LTI (2014) (Learning Tools Interoperability) specification is a major candidate.
- Textbook specific metadata items are under discussion.

The author is a member of MEXT Digital Textbook project, ISO/IEC JTC1/SC36 e-Textbook project, and IDPF EDUPUB Project. In the EDUPUB project, there was a proposal to specify a set of data items to be collected with use of LA. For this proposal, the author started to survey conventional research papers in order to specify commonly used data items, and also proposed a new set of items which are able to collect with use of tablet PCs. Section 2 shows this proposal.

2. Data Items Acquired with use of Digital Textbooks

2.1 Characteristics of Tablet PCs

There are many types of PCs utilized in classroom and individual learning. Both desktop PCs and laptop PCs have been common. In addition, tablet PCs have become popular in these years. Apple launched a first iPad in 2010. Also, Google and China/Korean hardware companies began to launch Android based tablet PCs in 2010. Nowadays, worldwide shipments of desktop / laptop PCs and tablet PCs are almost equal in 2014. In 2015, shipments of tablet PCs will be 20% more than desktop / laptop (Gartner 2014).

Even traditional laptop PCs are able to connect to computer network, download information from a certain server, upload it to a server, or communicate each other with use of e-mail and SNS. Also they have some sensors: brightness sensor, camera, and microphone. With use of these functions, they are able to generate data to be used in LA:

- Enroll to a class in LMS
- Access materials in LMS
- Upload quiz answer / assignment / reaction
- Show hint / advise
- Send, receive and read messages from / to instructors
- Enroll to a group in LMS
- Send / receive text / audio / video messages from / to instructors / another learner
- Access to shared whiteboard / file
- Timestamp of these activities

In conventional way, all of these information are collected in LMS. With use of additional functions attached with learners' Web browsers, some information can be collected in client (=learner) PCs, but this approach is not common.

However, modern tablet PCs equip many other types of sensors: screen touch sensor, GPS, digital compass, gyroscope, acceleration sensor, etc. With use of these sensors, a tablet PC is able to collect various information about learning activities and their environment. For example:

- View / flip one's textbook, reference or dictionary
- Insert highlights or underlines in one's textbook, reference or dictionary
- Write notes or annotations on one's textbook, reference or dictionary
- Refer reference or dictionary by specifying a certain part of textbook
- In addition to timestamps, places of these activities
- Environmental voice and noise of these activities
- Learner's face, expression, and visual environment of these activities

Some of these data are collected with use of equipped sensors directly, others should be analyzed by Digital Textbook viewer software or related application software. Also, the data collection implies privacy violation. This issue will be discussed in the later section.

2.2 Proposed Data Items

Based on investigation and consideration stated above, the author proposes data items below to be collected with use of Digital Textbooks. Figure 1 shows a framework. One atomic data includes "who" (Subject), "when" (Date & Time), "where" (Geographic point location, optional), and "what". A detail of lower right side table of Figure 2 is shown in Table 3.

Data items in Table 3 consist of two categories: (1) commonly used in conventional LA researches, shown in Table 1 and Table 2, and (2) assumed to be collected on Tablet PCs, Digital Textbook viewer and related software mentioned in Section 2.1.

This proposal is now disclosed to EDUPUB community, and weekly discussion is ongoing.

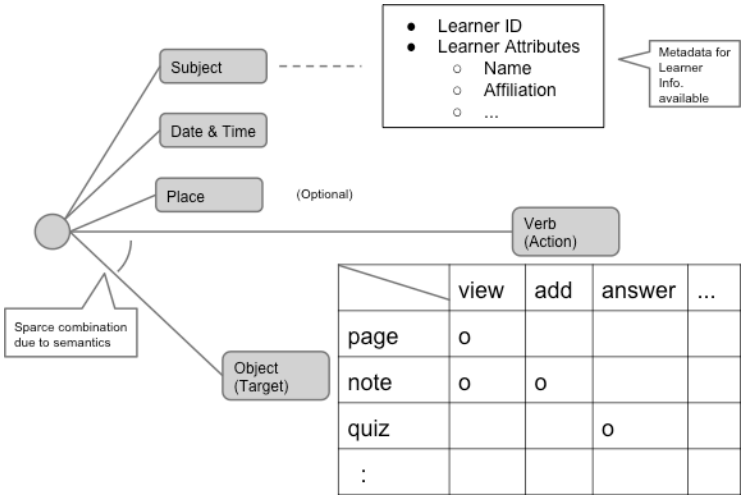

Figure 2. Framework of proposed data items.

Table 3. Detail of Proposed Data Items: Verbs and Objects.

Category	Verb (action)/ Object (target)	attend/quit	flip/view	add	modify	delete	answer	send	receive
Classroom / individual Learning	Class	o							
	Page of e-textbook or reference		o						
	Highlight / underline			o	o	o			
	Note (annotation)		o	o	o	o			
	Link		o	o	o	o			
	Quiz		o				o		
	Assignment		o				o	~~o~~	~~o~~
	Feedback		o				o		
	Message							o	o
Collaborative and active learning	Group	o							
	Shared whiteboard		o	o	o	o			
	Shared file		o	o	o			o	o

3. Discussion and Conclusion

During development process of the draft proposal above, there were some discussions whether tablet PC based fine-grained data should be included, for example:

- Face expression of a learner,
- Attitude of a learner,
- Voice of a learner and environmental sound,
- Acceleration data,
- Digital compass data, and
- Gyroscope data.

Also, it is emerging to utilize so called “wearable devices” to collect biological and environmental data, for example:

- Temperature of learner’s body and environment,
- Humidity of environment,
- Body sweat of a learner,
- Heart race of a learner,
- Blood pressure of a learner,
- Eye-tracking data of a learner, and
- Brain waves of a learner.

Currently, it is not clear that these data are useful to identify learner’s status or not, at least from preceding research results. Therefore, the author thinks that the data listed above are still early to include as “standard” data items for learning analytics. It’s why the listed data is omitted from Table 3. However, as far as the author knows, the proposal appeared in Figure 2 and Table 3 is the first appearance for “standard” data items for learning analytics activities. This “standard” means that major stakeholders support to adapt them as useful ones. There are many goals in LA, shown as samples in Table 1 and Table 2. This proposed data items cover these, and similar LA goals.

A major discussion point for the proposed data items is a risk of privacy violation of learners. This proposal includes geographical data and timestamp. So, an analyst or an instructor is able to grasp when and where a learner is. Also, a tablet PC is able to collect visual and audio data during learning activities. It might clarify a scene and accompanying friends during learning. Currently it is not clear what data violates learner’s privacy and doesn’t. We should clarify a threshold of private data, and make broad consensus. From this viewpoint, Table 3 does not include visual and audio data not intentionally recorded by learners.

One of the future issues is comprehensiveness of the proposal. Currently there is no major argument for the proposal. However, there are many other existing researches of LA. They should be investigated in order to guarantee comprehensive of this proposal. Also, IMS proposes Caliper specification. It also specifies a data set for LA. The document is not opened, but needs investigation.

The other one is to verify usefulness of these data items for LA activities. The proposed data items are listed from viewpoint of technical feasibility with use of tablet PCs and Digital Textbook software. However, it is not clear what characteristics can be analyzed with use of these items. Some them are already clear based on the conventional researches in Table 1 and Table 2. However, especially Digital Textbook specific items should be verified in this usefulness.

To conclude, the author proposes a set of data items to be collected with use of tablet PCs and Digital Textbook viewer software, shown in Figure 1 and Table 3. They are far more detailed than conventional LMS based data collection. However, it should be enhanced and brushed up in order to guarantee comprehensiveness and learner’s privacy.

Acknowledgements

This work was supported by JSPS KAKENHI Grant Number 26282059. The author would like to appreciate Markus Gylling and all EDUPUB project members for dedicated discussion and continuous encouragement for this work.

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