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Tracking and Visualization from in-class Moodle Page Views Using TSCS Monitor

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Abstract: This paper describes the development and trial performance of Time Series Cross Section (TSCS) Monitor, an interactive student monitoring and tracking system that uses an Excel macro to extract tracking data from Moodle page views. TSCS Monitor generates pivot tables using a Time Series Cross Section framework that can be used by the course instructor. TSCS Monitor and the tables it provides allow comprehensive visualizations that give an overview of the entire class, rather than solely tracking the activity of individual students or focusing on a particular resource. Instructors can perform an analysis of the entire class and produce a clear picture of when learners have opened the material, either in-class or previously. The numerical data provided by the TSCS tables can be used to identify learners who access the materials without properly following instructions as well as those who delay accessing the materials.

Keywords: time series, cross-section, engagement, page views, educational data mining, student tracking

1. Introduction

Educational Data Mining has developed as an application of data mining in the education field. Its object is to produce information that will improve the quality of education for teachers and learners. Recent Course Management Systems (CMSs) and Learning Management Systems (LMSs) such as Moodle keep track of learning histories for system developers as well as teachers and learners, and have the potential to generate valuable information (Baker & Yacef, 2009). Records of the learning histories of learners are being collected on an increasingly large scale. Using these learning histories to improve the quality of teaching and learning shows great promise. Many kinds of data mining methods have already been proposed in the education field (Romero & Ventura, 2013).

The success of learning in the classroom is ultimately due to the interaction of teachers and learners. This interaction, especially during class time, has a direct effect on teaching evaluation. In a blended face-to-face learning environment using a CMS, the teacher provides learners with a description of course materials and instructions for how to use them; the response of the learners is recorded in logs showing their learning histories. As one of the more common learning management systems, Moodle enables the automatic accumulation of data such as a student's history of access to pages of the course materials. The information obtained from the Moodle system, however, is insufficient for direct use as a basis for enhancing teaching quality and judging how a teacher should proceed with the class.

What is needed is a data mining method for use with a CMS that would analyze learning histories in real time and report the status of the learners in a timely manner. Classroom teaching can be expected to improve if educators are provided with a means of early detection of student status without having to leave their desks—a method by which they can readily assess student progress and facilitate thorough instruction for learners. The challenge is to provide appropriate data to both educators and learners. A favorable strategy would be to supply teachers with the results of appropriately conducted analyses in a timely manner so that the analytical insights gained can be used to advance teaching effectiveness. A tool that could be employed frequently in-class for such a purpose would be highly desirable.

This paper discusses a method that was developed for viewing student access to course materials during class and visualizing student engagement with the materials as change numerical values. It also describes the development of an Excel macro system called TSCS Monitor that automatically generates Time Series Cross Section (TSCS) tables from Moodle page views. The system monitors learners' in-class page views and provides information that can be used as a reference for reinforcing classroom instruction and keeping track of student engagement. The TSCS Monitor macro can be accessed by any Moodle course administrator (Dobashi, 2015a, 2015b).

2. Related Research

Romero, Ventura, and Garcia (2008) classified the trends of data mining in education for specific areas, such as statistical analysis, visualization, and text mining. They also investigated the various data mining methods that have been attempted by researchers. They found that Moodle learning history data used to classify learners with features derived by mining are applicable to measures for improving the educational effects of data mining (Romero et al, 2008).

Moodle page views shows a record of when and how students access course materials, duration of access (initiation, time spent), IP addresses, users' full names, operations, and accessed items. This information is summarized in a time series list. However, the original Moodle logs provide only a rough picture of classroom situations and are therefore minimally useful. To address this issue, Dierenfeld and Merceron (2012) and Dobashi (2015a) show various kinds of learning analytics methods using Excel pivot tables. Konstantinidis (2013) has also developed Excel macros to process the Moodle logs in order to analyze page views and overall usage.

Attempts to track the behavior of online visitors by taking advantage of the system of access logs is increasingly common (Sen, 2006). For example, tracking the behavior of visitors to online shopping sites to improve advertising messaging is now widely practiced. Such efforts have led to the development of systems that aim to track the behavior of students during a lesson (Chen, 2003; Mostow etal, 2005; Mazza et al, 2012; Stephens, 2014).

In addition, Google Analytics provides a website analysis service that enables data analyses grounded in different perspectives (Google, 2016). Such service also helps educators improve course materials and lessons. Related Google Analytics offerings, such as the provision of data on aggregate visitors and frequency of website visits, number of users that access a website, and website content viewed, are available in real time. Google's services likewise allow for visually analyzing the behaviors of users who are executing any operation on a page.

Moodog reports that Zhang and Almeroth have developed an approach that incorporates an analysis function for logs in Moodle. Their system is able to analyze the course materials browsing rate, page views and viewing time of students. The analytical results are displayed on Moodle screens showing the interaction of the students and Moodle using graphs and the tables (Zhang & Almeroth, 2010).

Mazza and Dimitrova have developed a system called CourseVis (Mazza & Dimitrova, 2003, 2004, 2007) that tracks student behavior in an online class. Such behavior can be visualized graphically, along with the status of student access to content pages following the course schedule. GISMO (Mazza & Milani, 2004; Mazza & Botturi, 2007) uses Moodle access histories to produce a graph of student access of course and teaching materials in order to better understand student behavior. It has been integrated into the Moodle open source learning environment and is currently installed in many educational institutions involving actual users.

3. Tracking and TSCS Analysis

3.1 TSCS Analysis

Moodle offers an accumulated learning history for such elements as page views of course materials and quiz results. For this study, we created course materials on Moodle in order to collect page views and developed a method using Excel macros that apply TSCS analysis. The system continuously

provides TSCS analysis of learner page views during the lesson. A TSCS table is automatically generated to apply the concept of TSCS analysis and panel data. TSCS data represent continuous observations of a single investigated unit and enables both time series and cross-sectional analysis (Fig. 1).

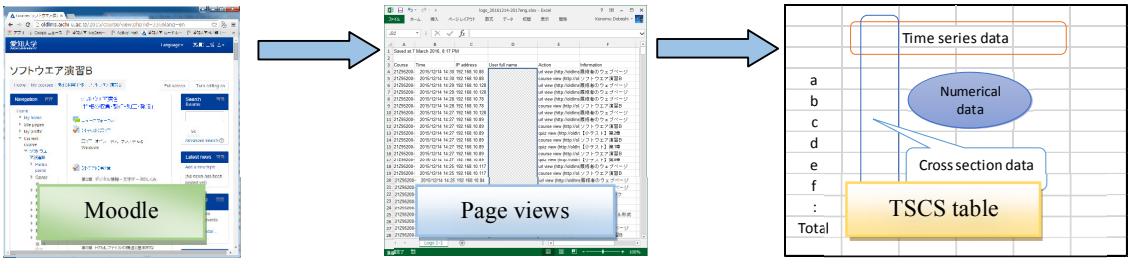

Figure 1. Flow of Processing a Time Series Cross Section table.

The work described here is based on the TSCS theory of Fisher (1973) and Beck (2008). Both TSCS and panel data-based analyses can handle quantitative data and quantify qualitative data. Quantification can be performed by, for instance, assigning a value of 1 to the selection of an item and a value of 0 to non-selection.

3.2 Overview of Course Materials and Page Views

Collecting data on page views necessitates preparing course materials on Moodle in advance. In Moodle, PDF, Word, Excel, and Text document users can employ various file formats, such as external referrers. This study primarily used PDF files that are viewable through a PDF viewer by clicking on a link in the table of contents created in the Moodle topics format, which is commonly used in Moodle-based courses.

Because topics can be easily entered into the Moodle system, we created a digital section that corresponds to the table of contents of paper textbooks by entering the heading that corresponds to a chapter section and minor material items. When students click on these topics and browse the course materials (corresponding to Moodle resources), the topic name (resource name) and course material browsed are recorded in a log and displayed in table form. This process retrieves page views.

Table 1: Example page views (Used material's page views) in-class of Excel format of Moodle logs.

Saved at:14 December 2015, 14:21 PM			Teacher's page views		
Course	Time	IP address	User full name	Action	Information
21Z95200-B	2015/12/14 13:02	192.168.10.73	Teacher	course view (http	0.1 Introduction to software
21Z95200-B	2015/12/14 13:03	192.168.10.73	Teacher	quiz view (http://	0.2 Quiz Chapter 8
21Z95200-B	2015/12/14 13:14	192.168.10.73	Teacher	course view (http	0.1 Introduction to software
21Z95200-B	2015/12/14 13:15	192.168.10.73	Teacher	resource view (ht	9.2 Basic style sheet
21Z95200-B	2015/12/14 13:17	192.168.10.73	Teacher	resource view (ht	9.6 Pseudo-classes and color of link
21Z95200-B	2015/12/14 13:22	192.168.10.73	Teacher	course view (http	0.1 Introduction to software
21Z95200-B	2015/12/14 13:28	192.168.10.73	Teacher	resource view (ht	9.7 Display position of the image
21Z95200-B	2015/12/14 13:38	192.168.10.73	Teacher	resource view (ht	Sample sentences
21Z95200-B	2015/12/14 13:55	192.168.10.73	Teacher	resource view (ht	10.0 Overall layout
21Z95200-B	2015/12/14 13:56	192.168.10.73	Teacher	resource view (ht	10.1 Margin of the text
21Z95200-B	2015/12/14 14:04	192.168.10.73	Teacher	resource view (ht	10.2 Indent
21Z95200-B	2015/12/14 14:15	192.168.10.73	Teacher	resource view (ht	10.3 Layout of the background
21Z95200-B	2015/12/14 14:16	192.168.10.73	Teacher	url view (http://l	Students' web page

3.3 System Configuration and Data Processing

The steps of the algorithm used for TSCS table generation can be summarized as follows: (1) Download logs in Excel format from Moodle, with focus on the logs recorded on lesson day, (2) Retain data that contain lesson times and remove those without lesson times, (3) Extract the page views of the teacher, (4) Use the page views of the teacher to distinguish materials that are used and unused during a lesson, (5) Incorporate the time series data into the string at 1- to 5-minute intervals, (6) Generate a TSCS table of page views for course materials, (7) Produce a TSCS table of page views of students, (8) Generate a graph to visualize TSCS data.

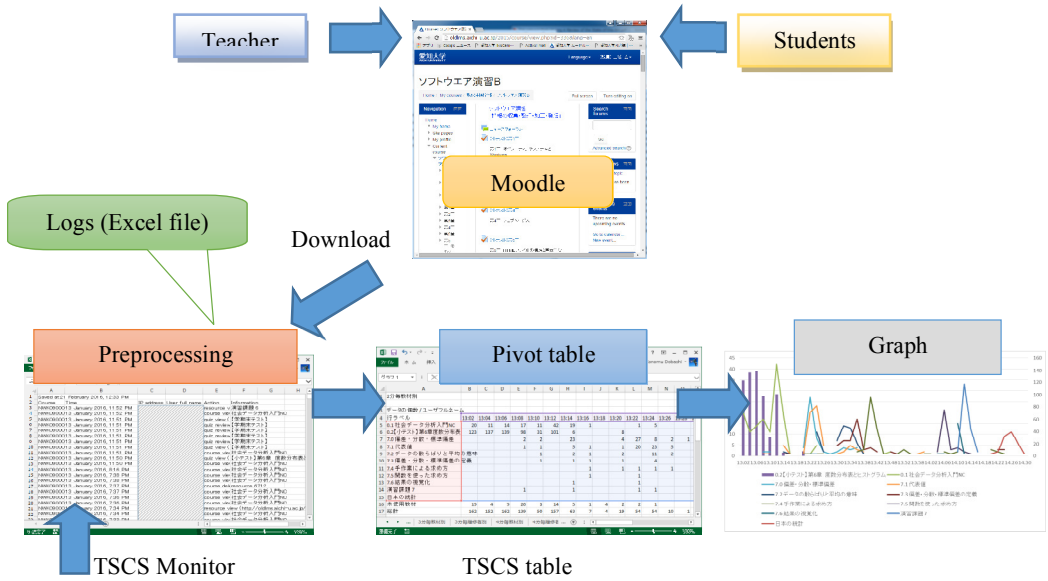

Figure 2. Flow of processing and TSCS table.

4. Experiment

Moodle's capability for downloading and collecting data on page views was used in this study. As previously stated, we developed a system that analyzes logs and employed it to create course materials. The system was developed using an Excel macro to be used in actual classes. Permission was acquired from the Moodle administrator of the case university to create an account that provides the same privileges as those offered by a general student account. This account affords both teachers and students access to course materials during class. Additionally, the account was prepared as a course management account with which logs and course materials can be managed. The account course administrator was used primarily for functions such as downloading logs of a lesson and it was used on the notebook computer.

4.1 Overview of the Whole Class for a Comprehensive Perspective

To demonstrate how a TSCS table is generated, the macro that was developed was used in an "Introduction to Software" class offered at the case university. Table 2 is the TSCS table of page views for course materials. The course materials contain commentary concerning HTML and CSS, and students learn how to make and design web pages. On December 14, 2015, the teacher discussed the lesson for 90 minutes. The lesson was initiated at 13:00 and ended at 14:30. Table 2 and 3 illustrate the TSCS table generated at 1-minute intervals, downloaded at 14:21 from Moodle logs and aggregated.

Twenty students attended the lesson that day. First, a quiz was given in the classroom. The teacher then opened thirteen files (Table 1). Table 2 shows all the course items used in the lesson and displays the number of views in a time series. From such a table, it is possible to identify the more heavily engaged portions and the less heavily engaged portions of the lesson.

Table 2: Example of a TSCS table for used course items by minute of class time (Introduction to Software, Saved 14 December 2015, at 14:21 PM).

Saved at:14 December 2015, 14:21 PM																			
Number of data / User full	Column label																		
Row label	13:00	13:01	13:02	13:03	13:04	13:05	13:06	13:07	13:08	13:09	13:10	13:11	13:12	13:13	13:14	13:15	13:17	13:18	13:19
0.1 Introduction to softwar	3	8	2	2	4	1	2	2	1	2	5	12	5	9	6	1			
0.2 Quiz Chapter 8	5	48	33	32	55	24	10	14	12	1	10	58	14	11	3				
9.2 Basic style sheet																14			1
9.6 Pseudo-classes and color of link																	12	2	
9.7 Display position of the image																			
Sample sentences																			
10.0 Overall layout																			
10.1 Margin of the text																			
10.2 Indent																			
10.3 Layout of the background																			
Students' web page									1	1		1			1				
Unused materials		2			1			2	2	6				3	3				
Page views	8	58	35	34	60	25	12	18	16	10	15	71	19	23	13	15	12	2	1

See Table 5

13:20	13:22	13:25	13:28	13:29	13:30	13:31	13:32	13:33	13:37	13:38	13:39	13:40	13:41	13:44	13:45	13:46	13:48	13:54
	1		1															
						1												
1	3	1				1			1									
			10	1	1	1	1	1	1	1			1		2	3	1	
										13	3	3		1				
					3						1				1				1
1	4	1	11	4	1	3	1	1	2	15	3	3	1	2	2	3	1	1

13:55	13:56	13:57	13:58	13:59	14:02	14:03	14:04	14:05	14:06	14:10	14:15	14:16	14:17	14:18	14:19	14:20	Page views
				1								1		1			70
																	330
																	16
																	21
	1				1												26
1		1				1											23
5	2			1													8
	9	2	1	3													15
								11	2	3							16
1										1	3						5
												13	1	3			21
1		2		2		4									4	1	39
8	12	5	1	7	1	5	11	2	3	1	3	14	1	4	4	1	590

See Table 4

See Table 5

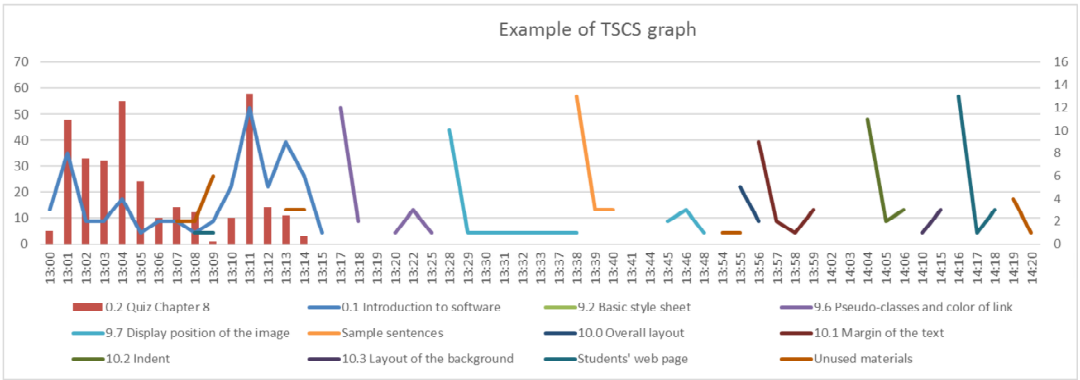

Figure 3. Example of a TSCS graph for used course items by minute of class time (Introduction to Software, saved 14 December 2015, at 14:21 PM, Twenty students attended).

The graph in Figure 3 was created from Table 2. In total, five quizzes were given in this class during the term. We have created a complex graph because the viewing times of the quiz are relatively

larger than the viewing times of course materials. The left side of the bar graph in Figure 3 shows the number of views of the quiz; the scale is at the left. The line graphs show the number of views of course materials; the scale is at the right. The higher mountain portions of the graph indicate that there were many page views; the lower mountain portions indicate fewer page views.

Table 3: Example TSCS table for the entire list of students in the class (Introduction to Software, Saved 14 December 2015, at 14:21 PM).

Saved at:14 December 2015, 14:21 PM																						
Number of d	Column label																					
Row label	13:00	13:01	13:02	13:03	13:04	13:05	13:06	13:07	13:08	13:09	13:10	13:11	13:12	13:13	13:14	13:15	13:17	13:18	13:19	13:20	13:22	13:25
Student01				4	4	5							2						1		1	
Student02		4	1	1	5							7	1	2		1	1					
Student03	1	6	3		1	2	2		2	8		2	2	3	2	1						
Student04	2	2	1	1	2		1	5	8			1	8	3		2						
Student05					5	1	1	4				7	2				1					
Student06	1	3	1	1	8						1			1	1	1	1					
Student07		3	2	2	1	4					1	2		1	1							
Student08		4	2	1	3	4						5		1		1					1	
Student09		3	2	2	4				1			6	1	8		1	1					
Student10		3	1	2	2	3	1					7				1	1					
Student11		4	3	3	6					2		3			3	1	1					
Student12		5	3	3								10				1	1				1	1
Student13		4	1	3	3						1	4						2				
Student14		4	2	2	3							2			1	1	1					
Student15		5	2	1	3						1	1		3	3							
Student16		4	2	1	1	3	1				1	1				1						
Student17			4	1	3	1	3	6			10											
Student18				4	1	2		3	5			8	2	1		1	1					
Student19	4	1	2	1	3							4	1				1					
Student20		3	2		2		3					1			1	1	1					
Teacher			1	1											1	1	1				1	
Page views	8	58	35	34	60	25	12	18	16	10	15	71	19	23	13	15	12	2	1	1	4	1
Students	4	16	17	17	19	9	7	4	4	2	6	17	8	9	7	13	11	1	1	1	3	1

More data cut here

Table 3 is a TSCS table for the entire list of students who attended the lesson. In Table 2, we can see the student viewing times and page views. Used when conducting a lesson, such a table can identify students whose views of a course item are delayed or indicate whether a particular student is viewing course items according to the instructions of the teacher.

In Table 2 and Table 3, some portions of the time data are not displayed; such portions have no page views. For example, the time of 13:21 does not appear in the table, indicating that no students were viewing the course material at that time.

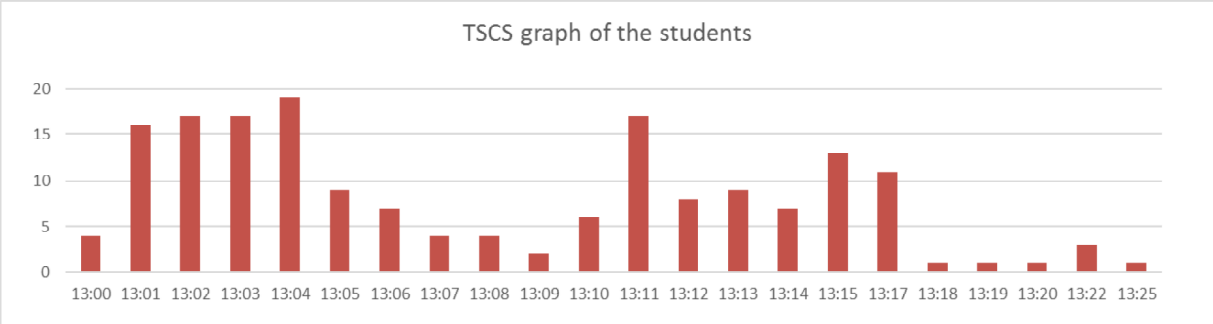

Figure 4. Example of a TSCS graph for the entire list of students in the class (Introduction to Software, Saved 14 December 2015, at 14:21 PM)

The graph in Figure 4 was created from Table 3 using the time data and the corresponding number of students. It shows, minute-by-minute, the number of students who opened the course materials.

As mentioned above, twenty students attended the lesson. However, there was no time interval during which all of the students opened the course material. Students who did not open the course materials on their own computer may have been looking at the teacher's

projector. Although the quiz continued until 13:10, it can be seen that more than half of the students had completed it by 13:04.

4.2 Overview for a Particular Resource

Table 4 is a TSCS table of page views for a particular course item (here, "10.1 Margin of the text," as shown in the fourth row from the bottom in Table 1) in the lesson. It displays page views of the targeted item by individual students during each minute of class time. In Table 4, the row showing the teacher's page views indicates that at 13:56 the teacher instructed the students to open the course item. Six students exhibited a delay in accessing the materials at 13:57, 13:58, and 13:59. As shown on the right side of the table, there is no value for total page views for six students in the class. However, this table does not track cases in which a student may have viewed or downloaded the item previously.

Table 4: Example TSCS table for particular course item in the class (Introduction to Software, Saved 14 December 2015, at 14:21 PM).

10.1 The margin of the text																	
Number of	Column label																Page
Row label	13:00	13:54	13:55	13:56	13:57	13:58	13:59	14:02	14:03	14:04	14:05	14:06	14:10	14:15	14:16	14:17	views
Student01						1											1
Student02				1													1
Student03							1										1
Student04							1										1
Student05				1													1
Student06				1													1
Student07																	
Student08				1													1
Student09				1													1
Student10				1													1
Student11					1												1
Student12				1													1
Student13																	
Student14																	
Student15																	
Student16																	
Student17							1										1
Student18				1													1
Student19																	
Student20					1												1
Teacher				1													1
Page view				9	2	1	3										15
Students	0	0	0	8	2	1	3	0	0	0	0	0	0	0	0	0	14

Left side no data

Right side no data

5. Using Pivot Table Functions

We developed TSCS Monitor to automatically generate useful pivot tables in Excel. Thus, in the table discussed above, it is possible to utilize the functions of an Excel pivot table to produce a more detailed data analysis. For example, Table 2 is a TSCS table for the course materials used in-class that shows the opening of course materials by the class as a whole. By utilizing a function of the pivot table, it is possible to view the situation in more detail.

To illustrate, if we double-click on the course material cell on Table 2, we can display student names, IP addresses, and so on. Table 5 shows an example in which we have added individual student page views for the "Indent" course materials highlighted in Table 2 (and shown as "10.2 Indent" in the third row from the bottom in Table 1). Since the teacher's name is at the bottom of the list of names, we can be see when the teacher gave the instructions to the students, making it possible to identify students who delayed opening the materials.

Table 5: Example of a TSCS table and pivot table function (Introduction to Software, Saved 14 December 2015, at 14:21 PM)

3	Number of data / User full name															
4	Row label	13:58	13:59	14:02	14:03	14:04	14:05	14:06	14:10	14:15	14:16	14:17	14:18	14:19	14:20	Total
5	0.1 Introduction to software		1								1		1			70
6	0.2 Quiz Chapter 8															330
7	9.2 Basic style sheet															16
8	9.6 Pseudo-classes and color of l															21
9	9.7 Display position of the image			1												26
10	Sample sentences				1											23
11	10.0 Overall layout		1													8
12	10.1 Margin of the text	1	3													15
13	10.2 Indent					11	2	3								16
14								1								1
15							1									1
16								1								1
17							1									1
18								1								1
19						1										1
20						1										1
21						1										1
22						1										1
23						2										2
24						1										1
25						1										1
26						1										1
27						1										1
28						1										1
29	10.3 Layout of the background								1	3						5
30	Students' web page										13	1	3			21
31	Unused materials		2		4									4	1	39
32	Page views	1	7	1	5	11	2	3	1	3	14	1	4	4	1	590

6. Discussion and Conclusion

If one were to attempt to manually produce information similar to that provided in the TSCS tables, it would take approximately one hour or more. By contrast, using the macro described here requires only a few seconds. To achieve maximum effect, a teacher should be able to quickly incorporate data such as the number of student page views and the material content being viewed into their assessment of their classroom effectiveness.

If the data reveal a low level of student browsing of class materials, this may well indicate that the instructions and descriptions that the teacher is providing to students may be insufficient. This issue prompted us to develop an independent means for determining whether teacher explanations or instructions are, in fact, effective. Accordingly, lectures were documented by using a voice or video recorder—a countermeasure that can be easily implemented to assess effectiveness at a later time.

TSCS tables have undeniable possibility of looking at student activity in downloading materials. Clearly, after a teacher provides directions for opening an item, students will spend several minutes accessing the resource. This lag should be considered before teachers advance to the next part of the lesson.

In this paper, we described how Moodle logs and TSCS Monitor can be used to efficiently generate TSCS tables that track in-class course material page views by teachers and students. With these tables, one has a minute-by-minute, bird's-eye view of the page views and viewing times for all the various course items. The generated tables make it possible to look at changes in page views for individual students throughout the class period and can provide the means to assess the reactions of students to the teacher's instructions. Additionally, they can identify students who fail to open some of the course items, are

delayed in opening some items, or are viewing course items not used in the lesson. Such features can be extremely valuable as a guide to teaching and learning improvement.

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