

# Learning Analytics with Excel Pivot Tables

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## Abstract

Different actors like teachers, course designers and content providers need to gain more information about the way the resources provided with Moodle are used by the students so they can adjust and adapt their offer better. In this contribution we show that Excel Pivot Tables can be used to conduct a flexible analytical processing of usage data and gain valuable information. An advantage of Excel Pivot Tables is that they can be mastered by persons with good IT-skills but not necessarily computer scientists.

## Keywords

Pivot Tables, Learning Analytics, Usage Data

## Introduction

Moodle is increasingly used in schools, universities and companies. There is a large variety of learning objects that can be put into the system. Different actors like teachers, course designers and content providers need to gain more information about the way provided resources are used by the students so they can adjust and adapt their offer better. They have questions like: Do students use the resources at all? When? What are the most, the least popular resources? How are specific contents such as e-books used? Are there resources that are often used together? Do students participate in forums? In Wikis? Is there a link between the use of some specific learning objects and grades in the examinations? Which contents affect learning particularly positively? Are there contents that should be recommended?

To answer these questions, usage data stored by the system needs to be explored and analyzed. In this contribution we show that Excel 2010 Pivot Tables (Jelen & Alexander 2010) can be used to answer many of these questions. An advantage of Excel Pivot Tables is that they can be mastered by persons with good IT-skills but not necessarily computer scientists. This means that a number of our targeted actors know them already or could learn to utilize them with little effort and use them to explore user data thoroughly.

In our approach we do not generate the Excel Pivot Tables using the export towards Excel of reports or grades provided by Moodle. Instead we have developed an application to extract data stored by Moodle towards our own data model presented in (Krueger, Merceron, & Wolf, 2010). There are three main reasons for that. First data is extracted and anonymised, which allows us to comply with the laws concerning data privacy in Germany. Second it is possible to merge data from different learning systems that are used parallel by a single institution. Finally other tables than the two currently available in Moodle can be generated more easily.

There is a number of tools that can be integrated with Moodle enabling teachers to explore user data. (Graf & all 2011) and (Leony & all 2012) present such examples. Our approach is different because our tool essentially provides the desired tables. The analytical processing does not take place inside the tool but relies on the existing Excel Pivot Tables. The desktop application presented in (Pedraza Perez, Romero & Ventura 2011) will allow users to apply a number of different data mining techniques on Moodle data. Their focus is not on a flexible data exploration or the analytical part as we concentrate on but on the data mining part itself.

There is a great number of research works analyzing usage data in Moodle, many of them are cited in (Romero & Ventura 2010). Most of these works tackle a particular problem and solve it using data mining techniques that only specialists can use properly. (Zafra & Ventura 2009) for instance, uses genetic algorithms and students' user data stored in Moodle courses to predict the grades of students in those courses. More recently (Hershkovitz & Nachmias 2011) used statistics and decision trees to analyze online persistence of students during a semester course in a context where Moodle is used to support face to face teaching. It is well known that in the whole data mining cycle the step of knowing and understanding the data is essential, and this step can be performed by analytical processing (Han, Kamber & Pei 2011). Our contribution is the usage of the Excel Pivot Tables to

perform analytical processing with educational data. Afterwards a proper data mining step can be performed if necessary.

The paper is organized as follows. In the next section Excel Pivot Tables are presented as well as the way we generate them. In the third section we show how we have utilized Pivot Tables to explore how learning material is used in courses and whether the use of specific self-evaluation quizzes has an impact on the final mark. Final remarks and future work conclude the paper.

## Pivot Tables

Learning management systems like Moodle store many user data in a database. This data can be analysed to provide information to different actors in the educational field and help them to improve the learning experience of students by optimizing their learning offer. Our approach is to allow actors who are not necessarily computer scientists to perform part of the analysis themselves. We propose Pivot Tables for doing so.

In this section we will first explain why we chose to use our own data structure to export towards Excel and give a quick overview about Pivot Tables afterwards.

### Exporting Usage Data towards Excel

Moodle offers export in Excel format at two levels: reports and grades. To investigate the use of a course's learning objects it is best to create a report containing all actions from all users on all objects since the course has been created. With both Excel sheets it is possible to create an Excel Pivot Table.

We encountered some problems with Excel sheets that have been generated with Moodle:

- First the report contains too much personal information like names and ip-addresses. This information can be blocked by the Moodle administrator which however makes it impossible to determine which user has performed a specific action. Unfortunately this determination is necessary to answer questions like "are users who are using self-tests earning better grades than users who don't?"
- Second the relevant information is given in the column 'action' in combination with the column 'information'.  
The 'information' column contains rather general data, so it is necessary to highly filter the given table in order to get the needed values.
- Third log files are deleted on a regular basis. To compare different courses you have to store the data manually. Laws about data privacy in Germany do not allow keeping non-anonymous data for long periods

Due to the reasons mentioned we have developed an application to extract data stored by Moodle towards our own data model presented in (Krueger, Merceron, & Wolf, 2010). This way we are able to keep historical data and provide a reasonable data protection by replacing user names with ids in such a way that user names cannot be recovered from the ids. In addition it is possible to integrate user data from several learning management systems into our data model. Further with this model we are able to create various data source tables for the Pivot Tables making it easier to get different perspectives of the data.

### Working with Pivot Tables

A Pivot Table is a highly flexible contingency table. The table can be created from a large dataset and offers the possibility to look at one section at a time. We use the Pivot Table Tool from Microsoft Excel 2010 (Jelen and Alexander 2010). In order to create a Pivot Table it is necessary to have a data source table for Excel. The data source table should have the following format: In the first row you need to include the column's titles. There must not be an empty row or column in the table but empty fields are possible.

Figure 1 shows a small example. On the left side of this figure the source data table can be seen. The first line includes the following columns: 'action' the type of action performed in Moodle, 'date' the date of the action, 'quiz title' the title of the quiz the action was performed on and 'user id' the user id who performed this action. This table was generated by a MySQL query (MySQL 2012) from our data structure. On the right side there are two Pivot Tables generated from this source table. The Pivot Tables are generated by selecting a field of the data source table and choosing insert -> Pivot Table from the menu. For example the top pivot table was generated selecting the field B5 and then the Pivot Table Tool from the menu. Excel then automatically detects the range of the table to use. After this step Excel shows a list of all the headers detected from the data source (in this case 'action', 'date', 'quiz title' and 'user id'). It is then possible to choose which data of this list should be in the row

and which in the column of the Pivot Table (in the Pivot Tables in Figure 1: the column with the action or date and in both rows the quiz title). Last it is required to select which data and which operation should be used in the calculating field. In the example given in Figure 1 we chose to count the number of users, so as an example the field G4 is calculated by all user actions ‘attempt’ performed on Quiz 1. It is also possible to use other calculations, such as sum, mean, variance, minimum and maximum (but this wouldn’t make sense here because the user id’s are no real numerical data). Furthermore own measurement methods can be included.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	action	date	quiz titel	user id									
2	view	07.10.2009	Quiz 1	17380		number of actions							
3	view	08.10.2009	Quiz 1	16955		actions perform	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5	Quiz 6	sum
4	view	08.10.2009	Quiz 1	13498		attempt	1	1				1	3
5	view	09.10.2009	Quiz 4	17164		continue attemp		2		1	2		5
6	view	09.10.2009	Quiz 5	14644		view	4	4	1	3	1		13
7	attempt	07.10.2009	Quiz 6	14644		sum	5	7	1	4	3	1	21
8	view	07.10.2009	Quiz 4	17164									
9	continue attemp	07.10.2009	Quiz 4	14644		number of actions							
10	view	10.10.2009	Quiz 2	16972		date	Quiz 1	Quiz 2	Quiz 3	Quiz 4	Quiz 5	Quiz 6	sum
11	view	12.10.2009	Quiz 2	17164		05.10.2009		1			2		3
12	view	05.10.2009	Quiz 2	14944		07.10.2009	3	2		2		1	8
13	view	07.10.2009	Quiz 1	17125		08.10.2009	2	2					4
14	attempt	07.10.2009	Quiz 1	17125		09.10.2009				1	1		2
15	continue attemp	05.10.2009	Quiz 5	17125		10.10.2009		1	1	1			3
16	continue attemp	05.10.2009	Quiz 5	17125		12.10.2009		1					1
17	view	10.10.2009	Quiz 3	17125		sum	5	7	1	4	3	1	21
18	view	10.10.2009	Quiz 4	16955									
19	view	08.10.2009	Quiz 2	16955									

Figure 1: Example of Excel Pivot Tables: On the left is the original data source. On the right are two possible Pivot Tables that can be created from it

### Case Study

In this section we show a case study conducted with the first semester course “Formal basics of Computation” taught in the Bachelor degree computer science and media in face to face teaching and supported through Moodle. The course is organised in a weekly format. The top middle section contains materials for general readings and two forums. Below, each week contains a file with slides and a non-compulsory self-test related to the theme of the week. Each self-test closed after one to two weeks in winter semester 09/10, the user data that we explore here as a continuation of the work started in (Krueger, Merceron, & Wolf, 2010a). The final mark for this course is calculated by equally incorporating the grades obtained at two exams. The first exam takes place in the middle of the semester and the second one at the end of the semester. These exams are not conducted with Moodle. The functionality ‘offline assignment’ of Moodle is merely used to inform students about their grades. Past exams are uploaded in Moodle in the weeks in which these exams take place so that students can practice and train themselves. In winter semester 09/10, 57 students were enrolled in Moodle for this course.

### Analytical Processing of Content Use

First we extract an excel table containing all resources of the course from our database with the actions performed on them and generate the corresponding Excel pivot table with an appropriate query. We adopt the idea “overview first, then zoom and filter, details on demand” of (Shneiderman 1996). Using the function pivot chart with the methods to generate a Pivot Table mentioned in the section before, we obtain a histogram giving the total number of actions performed on it during the semester for each resource. It is possible to sort the table given in the histogram as shown in Figure 2. At a glance it is possible to have an overview of the use of all resources as well as the information concerning most and least accessed resources, shown on the left respectively on the right of the histogram. Note that if a resource is not used at all, it will appear with 0 action because our Excel table is extracted taking not only the log entries but also the set of resources uploaded in that course. This is different to exporting the report table directly from Moodle. Any resource which is not used at all will not appear in the report so that kind of information cannot appear in the histogram.

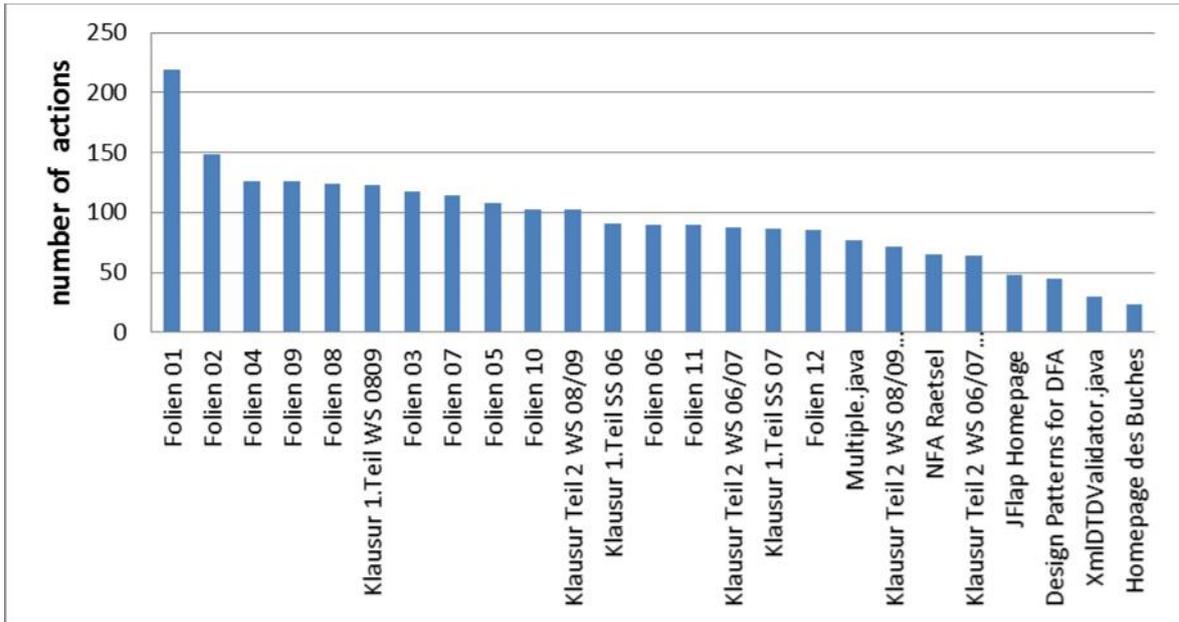


Figure 2: Overview of the number of actions per resource in increasing order

A second useful overview is access over time: When are resources used by students? This is important for reliability issues, when should the Moodle system not be failing for example, and for pedagogical issues. Teachers are interested to get information on how their students are learning: Do they learn regularly during the semester, or only just before the exam? Do they consult special contents to prepare for the next lecture or after the lecture as a review and consolidation? In this case study we were interested to know how the self-test exercises are used. Are they used at all? Are they used before the lecture or after or both? Is there some more intensive use before the exams? We use the filter options to select the actions ‘attempt’, ‘close attempt’ and ‘view attempt’ to dismiss access in which students do not actually attempt to solve the tests. We also use the filters within the time range to zoom on a particular time-window. Figure 3 shows the access to self-tests exercises with a daily granularity from November the 1st till December the 4th, the first exam being on December the 2nd as a surface chart. Note that the diagram shows cumulated actions for the time before November the 1<sup>st</sup> on the Day November the 1st, and similarly for the time after December the 4th. The self-tests are called Aufgabe1, Aufgabe 2 and so on in German. One notices that the use of self-tests generally tends to decrease, the colour is less intense. The self-tests still opened are reused before the exam, see the vertical lines on November the 30th and December the 1st, which suggests to keep the self-tests open during the whole semester. The general decrease of the use of the self-tests was already noticed before. Closing the self-tests after 2-3 weeks was an experiment to investigate whether the behaviour of students would change when the self-tests become more scarce meaning not available all semester. A quick look at the Moodle reports in 2010 could not show a noticeable change.

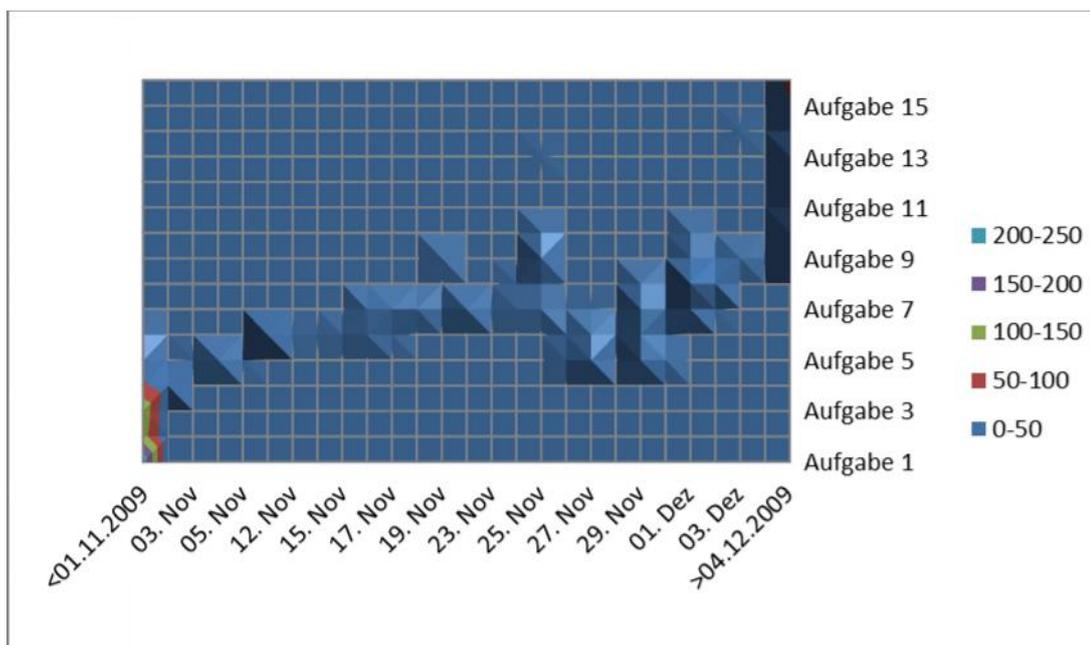


Figure 3: Overview of the use of self-tests before the first exam

It is interesting for teachers to be aware of their individual students: are they homogeneous or do they differ in their use of resources? We selected a surface chart to show the details of individual access to non-compulsory self-tests as shown in Figure 4. Even if the general trend is a decrease in usage, some students like 11373 begin late, which fits into the findings of (Hershkovitz Nachmias 2011) identifying late users in a similar setting, Moodle course to support face to face teaching, though the general trend is less usage as the semester progresses. Note that in our approach the data is anonymised. Teachers cannot control particular students, as it might be possible when working with a Pivot Table generated directly from the Moodle report. Our aim is to get general information about diverse behaviors of students to support reflection and pro-activation, not to follow any particular student.

The exploration presented here investigates the total number of actions on each resource. It is equally interesting to explore the number of students who have used a resource at least once, the total number of actions is not relevant anymore, only the fact that a resource has been used. For this, we would change the query to extract another table from our database. It is also possible to gain that table in Excel directly, but rather complex.

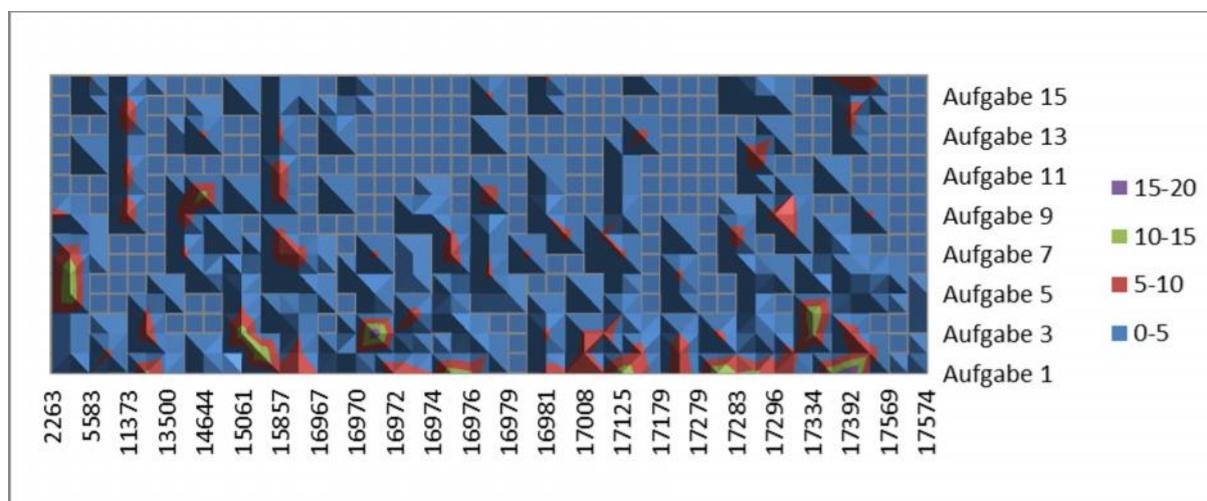


Figure 4: Use of self-tests detailed per student

**Analytical Processing of Impact on Success**

Using an appropriate query we have extracted the table shown in Figure 5, which is similar to the grades table provided by Moodle except for the anonymised data. The average mark in the first exam, 34.25532915, is shown at the bottom of the column called '1. Teilklausur', German for first exam. To investigate whether attempting some self-test has an impact on success, clicking on the top of a particular self-test we deselect the empty line box. The table only shows the students, who have attempted that particular self-test, here self-test 5. Selecting all figures of the column '1. Teilklausur' gives the average mark for that subgroup in the bottom line below the table, here 34.48148148. This small difference does not suggest any particular impact, contrarily to the analysis performed on other data in (Krueger, Merceron, & Wolf, 2010). A large difference might suggest an impact, and should be checked for statistical significance if the number of students is at least 30.

user Id	1. Teilklausur	Aufgabe 1	Aufgabe 2	Aufgabe 3	Aufgabe 4	Aufgabe 5	Aufgabe 6	Aufgabe 7	Aufgabe 8
2263	26	10	10	10	10	10	10	10	0
2326	29	0	10	10	10	10	10	10	0
11373	30	0	0	0	0	0	0	0	0
14948	14	0	0	0	0	0	0	0	0
15061	32	0	0	10	0	0	0	0	0
15497	0	0	10	0	0	0	0	0	0
10967	50	10	0	0	0	0	0	0	0
16971	0	0	0	0	0	0	0	10	0
16972	40	4	0	0	0	0	0	0	0
16975	41	0	0	0	0	10	0	0	10
16976	46	5	0	0	0	0	0	0	0
16978	31	0	0	0	0	0	10	10	0
16979	43	0	0	0	0	0	0	0	0
16981	50	5	10	0	10	0	0	0	0
17008	36	9	10	0	0	0	0	0	0
17125	44	4	10	10	0	0	0	0	0
17179	17	0	0	0	0	0	0	0	0
17217	47	10	10	0	0	10	0	0	10
17283	36	6	0	0	0	0	0	0	10
17286	46	9	0	10	10	10	10	0	0
17296	36	10	10	10	0	0	10	0	0
17334	37	0	0	0	0	0	0	0	0
17380	36	4	0	0	10	0	0	0	10
17392	45	6	10	0	0	10	0	0	0
17393	31	10	0	0	0	10	0	0	0
17569	40	0	0	0	0	0	10	0	0
17574	48	10	0	0	0	0	0	0	0
mean	34,25532915	8,66666667	8,66666667	5,45454545	10	8,66666667	8,66666667	8,66666667	8,66666667

Mittelwert: 34,48148148 Anzahl: 27 Summe: 931

**Figure 5: Average Mark in the first exam in general and for students who attempted self-test 5**

With another query on our database it would be possible to generate a Pivot Table containing the results of the two exams and the students who have used other learning materials like slides, past exams or complementary reading. The impact of using that specific learning material on the final mark can be investigated in a similar fashion.

**Conclusion and Future Work**

In this paper we have investigated the usefulness of Pivot Tables to analyse usage data stored by Moodle. For this purpose, after a short introduction to pivot tables, we have shown an analysis performed on the course “Formal basics of Computation” taught at the Beuth University of applied science. The analytical processing shown focuses on use of resources by students and impact of specific learning material, here non compulsory self-tests, on the final exam.

Working with the Pivot Tables is in most cases quite intuitive and allows a flexible analytical processing of user data. Though the present surface charts are enough to grasp the trend, their quality is not optimal. Excel 2010 Pivot Tables lack the facility of a nice hit map (or we have not found it yet).

The immediate next steps go into two directions. One direction is to conduct more case studies with our partners to gain a better overview and understanding of the various learning analysis processes that different actors perform and to establish a kind of roadmap or list of best practices for newcomers. Another direction is to integrate the export towards Excel facility into the tool LAMA we are developing (Dierenfeld 2012). LAMA is a web application that users can access from Moodle over a Moodle block. Its aim is to support different actors to analyse user data from learning management systems. It should be adaptable to and by different kinds of actors according to their needs or skills and therefore have different modes. For the time being we have identified two modes: the simple mode for a quick overview, and the mode for actors with knowledge on Pivot Tables. A challenge is to integrate a mode with data mining techniques that non computer scientists can use in a correct way. We also pursue work in that direction.

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