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MOCLog – Monitoring Online Courses with log data

Riccardo Mazza[1], Marco Bettoni[2], Marco Faré[1], Luca Mazzola[1]

[1]eLab – eLearning Lab, USI – Università della Svizzera italiana, Via Buffi, 13, Lugano - Switzerland

[2]Swiss Distance University of Applied Sciences (FFHS), Überlandstrasse 12, Brig - Switzerland

Abstract

The purpose of the MOCLog project is to develop a tool for the analysis and presentation of log data on a Moodle server. The new idea of MOCLog is to combine in a useful tool a didactical theory with users' data and to serve the needs of four groups of stakeholders: students, teachers, study program managers and administrators. The approach that we followed with MOCLog is the analysis of learning activities in online-courses from a didactical point of view (learning process and outcomes), thus going beyond than simply counting and visualizing the numbers of posts and clicks. For this purpose, a model of the log file analysis was proposed, derived from didactical principles, and an analysis of user requirements. These requirements have been collected through interviews with stakeholders, theoretical studies from the literature, and from the experience of our team members as researchers in eLearning. Based on this, a model composed by a concept map, a solution map and use cases was developed. Implementation started from these use cases and specified a design that allows realizing them within the context of Moodle, either by reusing components available from the GISMO system, or by implementing new ones. After a series of different tests and the implementation of related improvements, the MOCLog system is now available for deployment and exploitation in academic institutions.

Keywords

Students tracking, log analysis, log file analyser, learning analytics, educational data mining.

Introduction

An important aspect of online teaching and learning is the monitoring of student progress and tools utilization in online courses. Educational research shows that monitoring the students' learning is an essential component of high quality education. Using log files of learning management systems can help to determine who has been active in the course, what they did, and when they did it. (Romero, Ventura & Garcia, 2007). Feedback about the status and the history of the activities in online-courses can be useful to teachers, students, study program managers and administrators. For example it can help in better understanding whether the courses provide a sound learning environment (availability and use of discussion forums, etc.) or show to which extent best practices in online learning are implemented (students provide timely responses, teachers are visible and active, etc.). Learning Management Systems provide some reporting tools that aim to monitor students' and tools' usage, but these are seldom used mainly because it is difficult to interpret and exploit them; the obstacles to interpretation and exploitation are the following:

- Data are not aggregated following a didactical perspective;
- Certain types of usage data are not logged;
- The data that are logged may seem incomplete;
- Users are afraid that they could draw unsound inferences from some of the data.

In the attempt of overcoming these difficulties, new reporting functions of LMS have been added, for instance Moodle now provides reporting tools which enable teachers to evaluate the activity patterns of individual students. Moreover in the last few years researchers have begun to investigate various data mining methods which allow exploring, visualising, interpreting and analysing eLearning data thus helping teachers in better understanding and improving their eLearning practice (Romero et al. 2010) (Mazza & Botturi, 2007).

In the project presented here we implemented MOCLog, a monitoring system that helps to analyse log files of Moodle by focusing on a didactical point of view; in this way we hope to provide foundations for improving the quality of teaching and learning. The specific objectives that contribute to reach this aim are:

1. A systematic process of log file analysis for online courses (MOCLog-process)

2. The definition of a suitable model of log file analysis (MOCLog-model)
3. The design and implementation of a monitoring tool (MOCLog-tool) based on the MOC-log-model

MOCLog combines in a useful tool a didactical theory with physical data (log files). By analysing the use of the contents in the online-courses from a didactical point of view, MOCLog allows deeper analyses than simply counting and visualising the numbers of posts and clicks. Another key feature is to avoid using entries by students and to rely instead on log files (obtained from system reports) as an input. The goal here is to measure the status of activities in the online-course as much as possible without distortions, 'objectively', by relying exclusively either on log file data or on planning data provided by the course administrators and by the teachers as reference values. The benefits of MOCLog for the higher education sector are:

- Offering relevant interpretation schemes for log file analysis
- Suitability of the interpretation schemes for transfer to other LMS
- Easier and faster analysing of the log files in the online courses in Moodle
- Feedback (numeric, graphic) for all important stakeholders of the LMS (Student, Teacher, Study Program Manager, Administrator)

Related works

An extensive analysis was performed, searching for software that shares similar goals with MOCLog. Several Moodle plugins (blocks and reports) were found and 29 plugins (15 blocks[1], 8 reports[2], 6 other types[3]) examined. None of them covers all 4 user types addressed by MOCLog. Furthermore, 4 papers on this subject were found and examined. Jong, Chan, and Wu (2007) present a learning behavior diagnosis system to study the students' learning status from learning portfolios. The proposed linking layer enables the proposed system to work on various eLearning platforms without reprogramming. Additionally, the use of a supervisory agent enables teachers and students to obtain their learning status or information provided by the proposed system in both Web and e-mail. Günes, Akçayb & Dinçera (2010) is a paper devoted to log analyzer programs and gives general information on this topic. Cocea and Weibelzahl (2009) investigates the possibility of predicting users' level of engagement, with a focus on disengaged learners, using data mining techniques for log file analysis. The paper presents the findings of three studies that refine this prediction approach. Zhang, Almeroth et al. (2007) describes an already implemented Moodle plugin that can send reminder to students about course summary, per-student statistic, per-resource statistics, and time-based statistics. Among the solutions found, GISMO is the tool that provides the most comprehensive set of information. GISMO (Mazza & Botturi, 2007) is a block plugin for Moodle, developed by one of the project's partners. GISMO is a graphical interactive student monitoring and tracking system tool that extracts tracking data from Moodle, and generates graphical representations that can be explored by course instructors to examine various aspects of distance students. Since GISMO provides already several functionalities needed by this project, it was included in the MOCLog tool for the analysis of students' and teachers' data. A related research field, that could make use of our results, is that of "Learning Analytics", where the analysis of LMS logs (and many other methods) are mentioned as useful tools for example for predicting students' success in the context of measures taken for assuring student persistence (Sharkey 2011; Goldstein and Katz 2005). Moreover, one of the findings in Learning Analytics research which needs to be taken into consideration here is that it is difficult to make meaningful comparisons between activity in different courses (Lauría and Baron, 2011).

User requirements

For interpreting the traces of learning activities we need to complement a theoretical understanding of eLearning quality with eLearning good practice, i.e. the experience of our stakeholders (LMS administrator, Study program manager, teacher, student). This is the role that stakeholder requirements play in our MOCLog model: they represent the view from experience in the shape of needs and benefits expected from the MOCLog tool from the different types of stakeholders involved (next is a first list of them).

[1] The blocks we examined are: ActiveUsers, Completition Report, Course results, Criteria Reference Display, GISMO, Inactive Users, Live Stats, Most active courses, Progress, Progress bar, resource stats report, Sysinfo, Timestat, Usage, Use stats block

[2] Reports we examined are: 5 admin reports (Category Activity Report, Comparative Reports, Course Size Report, Message Log Report, Module Use Report); 2 course reports (Summary Report of Log/activities between sequence of Dates, Use Time Based Progress Report); 1 grade report (Site Wide User Report).

[3] Plugins of other types were examined: 2 patches (Quiz Report Analysis, Progress Tracker); 1 unknown (Statistics in Moodle); 1 package (Checklist); 1 activity module (Course tracking module); 1 extension for administrator reports.

The requirements analysis performed in the beginning of the project was conceived as a case study, not as a representative statistical inquiry; our case study has pointed to some important needs and benefits for our stakeholders, while other were derived from the experience of our team members as researchers in eLearning, as teachers that use LMS systems and as contributors to the management of study programs and to the administration of Moodle sites.

The MOCLog system wants to support four stakeholders that are involved in the monitoring of online-courses:

- **Student**: focusing on self-monitoring the own learning process.
- **Teacher**: focusing on monitoring the students' learning process and on didactic-methodical aspects of the online-course.
- **Study program manager**: focusing on monitoring all courses of the study program and on the usage of the LMS by teachers/students) .
- **Administrator**: focusing on monitoring all online-courses of the institution and mainly on technical aspects, as well as on general didactic aspects.

In order to elicit requirements from our stakeholders, we conducted an analysis with a number of individuals of each category. Main results of our analysis are summarized here.

Administrator's requirements are driven by annual report and eLearning strategy. The use cases are often very complex. Their main goal is to switch from the current manual and time-consuming process to an automated, complete, comprehensive and consistent, no media break and standardized process. We found that administrators are interested in: compiling reports, identifying usage trends, identification of "good", "active/inactive" or "not used" courses - by parameters, selection, and the analysis of individual courses with the aim to offer individual coaching and to analyse why something happens (e.g. which teacher action generates which students reaction?)
Study program managers want different information about teachers e.g. identification of heavy and weak users. A diagram with the division of the log files in the three elements (distribution, interaction and collaboration) would be useful. In our case study we interviewed 6 study program managers and found out that for them the most important indicators are: the course access (how often teachers access a course), resources usage (see how often they are added or updated), news forum usage (how often teachers post messages) and an overview of the study program (what teacher does what number of courses and how, distinguished in the 3 categories: distribution, interaction, collaboration).
For **teachers** content related issues are more important than interaction related issues. Overall the major aspects of high importance to the teachers related to the course content are: students' course access, resources' visits, resources uploaded by students, course interaction (in which time frame do students upload the assignments, etc.)
Students spend an average of one hour per week on Moodle. The LMS platform is used mainly for test exam preparation, knowledge testing, and assignments. The most important monitoring functions that the students would like to have are: presentation of his test and assignment results, information about which areas he/she has weaknesses, indication about resources visited/unvisited, presentation of his test- and assignment-results related to the average of his class.

A model of log analysis

Based on a review of research literature and the mentioned requirements analysis, we developed the MOCLog model, a combination of a concept map, a solution map and a set of use cases. We wanted our model to act as a guide indicating the goals and direction in which tool implementation should go and what to pay attention to on the way to the implementation of those goals.

Concept Map
We need to clarify in terms of learning theory the monitoring questions by students and teachers. From our research review, the best approach that we have found for this task is constituted by the theory of eLearning functions by Reinmann-Rothmeier (2003) and Reinmann (2006). In order to transfer this model in our log file analysis, we will describe the Reinmann's model in terms of a concept map, and then we extend that concept map to fit it into our monitoring task (connect it with log files and with requirements).
The concept map (Figure 1) gives us a better understanding of log file analysis by clarifying the concepts involved and their relationships. We see on the left end of the map the "learning success" disc (where "success" means to reach the learning objectives) and on the right side the "log file" disc (meaning the collection of LMS activity traces). Between the two a sequence of 3 elements and their relationships connects the two discs like a conceptual bridge on which to walk for going from one end to the other. The learning success disc is on the left

because we start from here and it is here where we want to come back. This map answers the monitoring questions:

- Which way of eLearning enables to reach the given objectives?
- By which means (functions, tools) does the LMS enable these ways of learning
- How is the use of these means traced in the log files (activity log codes)?

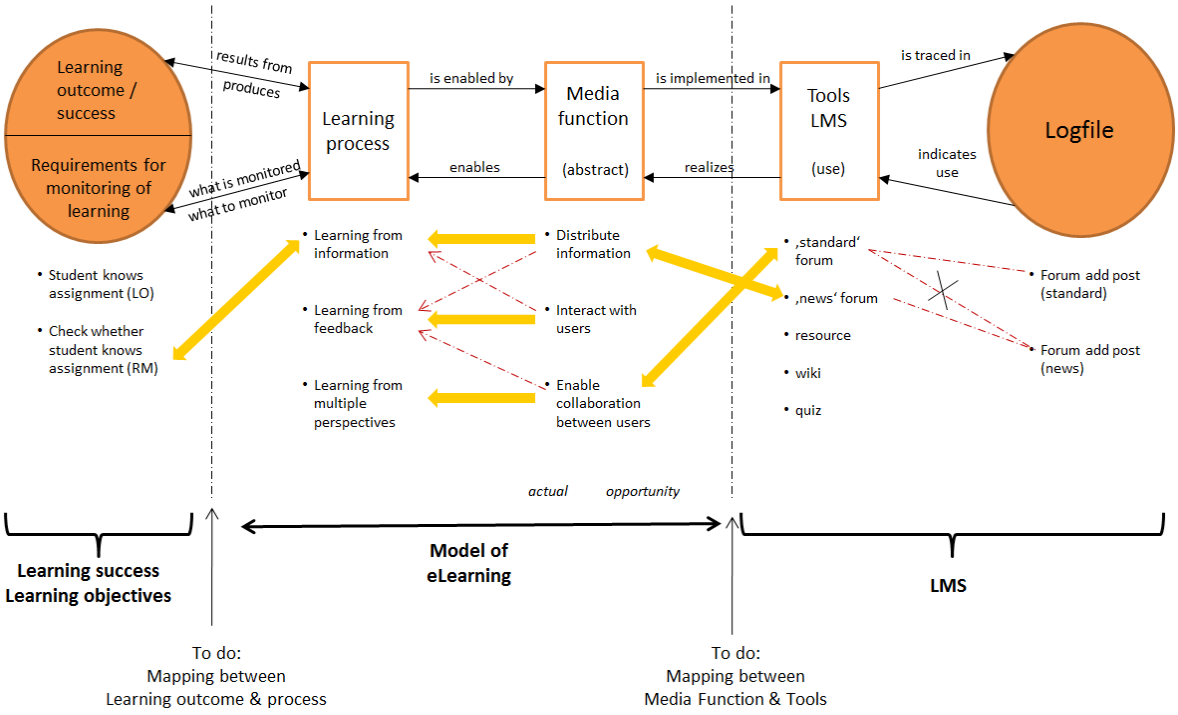

Figure 1: MOCLog concept map

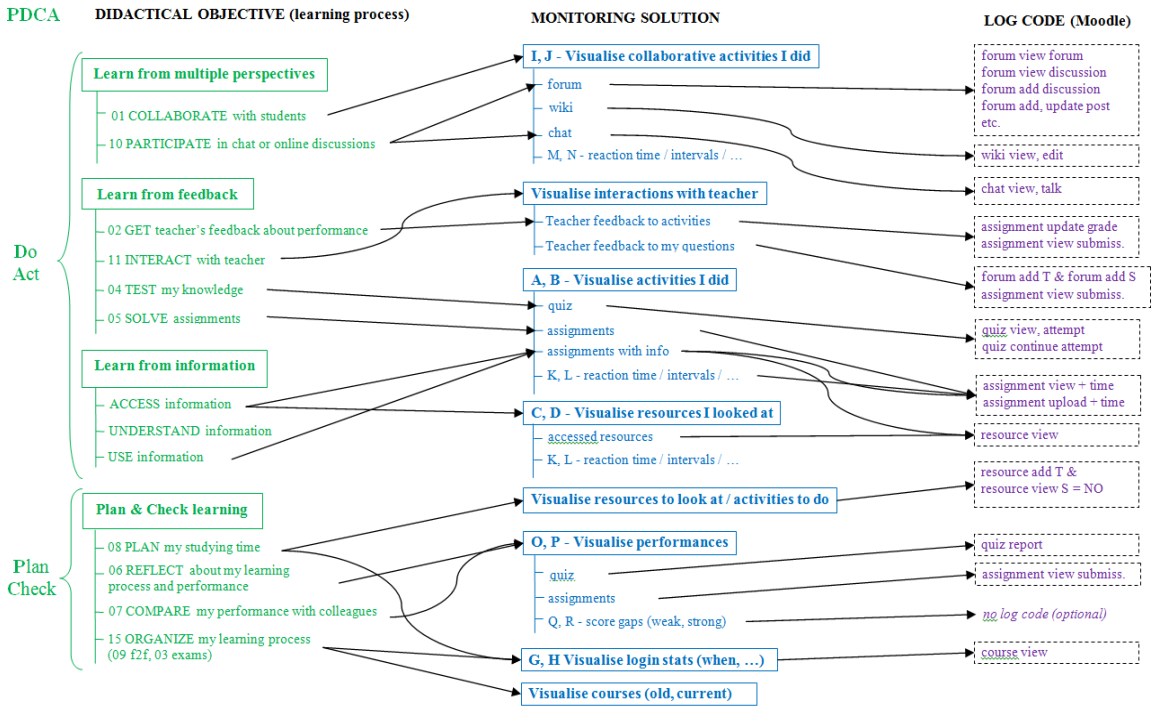

Figure 2: MOCLog solution map

Solution map

The MOCLog research team has defined a model that supports the design of MOCLog functionalities. This model is called *MOCLog solution map*: it is valid for all intended audiences and consists of the definition of functionalities based on the following elements:

1. The first column, "**PDCA**", specifies which of the map elements belong to the step "performing learning" and which to the step "controlling learning"
2. The second column, "**Didactical objective**", organizes needs (required "learning methods") in terms of the theory of eLearning functions
3. The third column, "**Monitoring solution**", displays another set of needs (required "desired functions") and shows with its left side connections how MOCLog could support the monitoring of a specific learning method; with its right side connections this columns shows how the solutions comply with metrics available in the LMS.
4. The fourth column, "**Log Codes (Moodle)**", displays logs (from Moodle) grouped in terms of the tool for which they are used in tracing the use of the tool.

The MOCLog solution map provides a mean to derive which information should be extracted and visualized from a Moodle LMS in order to satisfy a specific didactical objective. The solution map has driven the definition of the use cases, which are a specification of solution map for some didactical objectives that are requested by stakeholders.

Use cases

Use cases are the third component of the MOCLog model. By the term "use case" we indicate here a specification of how to use the MOCLog tool; it is an outside view (by stakeholders as opposed to the inside view of programmers) that is guided by the concept map, the solution map, and analysis and generalisation of user requirements

Table 1: Use cases for Students and Teachers

Use case	Indicators
Monitor Collaboration Among Students. Objective: to monitor how much the student collaborates with other students	Two different indicators: observations and contributions • Observations: reading of messages (in forum) or content (in wiki and chat). • Contributions: creation of new messages (in forum) or content (in wiki and chat) • Contributions: sum of contributions on forum, wiki and chats over the time
Monitor Interaction Teacher-Student. Objective: to monitor the interactions between teacher and individual students.	• Teacher view of forum • Teacher posting to forum • Teacher posting feedback to assignments • Teacher grading assignments.
Monitor Knowledge testing. Objective: to monitor the student's use of their available knowledge in tests	• Quiz view • Quiz submission • Assignment view • Assignment submitted
Monitor information access. Objective: to monitor the student's access to resources (file, HTML page, IMS package), assignments and quizzes.	• View of resource, also over the time • Submission of assignment, also over the time • Submission of quizzes, also over the time
Monitor organisation of learning. Objective: to monitor how the student organizes her own learning process by planning, preparing for f2f meetings, preparing exams, reviewing learning goals, looking at and comparing performances and reflecting about the learning statistics and outcomes as well as about the process itself.	• Pending resources: resources not viewed out of existing resources. • Pending assignments: assignments not viewed (or not submitted) out of existing assignments. • Pending quizzes: quizzes not submitted out of existing quizzes.

Table 2: Use cases for Administrators

Use case	Indicators
Monitor course activity level. The focus is on the course. The administrator wants to see the level of usage of courses.	• Course observations: activities of users aimed at observing course content (view of resources, reading discussions, etc.) • Course contributions: activities of users aimed at creating new course contents (adding or updating new materials, creation of quizzes, creating a new message in discussions, etc.).
Monitor tool use. The focus is on the tool. The administrator wants to distinguish which tools are used more and which less	• Observation of the use of tools • Contribution to the use of tools.

Table 3:use cases for Study Program Managers

Use case	Indicators
Monitor teacher facilitation level. The focus is on the teacher. The study program manager wants to identify the level of activity of teachers in facilitating learning with the LMS	• Teacher's facilitation of collaboration: observations and contributions by a teacher • Teacher's facilitation of interaction: usage of assignments and quizzes by a teacher • Teacher's facilitation of information: usage of assignments and resources by a teacher
Monitor Student learning level. The focus is on students (similar to the previous one)	• Students learning by collaboration: observations and contributions by a student • Students learning by interaction: usage of assignments and quizzes by a student • Students learning by information: usage of assignments and resources by a student
Monitor Course learning level. In this use case the focus is on course and on identifying the level of facilitation by teachers and the level of learning by students.	• Sum of Teacher's facilitation of collaboration and Students learning by collaboration • Sum of Teacher's facilitation of interaction and Students learning by interaction • Sum of Teacher's facilitation of information and Students learning by information

Implementation of the monitoring tool

By analysing the use cases for **students** and **teachers** previously described, we can see that the tool GISMO, developed by the University of Lugano, already provides most of the indicators for teachers. The current version of GISMO is aimed to support teachers. Hence, we proceeded with the extension of the GISMO tool to identify the role of the user (teacher, student) in order to propose the proper visualizations. We implemented specific visualizations for each of the use cases identified for students and teachers. For instance, for the case "monitor the collaboration among students" we extended GISMO (which already visualizes data of quizzes and assignments) to visualize data of forum, wiki and chat. The principle behind each use case is that the teacher is able to see data of all enrolled students; whilst a student can see only his own data. Since GISMO is already documented in the previously mentioned publications, we omit here the details.

The use cases for **administrator** and **study program manager** instead require new computations and visualization that are not provided by GISMO. Moodle system administrators have other needs than teachers and students: they are interested in the overall activity of users, the evolution of the LMS's tools usage, and aggregated user or course activity. Study Program Managers are interested in the activities of teachers, or the activities of whole classes. Showing detailed student activity within the context of a specific course over a short period will not be relevant. For this reason, we implemented a specific Moodle block that is accessible only to users having the *administrator* or *manager* role.

Moodle already provides some specific reports for administrators. However, standard Moodle server reports do not contain facilities to configure reports based on user-specific parameters. For this reason, we implemented a customizable reporting system serving to permanently choose and store parameter configuration sets. For instance, we generated specific reports for administrators use case (see Table 2): *course activity* report (which

focuses on course and students data), *tool activity* report (which focuses on specific Moodle activities). The novelties with respect to the existing reporting Moodle server reports are the configurations and the calculation schema that we can set. In particular, for each report, we can set the following configurations:

- **Course domain:** a selection of relevant courses, based on course categories;
- **Date/Period:** time or timespan of interest;
- **Report settings:** layout and data selection of the reports;
- **Role:** user roles to be included in reports;
- **User:** user groups (configurable by administrator or study program manager);
- **Profile:** specific criteria for calculating the usage in tools and courses (each report can have more profiles associated).

Each profile has specific **parameters** that allow an administrator or study program manager to assign weights to the different ways (read, write, update, etc.). Moodle users can apply tools such as assignments, wikis, or quizzes. The system proposes scores, which should be normalized to some constant sum (10). For instance, we can set that reading a messages thread in discussions counts 2 points, while the submission of a new message counts 8 points. Scores are calculated taking into considerantion users' activities registered in log entries and other data registered in Moodle database (taken as they are collected by Moodle, without any data cleaning). Parameter sets can be saved, recalled, and modified. This allows users to **create different profiles that reflect specific use cases** and specific users' needs. For instance, the use case "*Monitor course activity level*" for administrators (see Table 2) requires the implementation of two reports: *course observations* and *course contributions*. These two reports can be obtained by creating two different profiles having the following parameters:

Points

	view	update	delete	upload/write
assignment	10	0	0	0
folder	10	0	0	0
forum	10	0	0	0
page	10	0	0	0
quiz	0	0	0	0
resource	10	0	0	0
wiki	10	0	0	0

Figure 3: Profile settings for monitoring course observations

Points

	view	update	delete	upload/write
assignment	0	2	0	8
folder	0	2	0	8
forum	0	0	0	10
page	0	1	0	9
quiz	0	0	0	10
resource	0	2	0	8
wiki	0	5	0	5

Figure 4: Profile settings for monitoring course contributions

These configurations are used to create the course activity reports with two possible configurations: one for course observations and one for course contributions. Reports can be generated in textual format or graphical format, and the choice of the type of visualization is decided by the user (see Figure 5).

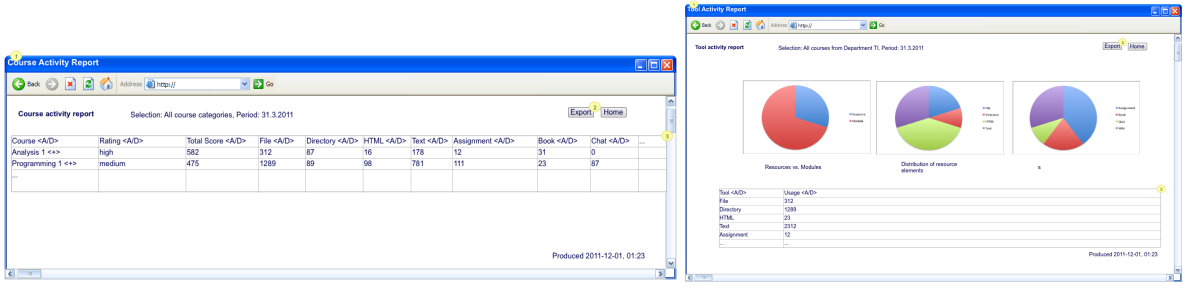

Figure 5: Two examples of reports, textual format (left) and graphical format (right)

ISBN

Conclusions

In developing the MOCLog system we focused basically on three principles or guidelines: a diversified set of stakeholders, a didactical approach and the reuse of an existing monitoring system. The challenge was how to equilibrate these 3 very different influences into one integrated system. The solution that we found had three stages; first eliciting and analysing requirements from all the 4 envisaged stakeholders groups; then developing an innovative, didactically oriented model of log file analysis; and last but not least implementing a flexible monitoring tools that allows to create different profiles that reflect specific use cases, by configuring specific usage parameters. A preliminary evaluation of the MOCLog tool was performed using two methodologies: an experts analysis and a restricted users analysis. Goal of these analyses was to test if specific users can use the tool to achieve specific goals with effectiveness (task completion), efficiency (task in time) and satisfaction in a specific context of use (ISO 9241-11). Testers tested the tools following a predefined set of tasks included in a given scenario, based on requirements. The next step in this project is the professional analysis of the usability based on scientific methods with objective eye tracking systems/data. The usability testing results will be evaluated and the tool will be revised based on the usability evaluations. With this in the background our next goal will be the exploitation/deployment of the tool both in the institutions of the project partners as well as in other institutions (universities, universities of applied sciences and education that use Moodle).

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