# タブレット端末用電子書籍リーダーを活用した学習効果改善への学習分析的アプローチ

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〈論　文〉

# A Learning Analytics Approach to Improving Learning Outcomes Using Tablets as e-book Readers

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# タブレット端末用電子書籍リーダーを活用した学習効果改善への学習分析的アプローチ

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***Abstract***

Over the last several years, tablet computers have become very common in the classroom. In particular, the Apple iPad series of tablets has become a popular choice from early to higher education. One growing use is their application as electronic book (e-book) readers. The effectiveness of such utilization however is difficult to measure. Taking a Learning Analytics approach, this research aims to develop a way to log student data when using the iPad as an educational tool, with the aim of analyzing and assessing student progress as well as utilizing the data to improve the electronic educational material (especially e-books). Being able to visualize student usage and frequency will allow better educational material design, in addition to indicating the degree of participation on the part of the students, while allowing data-driven decision making on the part of the educator.

要旨

ここ数年，タブレット型コンピューターは授業において一般的になってきた。とりわけApple社のタブレット端末iPadシリーズは，高等教育機関において早期から第一の選択肢となってきた。その使用が増大した理由の一つが，電子書籍（e-book）の閲覧のためのソフトウェア（電子書籍リーダー）の存在である。しかしながら，それを用いることの効果を測定するのは難しい。本研究ででは，学習分析の観点を取り入れ，iPadを教育ツールとして使用する際に，学生の進捗を分析，評価するのと同時に，電子的教材（とりわけ、e-book）を改善するためのデータとともに学生の学習記録を行う方法を開発すること目的とする。学生の使用方法，使用頻度を可視化することができれば，より良い教材設計につながるのに加えて，学生の側からは，授業への参加の度合いを示すことができ，もう一方の教育者側では，データに基づいた意志決定を行えるようになると考える。

***Key Words:***
Learning Analytics, tablets, e-book readers

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## 1 Introduction

Mobile tablet computers have been on the market for many years, but after the arrival of the iPad in April 2010, many schools and colleges began trialling iPads in the classroom. While PDFs were in common use, there were few e-books available, leading to many schools employing iPads as course management devices, presentation tools or media viewers. However, as tablets both decreased in price and increased in popularity, they became more ubiquitous in the classroom, leading to an increased use as e-book readers.

Since its initial use in education, the iPad has been the subject of both acclaim and criticism. It has variously been praised as a motivator, a cheap alternative and compact solution to printed matter, and a way to promote autonomous learning through inquiry. Conversely, it has been derided as a fad, a distraction, and inappropriate for note taking (Mueller & Oppenheimer, 2014). While some of the areas of concern will likely be, or are being, addressed, such as higher resolution screens yielding improved readability, or note-taking software becoming easier to use, there still remains a critical obstacle to effectively using iPads in education: There is no facility for Learning Analytics.

Learning Analytics is defined as "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Long & Siemens, 2011, p. 34). It is important for the teacher because, not only does it allow an ongoing evaluation of the course material and monitoring of the student, it also allows teacher to suggest and provide new learning opportunities or different courses of action to the students (Campbell, DeBlois, & Oblinger, 2007). Established e-learning programs and/or LMSs readily provide such data for the teacher, allowing the teacher to tailor or modify the learning experience to suit the students. By monitoring student performance and participation in a course, as well as examining how this relates to grades, faculty can potentially target areas of the course (and course material) to improve.

In this research, the authors developed and implemented a way to log and collect data concerning individual student use of educational iPad applications and e-books. By utilizing Learning Analytics, learning material, or the course itself, is able to be revised to better allow learning objectives to be met, in addition to improving monitoring of student progress and initiating timely educational intervention when appropriate.

## 2 Books, PCs or Tablets

Ferguson (2012) notes that the appearance of Learning Analytics in education closely follows the increase of universities instituting online learning. Learning online, especially using a portable device such as a tablet, offers numerous advantages summed up in the term *ubiquitous learning*; the learner can study anywhere, at any time, and without a teacher.

This is summarized in *Diagram 1* below, where the educational classroom utility of textbooks, PC notebooks and tablets (as e-book readers) is compared, according to six different criteria; motivation, ability to engage, cost, interactivity, portability and analyzability. The table is a synthesis from a number of studies, specifically research by Li and Pow (2011), Morrone, Gosney and Engel (2012), Goodwin (2012), Weisberg (2011) and Enriquez (2010). As can be seen, newer technologies tend to outweigh more traditional teaching tools, with the tablet being the preferable option.

*Diagram 1: Lesson Delivery Comparison*

| | Text | PC | Tablet |
|---|---|---|---|
| Motivation | × | ○ | ○ |
| Ability to Engage | × | ○ | ◎ |
| Cost | △ | △ | ○ |
| Interactivity | × | ○ | ○ |
| Portability | △ | △ | ○ |
| Analytics | × | ○ | × |

Li and Pow (2011, p.325) noted that students felt the "impact of technology on enhancing their learning motivation, developing their cognitive skills and planning for their learning in their daily learning activities was significantly higher in the Tablet-PC classes". This was reiterated by Morrone, Gosney and Engel (2012, p.1) who added that "iPads were found to increase student engagement by providing innovative and creating learning environments", and by Geist (2011, p.8) noting that students "did not want to sit at a desk" and study when they could enjoy more mobile alternatives, adding that "it was cheaper . . . [to] buy so many [digital] books" (p.8).

The apparent advantages of using a tablet are also statistically supported by various studies. One of the first universities to pioneer the use of iPads in university classes, Lynn University in Florida, USA, noted in a student survey that 94 percent of students (fall semester, 2014) said they felt the tablet contributed to their learning experience (Straumsheim, 2014). Of these, 9 out of 10 mentioned that they used the tablet in courses that didn't require it. Furthermore, possibly due to recognizing the advantages of new technologies, 61 percent said the prospect of receiving their own

iPad (mini) significantly influenced their decision to attend Lynn. Director of Faculty Development and Active Learning, Mike Petroski (Straumsheim, 2014), further added that he had noticed the largest performance jump to date among students in the first trialled course, personal finance. Chief Information Officer Chris Boniforti further supported this finding, pointing out that students using iPads outperformed those who didn't, and just over three-quarters of students preferred the e-book used in the course over a traditional textbook, that number rising from approximately 65 percent at the beginning of the course.

As of 2015, Lynn University has gone one step further, phasing out its Blackboard Learn learning management system, managing all daytime undergraduate courses through Apple's course management software, iTunes U.

## 3 *Potential Disadvantages*

While using tablets in class seems to offer many benefits, such usage has also been associated with a number of problems by several researchers, especially when applied to online learning. Mazza and Dimitrova (2004) note that students may feel isolated due to a lack of, or diminished, contact with teachers or peers. They may also lose focus, experience technical problems or lose their motivation.

An early study carried out by Reed University and fifteen other North American universities (Marmarelli & Ringle, 2010) found that students preferred using books to e-book readers, given the price and lack of simultaneous multi-book access.

Furthermore, depending on how the tablet is used, the teacher can also feel removed from the learning. Online education, for example, doesn't provide teachers with the visual, oral or aural cues that may indicate when students are bored, confused, overwhelmed, unengaged or even absent. Dringus and Ellis (2005) note that lack of a conventional teaching space and/or evaluation system may also lead teachers to struggle in decoding and evaluating what learning has taken place, or in assessing the degree of individual participation exhibited by students over the course.

## 4 *Using Learning Analytics*

It could be argued that Learning Analytics resulted from the recognition of a need to address some of these difficulties. It is no coincidence that the appearance of Learning Analytics in education followed the rise of online learning. Ferguson (2012, p.305) notes while "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" is an appropriate definition, it should be realized that there are two assumptions included: that Learning Analytics make use of preexisting, machine-readable data, and that its techniques can be used to handle 'big data', large sets of data that would not be practicable to deal with manually.

In a higher education setting, practical applications of Learning Analytics are multifarious. Macfadyen and Dawson (2010. pp. 588-99) note that at-risk learners can more easily be identified, and appropriate intervention to help learning outcomes can be implemented in a timely manner. Analysis may range from messages posted, to assignments completed, to LMS messages read.

Long and Siemens (2011, p.36) further add that Learning Analytics can provide learners with insights into their own learning practices, and in doing so, can suggest recommendations for improvement, as demonstrated in a system used by the University of Maryland, which allows "learners to compare their own activity . . . against an anonymous summary of their peers" (Fritz, 2011).

Learning Analytics has been in use at Hokkaido Information University since 2003. This is demonstrated in both *Mugendai Campus,* an e-learning system for off-campus students, and also in *POLITE* (Portfolio Oriented eLearning for IT Education), the on-campus e-learning portal site.

*Mugendai Campus* is primarily designed for students studying off-campus. Typically, such students choose to study from an combination of 4 different learning modalities: studying with a book by themselves, studying online by computer (*Mugendai Campus*), studying by attending intensive courses, or studying via a live class broadcast to an affiliated educational center. The first is the cheapest option and can be undertaken in any of four quarters over the academic year; the second includes only a limited number of courses, but is available year round; the third includes a more limited number of classes, and each intensive class will only be held in one of over 10 possible cities throughout Japan; and the fourth is only available to students enrolled full-time at an affiliated school.

Given the alternatives, although *Mugendai Campus* does not offer live interaction with the instructor, it does offer a selection of analytics, both for the benefit of the teacher and learner. This is seen in *Diagrams 2*, *3* and *4* below.

*Diagram 2: Total Time Online/Problems Completed*

*Diagram 3: Mistakes and Number Correct*

| 問題 | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 正解 | b | b | c | c | d | a | a | d | d | c |
| 回答(1) | a× | b○ | c○ | d× | a× | b× | c× | d○ | a× | b× |
| 回答(2) | b○ | b○ | c○ | a× | b× | c× | d× | d○ | b× | c○ |
| 回答(3) | b○ | b○ | c○ | a× | b× | c× | d× | d○ | b× | c○ |


*Diagram 4: Access Time Log*

| No | access_time | unit | kind | correct | |
|---|---|---|---|---|---|
| 497 | 2014-02-08 16:08:29 | chapter14 | Circle | 10 | correct=10:answer=T,F,T, |
| 496 | 2014-02-08 16:08:18 | chapter14 | Circle | 9 | correct=9:answer=T,F,T,T |
| 495 | 2014-02-08 16:07:53 | chapter14 | Circle | 8 | correct=8:answer=T,F,T,T |
| 494 | 2014-02-08 16:07:43 | chapter14 | Circle | 8 | correct=8:answer=F,F,T,T |
| 493 | 2014-02-08 16:07:33 | chapter14 | Circle | 9 | correct=9:answer=T,F,T,T |

*Diagrams 2* and *3* provide valuable information to both the teacher and the learner. *Diagram 2* logs the time studied for each chapter (or lesson), the number of attempts at each problem, the maximum, average and minimum scores, the number of times accessed and the total study time for the unit or course. *Diagram 3* lists the learner's number of correct and incorrect responses in a multiple choice exercise in each chapter. It also includes a motivational message indicating the progress, or ranking, of the learner. *Diagram 4* is accessible only by the teacher administering the course, and displays each keyboard input from the learner, the time it was made, and the duration of time that was spent by the learner on each page, or in each section.

Data logging on *POLITE* reflects its purpose as an aid to on-campus students, showing other numeric elements, such as the number and date of papers submitted and grades awarded (*Diagram 5*), the comparative length of time spent studying (*Diagram 6*), and detailed answers to problems set in class, or as homework (*Diagram 7*).

*Diagram 5: Date, Score & Number of Papers Submitted*


*Diagram 6: Study Time*

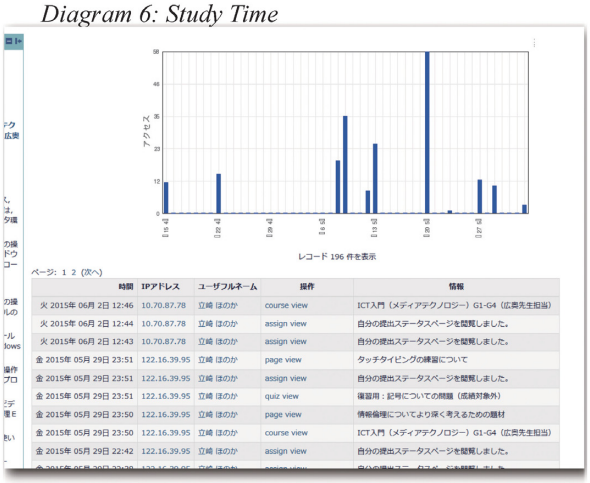
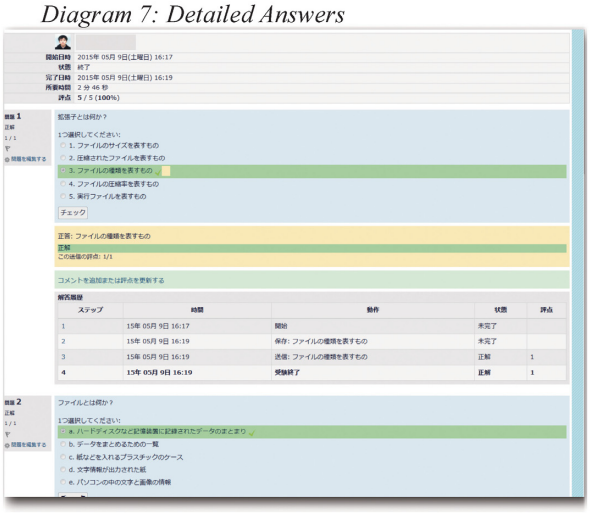


*Diagram 7: Detailed Answers*



## 5 *Learning Analytics and e-book Readers*

In all of these examples, it is easy to see how access to data logged is both beneficial to the student and the teacher alike. The server hosting the e-learning site, or portal site, naturally records the data as part of its hosting function. An appropriate interface accesses the data and expresses it in a way that is easily understood by the learner, and valuable for the teacher. It can be analyzed and examined to meet a variety of needs. Fields ranging from study duration, completion rates, success rates, incidences of repetition or revision, preferred study times, rates of progress or problematic areas, to name but a few, can all be scrutinized with the aim to improve learning by collecting and analyzing data. Additional information, such as answers to questions, or advice in problematic areas can be added accordingly.

However, it needs to be pointed out that such access to data can only be carried out when the computer (or tablet) is online. As noted by Ferguson (2012, p.306), significant amounts of learner activity take place externally, making records or data logging very important, if the teacher wants to utilize data reflecting student learning patterns to improve learning outcomes.

*Diagram 1*, which compares the utility of educational delivery modalities, also demonstrates this point very clearly: while tablets are motivating, reasonably priced, engaging, interactive and portable, they offer few advantages concerning analytics.

Thus, when the learner is using an iPad as an offline e-book reader, it is difficult to collect such data. There are fundamentally two reasons for this: The first is that while e-books can embed problems or exercises, they typically do not log data. Secondly, when the iPad is offline, or not in a WiFi zone (such as at the learner's home or while commuting to school), there is no way to send or receive any data to or from the hosting server. Finding a way to accurately record the data, and upload the data to an appropriate server for collection and analysis when the tablet is used on campus, is the essence of this research.

## 6 *Using e-book Readers on Campus*

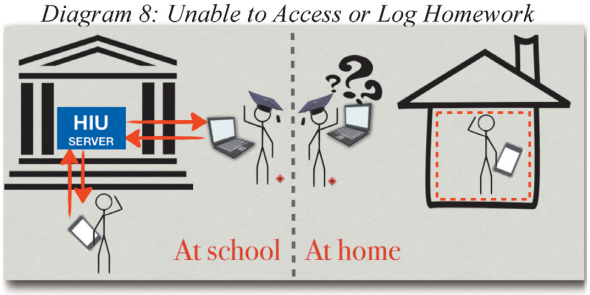
Hokkaido Information University has made a firm commitment to using tablets on campus. This is demonstrated by the fact that there are now more than 1200 iPads in use by all faculties, with all students (except final year students) being loaned an iPad by the university. They are an intrinsic, ubiquitous part of the learning process, both by students and faculty alike, and are utilized daily.

Their uses include student response system interfaces (including one developed in-house by HIU and the other commercially), an enrollment interface, an email reader, an internet browser, a note taking device and a media viewer, amongst other things. They are also increasingly being used as e-books in several subjects, and that usage is not expected to dwindle, with FD workshops on how to design and construct e-books being held several times a year.

However, as noted, one of the problems is that faculty have no way to verify whether set work has been completed. Whether the learner has accessed the e-book, how much time has been spent, how well the material was understood, and how much of the e-book has been read largely remains unknown to faculty. *Diagram 8* illustrates the situation. On campus, all data can be automatically logged using the campus WiFi network. Data is sent to the *POLITE* server, which is used to host learning material and also has a robust analytic capability, being able to collect, collate, analyze and display data. However, when the student is off-campus, and/or not logged into the campus WiFi system, any activity by the student is unable to be monitored, verified or checked by the faculty.

This is clearly not just a problem purely concerning e-book usage, rather a realization that when a student is using any PC or tablet offline, it is difficult to know what study the student has done, and there is no evidence or data reflecting what learning may have taken place.

*Diagram 8: Unable to Access or Log Homework*

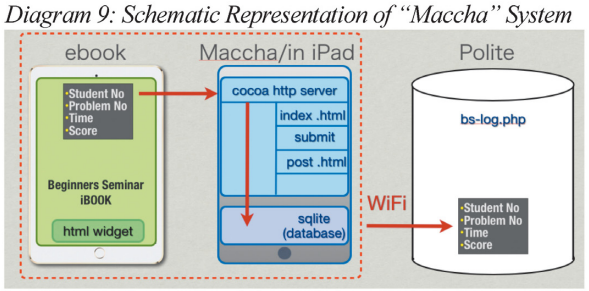



## 7 *Creating a Proxy Server to Run Under iOS*

To address this problem, the authors devised an iPad application called "maccha". *Maccha* fundamentally has two functions: to collect and log data, and to upload the data to a campus server, in this case, *POLITE*.

In the system, a widget is embedded into the e-book, and all input from the student goes to a cocoa proxy server, whereupon it is sent to a Sqlite data base, which is stored until the iPad is able to contact the designated hosting server (*POLITE*), and upload the data. When the iPad is in the campus WiFi zone, the data is automatically uploaded upon the student's logging in. In this way, the study habits and data of students can be recorded and accessed by both faculty and students. This is shown below, in *Diagram 9*.

*Diagram 9: Schematic Representation of "Maccha" System*




## 8 *Challenges and Evolution in the System*

In the initial version, which was primarily designed to test the viability of the idea, logged data included only the student number, problem number, time and score. Furthermore, up till the end of 2014, students were unable to log on to the school *POLITE* server from their own home, or any other non campus WiFi hotspot, hence the need for a built-in proxy server and database. However, from 2015, with improved security measures, this dramatically changed, allowing students to access the *POLITE* server from any external Internet connection.

To some extent, this made the development of *Maccha* partially redundant as the student's logging in to the *POLITE* server from any external hotspot automatically uploaded all analytics data. As noted, prior to 2014, the student was unable to access the school server outside the school WiFi zone.

However, there are two critical points that need to be considered: firstly, if the student does not log in before accessing the e-book, even using the 2015 system, data would not be automatically uploaded; and secondly, e-books do not readily support analytics, so the embedding of an HTML widget into the e-book, thereby allowing data to be represented as HTML files, fulfills the vital function of allowing data input by the student to be mined and later analyzed.

## *9 Discussion*

As noted by Siemens et al. (2011, p.5), Learning Analytics is a "means to provide stakeholders (learners, educators, administrators, and funders) with better information and deep insight into the factors within the learning process that contribute to learner success". In other words, Learning Analytics is about the learning process. Analytics can help guide decision making about educational, curriculum or course reform by faculty, and identify where help might be needed for at-risk, or under-performing students. Faculty can implement intelligent curriculum design, and patterns of success or failure will also become clear. In this way, it is beneficial for teachers and administrators while simultaneously providing learners with information to empower and monitor their learning, and increase their responsibility for their learning activity.

It has been conclusively shown that if students don't enjoy or can't succeed in a subject, they may become "turned off, disengaged, or uninvolved" (Sosa & Casanave, 2007). The field of Learning Analytics is largely concerned with improving learner success by finding ways to express the progress of the learner by measuring, collecting and analyzing data concerning the student's study.

While using an iPad in an educational setting has been shown to initially engage students (Li & Pow 2011, Enriquez 2010, Goodwin 2012, Morrone, Gosney, & Engel 2012), not knowing how well students are progressing, or what sections in the course material are causing problems, will likely hinder the learning process. This is borne out by Gee's (2003) premise that "without motivation, there is no learning". Thus, if students are not engaged by the material they are using, they will likely be demotivated, resulting in minimal or no learning. Clearly, to evaluate how the student is learning, what the student is learning, and whether in fact learning is taking place, data expressing the student's study habits is needed.

This research proposal argues that students using iPads as e-book readers would likely benefit by allowing their study habits and the course material to be objectively logged and examined, something which can only be achieved by analyzing student access data. Gaining such access not only allows course material to be modified to meet student demands, but also allows student progress to be followed on an individual basis. Improved material and student monitoring is expected to lead to greater motivation and improved autonomous learning.

## *10 Analytics and Privacy*

One potential problem that needs to be considered in this research is the issue of data privacy and data use in Learning Analytics. Ethical and legal issues, such as Japan's Educational Records Release regulations, need to be understood before teachers make use of any data, just as data ownership and access rights also need to be considered. Furthermore, it has been noted that some students may not like the feeling (or reality) of (their data) being watched or tracked around campus (Campbell, DeBlois, & Oblinger, 2007), just as some researchers have noted that there is also a potential danger of creating a profile of successful and unsuccessful students, and that Learning Analytics targets course completion more than measuring student learning (Watters, 2012).

However, research in role theory applied to SNS usage (Bruneel, De Wit, Verhoeven & Elen, 2013) tends to show that students clearly differentiate between privacy issues inside and outside schools, implying that data mining for course improvement and student monitoring will likely be accepted. Moreover, as noted, provision to access private course data not only by the faculty but the student allows student self-monitoring, which research shows leads students to become more cognizant of their actions, study habits and progress (Dietz-Uhler & Hurn, 2013).

Nevertheless, supervision and ownership of the data does remain an issue. There has been no directive on what rights learners have in relation to their data, just as there has been no agreed or accepted method for teachers and/or researchers to obtain consent to collect and use the data. Perhaps more importantly, there is no mechanism whereby learners can opt out of having their data collected, or ensure their records are erased when a given course has finished. Ethically, it seems questionable for the institution to mine data from students just to analyze study progress, develop trends and even award grades.

## *11 Conclusion*

In this research, we attempted to develop and create a method to apply Learning Analytics to iPads used as e-book readers. Learning Analytics ultimately aims to provide value to learners. Data is obtained from a learning event, expressed in an easily comprehensible manner, and employed to understand and optimize both the learning and the environments within which it takes place.

While we initially constructed an application named *Maccha*, comprised of a proxy server and database, able to store data until the iPad was within reach of the campus server, the major value in this research lies in the idea of finding a way to collect user data from an interactive e-book, and expressing that data to gain insight on a participant's behaviors and productions. It allows both teachers and learners to know "what is going on" (Schneider, 2015).

With over one billion people now owning and using tablets, more than doubling the number just 3 years ago, it follows that tablet use will rapidly increase in education. That means that not only will all tiers of education likely be using tablets, but they will likely be the primary educational interface, after the teacher. This further implies that as tablet usage increases in class, the importance of Learning Analytics in education will proportionately increase.

As Siemens *et al.* (2011) note, there are seven significant benefits from utilizing Learning Analytics: namely (i) reduction of attrition by early detection of at-risk students; (ii) ability to adapt learning processes and contents to suit individual's needs; (iii) ability to provide timely information to extend and enhance learner achievement, motivation, and confidence; (iv) better use of teacher time and effort by access to information on which students need additional help; (v) higher quality learning design and improved curriculum development processes; (vi) provision of comprehensive, interactive visualizations of complex information (dashboards) resulting in better meeting needs; and (vii) faster achievement of learning goals by giving learners access to monitoring tools.

Given these advantages and the impending ubiquity of tablets in all tiers of education, further pursuing the application of Learning Analytics to improve learning outcomes in e-books seems like a valid and valuable research topic, something which the authors plan to further develop and refine.

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