

Improving the User-Friendliness of AAT through a Staged Evaluation*

Tamra Ross^a, Ting-Wen Chang^b, Cindy Ives^a, Nancy Parker^a, Andrew Han^a and Sabine Graf^a

^a Athabasca University, Canada

^b Beijing Normal University, China

tross@athabascau.ca; tingwenchang@bnu.edu.cn; {cindy; nancyp; andrewh; sabineg}@athabascau.ca

Abstract—With the rapid adoption of online learning technologies, there is a pedagogical imperative to evaluate the success of online courses and analyze how student interact with electronic communication and learning resources. There is substantial data in learning management systems (LMSs) to inform this research, and many software tools aimed at mining LMS data or providing statistics or visualizations about those data. However, these tools provide either overviews or are very specific to the information they show. In this paper, we introduce the latest revision of the Academic Analytics Tool (AAT), which empowers users (e.g., teachers, learning designers) to do their own investigations into complex educational data stored in LMS databases. AAT allows non-technical users to answer almost limitless questions about learners' behavior and the impact of teaching methods and learning designs. To improve the user-friendliness of AAT, which is one of the core goals of the tool, a staged, qualitative evaluation study has been conducted. By improving AAT's user-friendliness, the tool gets more effective in supporting users and enabling them to use the huge amounts of educational data to learn how students interact with courses and learning materials as well as about the effectiveness of teaching methods and learning designs.

Keywords—Academic analytics; learning management systems; data extraction and analysis

I. INTRODUCTION

With the growth of online learning technologies, educational institutions have access to an unprecedented amount of data about how students learn and interact with educational resources [1]. Yet, teachers and learning designers often get little feedback about how students are interacting with and learning in online courses. The challenge is to develop tools and methods for analyzing this data, and making it accessible to teachers, course designers, and the administration [2].

There is also a need to analyze the effectiveness of modern course designs and teaching strategies, to ensure educational institutions are not only emphasizing on available resources, but the educational outcomes of courses [2]. The rapid adoption of online learning technologies has radically changed how students access courses and educational resources: recognizing and adapting to these changes is critically important in developing courses that are compatible with how students learn in a modern context [3]. While there are vast stores of educational log data to inform this research,

there is a need for tools to provide teachers and learning designers with direct access to the data [3].

To address these challenges and needs, we have developed a browser-based tool that allows users without programming skills to build queries and generate customized reports of complex educational data from learning management systems (LMSs). The Academic Analytics Tool (AAT) [4][5] uses a familiar wizard-like interface that allows users to “ask” questions to a LMS's database using a series of easy steps. Thus, AAT provides non-technical users with easy access to all data stored in a LMS's database, as well as functionality to investigate and analyze this data. In this paper, we introduce the latest revision of AAT as well as a staged evaluation that we performed in order to improve the user-friendliness of the tool.

The remainder of the paper is structured as follows. Section 2 provides an overview of related works. Subsequently, we introduce the latest revision of AAT, followed by Section 4 which describes the staged evaluation of AAT. Section 5 concludes the paper.

II. LITERATURE REVIEW

With the expanding store of educational log data at most educational institutions, there is an opportunity to gain significant insight into student behavior and the effectiveness of current teaching methodologies and course designs. Furthermore, there is a growing desire amongst educators to improve online teaching by offering learning opportunities customized to individual learners [6]. To accommodate these needs of learning designers and teachers, there is an urgent need for a tool or method to allow them to easily access and analyze student data, receive it in a format that is easily understood by users who are not versed in computational analytics, and share their insights and results with peers [7][8]. Providing access to the data is not enough, however. To encourage teachers and learning designers to explore and use the available data, tools must be designed in a user-friendly way, with their needs in mind [7].

Tools that are currently available for the purpose of learning analytics fall into two functional groups. Educational data mining (EDM) tools (e.g., CoSyLMSAnalytics [9] and MUSKUP [10], etc.) rely on statistical or artificial intelligence-based analysis, and other heuristics to provide fast and efficient automated quantitative analysis on large scale databases [11]. These tools efficiently detect patterns in very large sets of data, but they are typically focused on one (or a few) aspects of the learning process and are not tailored toward helping educators and learning designers direct their own investigations. Furthermore, some of these tools are not

* The authors acknowledge the support of Athabasca University and NSERC.

designed for use by non-programmers and rely on specialized training in analytics or additional software that is not easily accessible to the average user.

The other group of tools consists of those that provide visualizations of existing data (e.g., GISMO [12], LOCO-Analyst [13], SAM [14], etc.). While these tools are directed to users without programming skills, they only provide them with predefined visualizations. These visualizations are useful to provide educators with a good overview of what is going on in their courses. However, educators are limited to exactly these visualizations and if they want to know something else or would like to do some further investigations into the visualized data, such functionality is typically not supported by these tools.

AAT has a different purpose than these two groups of tools as it aims to provide users without programming skills (e.g., teachers, learning designers, etc.) with the freedom to do their own self-directed investigations into the complex educational log data of LMSs. Through its user-friendly interface and additional analytical functions, AAT allows users to do simple as well as complex investigations to learn about students' behavior, as well as the effectiveness of course designs and teaching strategies.

III. AAT

The Academic Analytics Tool (AAT) is a web-based software developed with the needs of teachers and learning designers in mind. It allows users without programming experience to build queries to access, extract, and analyze information from learning management systems (LMSs) about how students interact with and learn from online courses.

At its core, AAT is a query-building engine with a wizard-style interface that steps users through the process of selecting database tables, columns, and limiting criteria using plain English instructions. Each page has detailed help text to guide users through the process, and completed queries are saved so they can be recalled, shared, edited, or extended as desired. Very little text entry is required, as most options can be selected by checking boxes or performing selections from lists. Additional analytical features permit further refinement or expansion of results, or precise targeting of key data.

While the queries generated by AAT can be highly complex, users do not need any expertise in data analytics; all tasks in AAT are performed by stepping through the wizard. The process of developing the most complex queries is broken into additional stages; the user first creates a basic query to identify the data to be experimented on. Then, this query can be used for advanced functions to target specific data. This allows users to save their results in stages and experiment with different options to target exactly what is desired.

In the following, we show a few examples of the broad range of questions that AAT can help to answer:

- Does high participation in course discussion forums lead to better grades?
- When teachers share the best solution of an assignment with the class, does such behavior impact students' performance on subsequent assignments?

- Are optional quizzes actually used? Does the usage of optional quizzes lead to better overall grades?
- Which quiz questions are outliers in terms of the average grade achieved by students?
- When teachers are more active in discussion forums, does such behavior impact students' overall grades?

In the next subsections, AAT's architecture and structure, general functionality, and analytical features are described.

A. Architecture and Structure of AAT

To achieve the goal of making AAT highly accessible, the software has been designed to run on any computer, and from any web browser. It requires no additional software, and nothing needs to be installed on the user's computer. The AAT code is PHP-based, using JavaScript and jQuery/Ajax calls to ensure high platform compatibility, fast processing, and to allow the server to perform all processing tasks. Housing the software on a university server has the additional benefit of allowing all users to access queries and results shared by other users.

A key feature of AAT is that it is designed to be used with any LMS that uses a relational database structure (e.g., Moodle, Sakai, Desire2Learn, etc.). This is accomplished via templates—tables that interface between the tool and databases to define and translate the structure of the target LMS's tables to the internal ontology of AAT. Templates both specify precisely where data resides in a database, as well as the relationship between those tables. Adapting AAT to a new LMS is as easy as building a new template. This structure not only ensures that AAT can be easily ported to new LMSs, it also makes it easy to update when an educational institution decides to make substantial modifications to its LMS installation.

AAT is also designed to work with multiple databases using the same LMS and database management system (e.g., if an institution has several instances of their LMS). Furthermore, AAT supports different database management systems such as Postgres and MySQL.

Because data stored in LMSs is highly sensitive, and access requires adherence to security protocols, AAT provides strong data security and password protection options that can be applied to individual accounts for direct access, or tied to the authentication system of the institution.

B. General Functionality of AAT

The general functionality of AAT is based on four elements: profiles, datasets, patterns and a framework of learning objects. In the following paragraph, these elements are described in more detail.

A **profile** in AAT can be seen as an experiment for extracting and analyzing information. It is also, functionally, a container that groups and holds all of the selections made by the user for the respective experiment. In a profile, users need to specify (1) the LMS to be accessed (i.e., the user selects a template associated to a specific version of Moodle, Blackboard, etc.), (2) the dataset to be used for extracting and analyzing information (i.e., which courses should be used), and (3) the pattern(s), which indicate what the user is interested in investigating.

A **dataset** is a list of user-selected courses to provide the data for the experiment. There is unlimited flexibility in the building of a dataset: a user may select any course, all courses, or any combination of courses they desire to group courses in ways meaningful to the specific question being investigated. To give a few examples, a dataset might contain all courses updated in a given month, all courses that use a specific learning resource, all courses that are designated as humanities, or business, etc.

Patterns are based on types of **learning objects**, which are digital resources that students interact with and learn from. These learning objects can include learning materials, forums, quizzes, blogs, an outline of a course, video and audio files, etc. A pattern specifies which learning objects, time spans, and specific details are to be investigated. A pattern consists of two components: **concepts**, where users specify what elements of a course they want to investigate (e.g., forums, quizzes, students, etc.), and **attributes**, where users select specific features of concepts (e.g., forum post messages, grades of quiz questions, names of students, etc.). Each concept can have one or more attributes, and users may select as many as they wish for each pattern.

As a final step in the pattern creation process, a user may apply **limits**—functions to refine the data with filters (e.g., include only grades higher than 70%, or only those students who started a course in the last six months). The limits builder corresponds to the WHERE clause of a SQL query and allows users to filter data on any attribute or combination of attributes, using a variety of comparison and filtering functions.

After a pattern is created and saved, patterns can be subject to further processing by **chaining**, where two patterns are combined to expand the result set, and **analysis**, where simple functions (e.g., count, sum, min, max, etc.) can be used to analyze data in more detail.

The results of patterns are typically in table-format (e.g., a list of students and each student’s number of postings in

forums and their grades; a list of quiz questions and each question’s average grade achieved by students, etc.) and can be displayed in a sortable table on screen. Furthermore, results can be exported in CSV, XML, or HTML format for distribution. In addition, as AAT is mainly used to easily access complex data from LMSs and do some basic operations on these data (e.g., filtering data, building average, counting occurrences, etc.), results can be used in other tools to do more sophisticated analysis. For example, statistical tools (e.g., SPSS) can be used to calculate correlations based on the results outputted by AAT; visualization tools can be used to visualize results; data mining tools can be used to run advanced data mining algorithms on the results; etc.

To aid the user in understanding the effect of their selections, many of the stages of query development offer a preview window that is updated as the user selects or deselects different options. An SQL preview window also provides a dynamically updated view of the generated query, for the information of users who are familiar with query language. Furthermore, to provide a strong user support at every stage, a pane on the left side of each page is used to provide an explanation on what the respective pages is about. A user guide and additional descriptions for key terms/phrases on each page are also provided.

C. AAT Analytics

Once a pattern has been developed, it becomes available for further processing. AAT has built-in analytical features for this purpose. The pattern analysis interface (shown in Figure 1) provides options to extract precise data from a pattern using calculations and filters that can be applied to an individual field (to produce a single calculated result) or to the entire table of data (to produce a new column with the calculated result for each entry). Analysis options currently include count, sum, average, min, and max.

In the following, a few examples are presented, showing

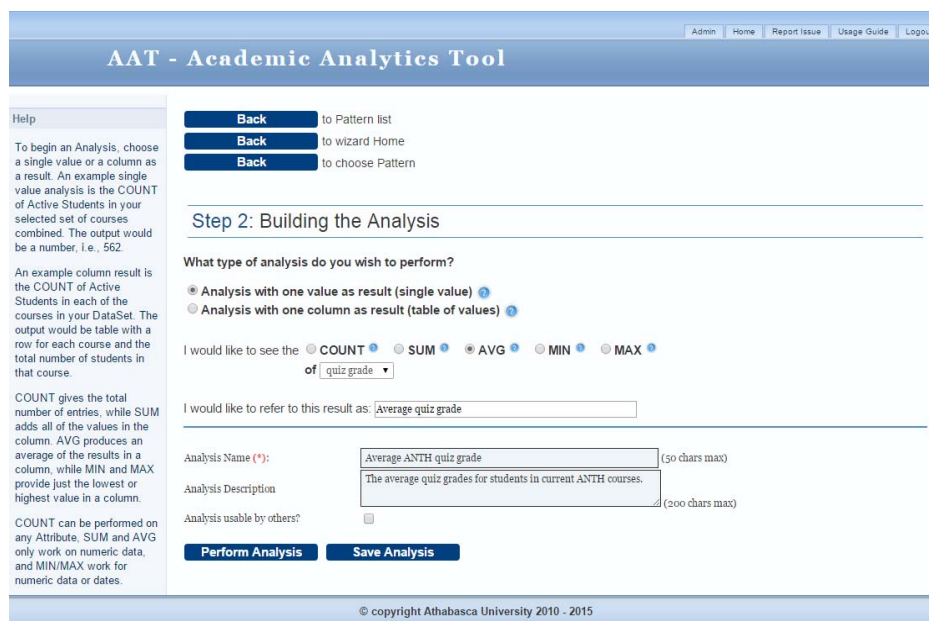


Figure 1. AAT Analysis Interface

the types of analyses that can be performed:

Analysis with a single result output:

- Count all of the forum postings in the selected courses and provide a single sum.
- Calculate the average grade of all students in the result set.
- Display the highest grade (maximum) achieved in the selected course.

Analysis with a columnar result output:

- For each student, calculate the highest grade achieved and return as a column added to the results table.
- For each course in the result set, calculate the average number of forum posts.
- For each learning resource listed, calculate the number of students who have accessed it.

In keeping with the broad applicability of AAT, a simple pattern can produce a generic, unfiltered list of data based on the selected concepts and attributes. With analytical and limiting features, a pattern can extract very specific data (e.g., list all students who achieved a grade lower than 60% on Assignment 1 in a given course), or may include a formula where the tool performs calculations on extracted data (e.g., to find out the average amount of time students in a given course spent on the quizzes, or the number of times a given discussion forum has been visited by students over a specified time range, etc.).

IV. EVALUATION

During the design and development of the tool, the project team, including people who are actively involved in teaching and learning design, were meeting frequently to discuss the progress of the tool and give feedback to the developers. Once the first version of AAT was ready, a staged qualitative evaluation was conducted, mainly focusing on evaluating the user-friendliness of AAT. In the next subsection, this evaluation process is described in more detail, and subsequently, the results of this process are described.

A. Research Design

The research design for evaluating and continuously improving the user-friendliness of AAT was based on two phases. In each of these phases, an evaluation was conducted, using the following steps. First, users were presented with a demo of the tool, explaining to them the aim of the tool and showing them how the tool works. Second, users were provided with access to AAT and had the opportunity in a training session to try out the tool. During this training session, users were provided with exercises in order to guide them from simple tasks to more complex ones, and help them to explore what kind of questions AAT can answer. Users were also provided with solutions to the exercises so that they could check whether they managed to use the tool correctly. Furthermore, during the training session, researchers were available to answer any questions users had. The exercises covered all functionality in the tool but in addition, users were encouraged to test the tool in any way they liked with any other tasks/experiments they may be interested in. Third, during and after the training session, researchers col-

lected feedback and suggestions for improvement from the users. Fourth, after the training session, the collected feedback and recommendations were analyzed and if feasible and in line with the aims of AAT, they were implemented in the next revision of the tool.

In the first phase, simulated data was used. The demo and training session were held in June 2014 with 4 users participating in the evaluation. In the second phase, real data from an entire educational institution were used. The demo and training session of the second phase was held end of January and begin of February 2015 with 5 users participating in the evaluation (3 of these users took already part in the first phase). All users were learning designers (who are one of the main two target groups of AAT).

While the sample size for this study is rather small, it has been shown that small sample sizes can be sufficient for qualitative studies [15][16].

B. Results

In the first evaluation stage, we mainly received feedback in three areas. First, users provided us with seven comments about general user interface aspects, including, for example, that the position of buttons was unintuitive, the sequence of columns in the result pane is not intuitive, and SQL queries should be hidden. As a result, we significantly improved the user interface and ensured a consistent design on all pages. Second, the presentation of concepts in the pattern creation caused some confusion and users provided four recommendations on how to improve this part of the tool. Accordingly, the presentation of concepts was revised based on users' feedback. Third, three users suggested adding help text at different places to make some functions easier to understand. Furthermore, two of the three users commented on the terms (e.g., patterns, profile, etc.) which would benefit from some help text or renaming. Accordingly, help text was added in two ways: (1) on each page, we added a pane on the left side which provides general information about the page, what a user can do on this page, as well as additional information related to the page, and (2) at each term or phrase on the page that may cause questions, a "question mark" symbol was added which provides the user with an explanation on what the respective term or phrase means once he/she hovers over the "question mark" symbol. In addition, one new functionality was requested dealing with not only having private and public patterns but also private and public profiles. This suggested new functionality was implemented.

In the second evaluation phase, we received feedback in four main areas. One of these areas was about navigation, where we received overall eight comments. While we have done some changes regarding the positioning of buttons as well as making screens look more consistent, it seems that with these changes, the pages were looking too similar and it was more difficult for users to know where they were in the whole navigation process. Some of the suggestions we received included adding a menu on the left or breadcrumbs at the top, showing where a user is in the whole process. Furthermore, as the tool was now close to being launched more broadly, users provided us with additional advice (five comments) on how to improve the user guide and provide addi-

tional help for people who are not familiar with the tool (e.g., posting exercises and videos on how to solve them, creating a FAQ section, creating a forum for answering questions, etc.). In addition, users came up with six suggestions on how to extend the functionality of AAT (e.g., providing visualizations of the results, having some default patterns that are available for users right from the start, etc.). Another issue for which we received five suggestions was the dataset interface. As we were using real data from an entire educational institution, there were a lot of courses to select from and users were suggesting having some functionality to make this selection process easier. As a response, we did some modifications to the interface, sorted all courses alphabetically instead of basing the sorting on the databases the courses were in, and added functionality to batch-select courses by holding the “Shift” key and clicking on the first and last course in a range. Furthermore, we received three comments for the limits interface and another three comments on the analysis interface, as well as a few other minor issues which we addressed through respective changes.

Overall, it could be seen that the feedback and recommendations provided in the first phase were more basic user interface and usability issues, while the feedback and recommendations of the second phase were more related to advanced usage of the tool, making it ready for launch, and ideas on extending the tool with new functionality.

V. CONCLUSIONS

This paper introduces the latest revision of the Academic Analytics Tool (AAT) as well as its evaluation addressing user-friendliness. AAT aims at providing non-technical users with easy access to educational log data. AAT can provide users with answers to almost limitless questions about learning performance, resources, and behavior, from the simple (e.g., how often did each student post in a discussion forum?) to the complex (e.g., how does a student’s grade in a prerequisite course correlate to their grade in the advanced course?). By using a staged evaluation process, we received different types of feedback for making the tool more user-friendly and were able to check whether our changes after the first phase were incorporated properly and helped to improve the user-friendliness of the tool.

By using AAT, teachers and learning designers can easily perform quick experiments to learn more about their students and courses, and answer questions as they arise. This addresses a need expressed by Siemens [17] that “the field of learning analytics (and its related research) must make such activities relevant to educators and administrators [via tools] that specifically aim at this group to help them understand, evaluate and act on the data that learning systems generate.” By improving the user-friendliness of AAT through a staged evaluation, the tool becomes more relevant for educators and learning designers, allowing them to easily access information and use evidence from student data for their interventions and course revisions, which again should make courses more effective and therefore, will lead to better student satisfaction and increased performance.

Future work will deal with incorporating the suggested new functionality into AAT. Furthermore, a quantitative

evaluation is planned through a questionnaire to evaluate AAT more comprehensively. Furthermore, we plan to use AAT for learning more about student behavior and the effectiveness of teaching strategies and learning/course designs.

REFERENCES

- [1] N. R. Aljohani and H. C. Davis, “Significance of Learning Analytics in Enhancing the Mobile and Pervasive Learning Environments,” Proc. of the Int. Conference on Next Generation Mobile Applications, Services and Technologies (NGMAST), 2012, pp. 70-74.
- [2] D. M. West, “Big Data for Education: Data Mining, Data Analytics, and Web Dashboards,” Governance Studies, Washington, DC: The Brookings Institution, 2012. Available at <http://www.brookings.edu/research/papers/2012/09/04-education-technology-west>.
- [3] F. Castro, A. Vellido, A. Nebot, and F. Mugica, “Applying Data Mining Techniques to e-Learning Problems,” *Studies in Computational Intelligence*, vol. 62, 2007, pp. 183-221.
- [4] S. Graf, C. Ives, N. Rahman, and A. Ferri, “AAT – A Tool for Accessing and Analysing Students’ Behaviour Data in Learning Systems,” Proc. of the Int. Conference on Learning Analytics and Knowledge (LAK 2011), ACM, 2011, pp. 174-179.
- [5] S. Kladich, C. Ives, N. Parker, and S. Graf, “Extending the AAT Tool with a user-friendly and powerful mechanism to retrieve complex information from educational log data,” *Human-Computer Interaction and Knowledge Discovery in Complex, Unstructured, Big Data*, LNCS, vol. 7947, Springer, 2013, pp. 334-341.
- [6] J. L. Hung, K. Rice, and A. Saba, “An educational data mining model for online teaching and learning,” *Journal of Educational Technology Development and Exchange*, vol. 5, no. 2, 2012, pp. 77-94.
- [7] J. C. Wayman, “Involving teachers in data-driven decision making: Using computer data systems to support teacher inquiry and reflection,” *Journal of Education for Students Placed at Risk*, vol. 10, no. 3, 2009, pp. 295-308.
- [8] Y. Zhao and K. A. Frank, “Factors affecting technology users in schools: An ecological perspective,” *American Educational Research Journal*, vol. 40, no. 4, 2003, pp. 807-840.
- [9] S. Retalis, A. Papasalouros, Y. Psaromiligkos, S. Siscos, and T. Kargidis, “Towards net-worked learning analytics – A concept and a tool,” Proc. of the Int. Conf. on Net-worked Learning, 2006, pp. 1-8.
- [10] H. Guruler, A. Instanbullu, and M. Karahsan, “A new student performance analysing system using knowledge discover in higher educational databases,” *Computers & Education*, vol. 55, 2010, pp. 247-254.
- [11] R. S. J. D. Baker and K. Yacef, “The state of educational data mining in 2009: A review and future visions,” *Journal of Educational Data Mining*, vol. 1, no. 1, 2009, pp. 3-16.
- [12] R. Mazza and L. Botturi, “Monitoring an online course with the GISMO tool: A case study,” *Journal of Interactive Learning Research*, vol. 18, no. 2, 2007, pp. 251-265.
- [13] A. Liaqat, M. Hatala, D. Gasevic, and J. Jovanovic, “A qualitative evaluation of evolution of a learning analytics tool,” *Computers & Education*, vol. 58, no. 1, 2012, pp. 470-489.
- [14] S. Govaerts, K. Verbert, E. Duval, and A. Pardo, “The student activity meter for awareness and self-reflection,” Proc. of the Int. Conf. on Human Factors in Computing Systems, ACM, 2012, pp. 869-884.
- [15] N. K. Denzin and Y. S. Lincoln, *Handbook of Qualitative Research*. Thousand Oaks, CA: Sage Publications, 1994.
- [16] G. Guest, A. Bunce, and L. Johnson, “How Many Interviews Are Enough? An experiment with data saturation,” *Field Methods*, vol. 18, no. 1, 2006, pp. 58-82.
- [17] G. Siemens, “Learning analytics: envisioning a research discipline and a domain of practice,” Proc. of the Int. Conf. on Learning Analytics and Knowledge (LAK 2012), ACM, 2012, pp. 4-8.