# Tales of a Companion Teacher Analytics

Paul Libbrecht, Ulrich Kortenkamp,[1] Sandra Rebholz, Wolfgang Müller [2]

[1]Center for Educational Research in Mathematics And Technology (CERMAT),
Martin Luther University Halle-Wittenberg, Germany `http://cermat.org/`
[2]MEVis, University of Education, Weingarten, Germany

**Abstract.** In this paper we sketch a multi-step scenario of a teacher and her classroom, who uses a few computer-based learning tools and their attached teaching analytics views. The tools that are described are extensions of the toolset of the authors (ComIn-M and SMALA) and others; the scenarios should thus serve as user-story in the design of future analytical softwares that support the teacher's management of her courses. Our sketch attempts to apply concepts of the instrumental approach where the computer-based artifact becomes an instrument as its usage obtains its sense in the user's life as well as their orchestration.

**Keywords:** teaching analytics, math learning, teachers, adapations, learning process, web-based learning

## 1 Introduction

The adoption of computer-based learning tools in schools has been slow. Difficulties of multiple sorts have been met by most teachers for which technology-enhanced learning is often a nice excursion with multiple pitfalls, the permanent requirement of a plan B, and the frequent experience of an overwhelming technique. Some categories of usages, especially in higher education, have been acquired (too often only for communication purposes), but the lack of trust of the teachers in the usage of learning tools remains widely spread.

In order to release this mistrust, approaches to model the usage of the computer-based tools by teachers have emerged, notably the *instrumental approach* [Trouche 2005] which describes how the users and the learning and teaching tools evolve based on their mutual enrichment (the user's perception of the feasible actions is influenced by the tool, the *instrumentalization*, the representations on the tool's states achieved by the user, the *instrumentation*). While this model helps to understand the broad variability of achievements in using learning tools or any computer-based tools, it does not provide methods to empower the learners in using the learning tools or to control the achieved progresses.

Derived from this approach, the concepts of *classroom orchestration* has been proposed to describe how the activities of the teachers, students, and their use of technology-based tools are coordinated. Among the latest publications on this subject, [Tabach 2013] attempts to list types of orchestration, several of which we shall use in the scenarios below. The classroom orchestration explains

the ways for the teacher to manage the activities so that learning happens. However, it does not really explain how to assess the learning performance and how to interpret this information to improve teaching and learning appropriately.

Teaching analytics [Vatrapu et al. 2011] provides ways for the learning to be tracked at the scale of a classroom, that is, it provides ways to monitor the effects of the orchestration. The analytical activity that the teacher can perform leveraging *log-views* [Rebholz et al. 2012] can lead her to better adapt the teaching taking in account the instrumentation and instrumentalization that happened thus far and the one that she wishes to happen.

The scenario we sketch below is based, mostly, on the SMALA toolset, described in [Rebholz et al. 2012] with all mentioned and depicted functionalities being implemented, except for Figure 5 and the facility to *spot and show*. SMALA provides an infrastructure for automatically tracking learning activities and recording the solutions and solutions steps taken by learners when they are working with computer-based tools. In addition to the documentation of individual learning processes, SMALA also provides summaries of the performance of the whole learning group. Visualizations support the teacher in getting a quick overview of the class' activities and point to common problems and possible misconceptions by representing the results detected by the automatic assessment component of the various learning tools. As opposed to the log views provided by other Learning Analytics toolsets [Dyckhoff et al. 2012, Govaerts et al. 2011], SMALA does not focus on data typically collected by Learning Management Systems (e.g., the number of used resources, the number of earned credit points) or advanced activity metrics, but allows the representation and analysis of learning data down to the level of the individual *solution process*.

Based on this perspective, the following usage scenario outlines the teaching practice in mathematics classrooms when using computer-based learning tools integrated in a learning analytics infrastructure. Real-life examples of technology-enhanced learning environments and details from current SMALA log view visualizations illustrate the scenario and demonstrate the practical relevance of the described setting.

## 2 Scenario: A Teacher's Instrumenting Activity

Our hero is a university teacher educating future mathematics teachers. He wishes to introduce the proper use of proofs by induction, a topic that is well known to create lots of confusion in young students but remains quite important for many proofs of the mathematical knowledge. Thus, he decides that the usage of a learning tool to train such proofs is desirable. ComIn-M [Rebholz & Zimmermann 2011] is such a learning tool. It can be run on contemporary laptops'and desktops'web-browsers, which also access the learning management system of the university for all students.

The teacher contacts the editors of the learning tool, which provide her with an online learning *activity*. In there, she can read the instructions to deploy the learning tool within the learning management system: simply uploading a

content package will create an online resource from which students can start the learning tool. She shall make it visible a bit later.

Following the didactical design pattern *technology on demand* [Bescherer et al. 2010], our teacher first presents a few situations of proofs by inductions and its typical errors in class and then introduces the usage of the tool. To do so, she presents the tool and performs one complete exercise with it. Somewhat similarly to the presentation on the right,[1] our teacher is able to connect in



**Fig. 1.** Demonstrating the usage of a tool in class.

words and graphics the learning tools'representations and the course's concepts. Her approach follows mostly the orchestration *explain-the-screen* [Tabach 2013].

At the end of the session, she invites the students to use the tool, demonstrating how it can be started in the learning management system; one of the exercises of this week's assignment is based on the learning tool.

Because exercises are optional, she cannot be sure that the exercises will be performed. As she feared, very few students actually attempted the requested exercise from what she can see in the log-views in the figure below: only 4 of her 150 students have trieds, and, as she can see in the assessment results table on the right, none have succeeded. In the graphic below, red cells represent wrong solutions, light red cells incomplete solutions, while (the missing) blue cells would represent correct solutions.
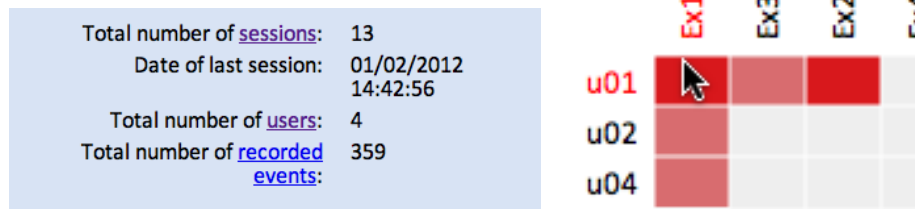


**Fig. 2.** Simple summary log-views for the class: a few numbers, a graphical display by user (u01, u02, ..) and exercise (Ex1, Ex2, ...).

For the following exercise session, thus, a plan change is communicated so that students come with their laptops to the university. The objective of the teacher is to let the students go through as many of the ComIn-M exercises as possible in small groups in front of the laptops but keep eyes wide open to ensure that they are progressing.

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[1] This presentation, about another learning tool, is available at `http://www.youtube.com/watch?v=jHBYtbdEic4`.

During the help session students are first given a briefing on the mission they are to aim at assorted with a set of practical and strategic instructions. Most of the rest of the class is spent in the classroom orchestration *monitor-and-guide* where the teacher, and possibly teaching assistants, come at each screen providing individualized help on demand. Typical help requests are answered in just a few minutes in an attitude similar to that pictured on the left.
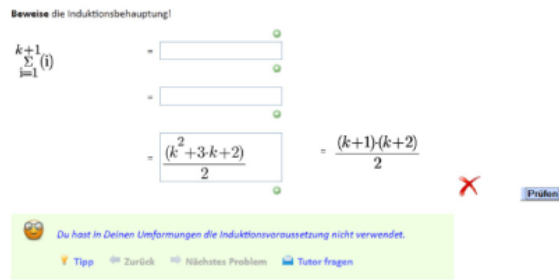


**Fig. 3.** *monitor and guide.*

The teacher's work there generally involves understanding the students'states, what they have done to reach it (which can be shown or told by the students, e.g., such as a particular type of problem which keeps being reported by the learning tool), and what they understand to have made these manipulations. Understanding the user's actions involves the expertise of the teacher, guessing the steps the learners have done or asking about them, and advising on the best possible continuation. In the situations where we have attempted this orchestration (described in [Libbrecht et al. 2012]) the teachers have not used the *my log* feature of SMALA as it would take them away of the learning tools.



**Fig. 4.** An example student screen.

The decision to stop and help can either be following a students'initiative or a teacher's observation. This observation can be over the shoulder or based on some analytics representations.

Hypothetically, the prototype log-view in Figure 5 could be displayed on a screen that the teacher has in her pocket, on her desk in a course, or at the class's projector when named logging is agreed upon. It indicates the amount of manipulations (buttons, clicks, in formulæ input and elsewhere,...), the amount
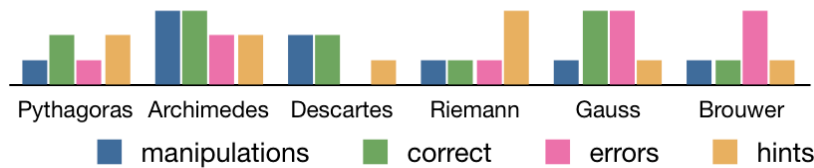


**Fig. 5.** A prototype log-view, displaying facets of the recent activity of each group that could direct a teacher in a classroom to help the group that needs it most.

of correct inputs, the amount of reported errors and the amount of displayed hints, each row for each of the groups. Such a view, for example, indicates that the *Riemann* group is employing many hints and not reaching many successful inputs or that the *Gauss* group is encounters multiple errors but is nonetheless progressing. This information supports students to situate each other and supports teacher to decide on where to best offer guidance.

The classroom of our teacher is pretty large however, and overall measures are necessary to assess the overall advances of the class. One of them can be the display of the successes as on the right, from the SMALA tool. One should note that users are not named there and that, although the teacher could drill down and analyze the sessions in more detail to identify the student, this precise display remains suitable to display in the overhead projector of the classroom to show progress.
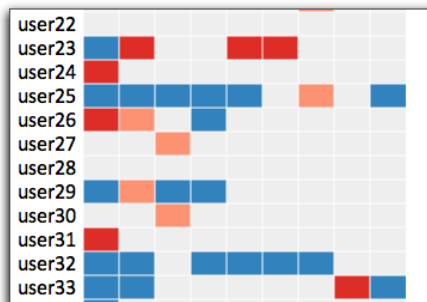


**Fig. 6.** An overall classroom progress view.

This design for anonymity has been a central element of the SMALA toolset, targeted to minimize students' fear of being constantly observed.

Similarly, this classroom benefits from the display of individual problems that the learning tool has automatically reported. ComIn-M is an intelligent tool, with a computer-algebra-system on the back, and a broad set of errors that are automatically reported on the basis of individual problem-solving steps to the students. The SMALA log view below, Figure 7 displays counts of error reports. Hovering the mouse on the individual errors indicates its text.
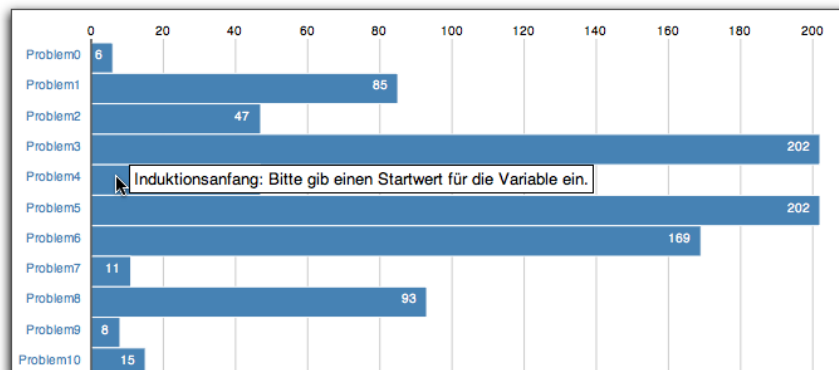


**Fig. 7.** Statistics of the problems reported by the learning tool with the text of tooltip indicating the complete text reported to the students. This text can be translated to: *Complete Induction: Basis: provide a start value for the variable.*

This list informs the teacher of typical errors and advises him to pause the *monitor-and-guide* orchestration to perform an *explain-the-screen* orchestration to explain the typical errors and how they can be avoided. The potential feature to continue a started session on the projector would even allow this error to be explained in the context of a realistic student work, applying the *spot-and-show* orchestration.

Moreover, such pauses are likely to be very necessary for the teacher to stop the students'attempts on individual exercises, demonstrating a solution to them on the projector or blackboard so that they can apply it to the computer successfully, and attempt other exercises.

## 3 Conclusion

The example scenario described in this paper covers just a handful of the analytics features that one would wish a teacher to use to enhance her course. It is likely that other features would support other adaptations'mechanisms.

Among others, multiple didactical designs exist which involve learning tools that perform less automatic evaluation than the ComIn-M tool. Many of them are described in the learning scenarios on `http://remath.cti.gr`, for example. The assessment of the achievements are then left to the teachers. Analytics tools can still apply in this situation, but in quite different ways. For example, it is likely that summarization of the input documents is quite important. As another example, the simple display of miniaturized geometry constructions delivered as assignment results, may help the teacher to rapidly spot an interesting contribution that he can analyze with the classroom.

The scenario we have described included references to the classroom orchestration types in action. We claim that this provides an effective way to describe the organization of the learning situation using the computer-based tools in the learning place. It is likely that the summary of orchestration types presented in [Tabach 2013] is insufficient to cover the more scattered use of learning tools, blended between exercise rooms, home, libraries, or multiple other locations enabled by mobile devices, especially at the higher education level. However, it still provides a good language to describe the practices of the teachers and learners.

**Future work**

The scenario that we have described essentially extends the SMALA tool set [Rebholz et al. 2012],. This toolset has been evaluated by 150 students and 7 teachers, as described in [Libbrecht et al. 2012] but with a much more preliminary set of log-views. Following these evaluations, and interview with teachers, the features described here all implemented except the below future work.[2], we see the following desirable extra features:

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[2]  SMALA is an open source software documented at `http://sail-m.de/sail-m/SMALA_en`

- A possibility to enroll the students in a fully tracked environment where the teacher is able to follow a dashboard summarizing the individual user's work by name and decide to advise so as to make the student's advance in a more precise direction. However, in such an environment concerns about privacy and acceptance from side of the learners have to be carefully checked and taken into account.
- A possibility for the learning tool to transport the solution path taken by a student, transmit to another place where other students can see it (such as the class projector). SMALA offers this function already (see scenario 3 of [Rebholz et al. 2012]). But the ability to resume the exercise from there would complement better the *spot-and-show* orchestration, as well as other forms of learning collaborations (for example the request for help between peers).
- The scenario we have described shows strong differences between the analytics views, each linked to a particular classroom orchestration, and potentially to a particular position (teacher private, student shared, student private, ....). It is likely that orchestration types serve as a good naming for the teacher to denote the various analytics views.

## References

**[Bescherer et al 2010]** Bescherer, Christine, Spannagel, Christian, Zimmermann, Marc, The TECHNOLOGY ON DEMAND Pattern, `http://sail-m.de/sail-m/TechOD_en`

**[Dyckhoff et al. 2012]** Dyckhoff, A.L., Zielke, D., Bültmann, M., Chatti, M.A. & Schroeder, U. (2012): Design and Implementation of a Learning Analytics Toolkit for Teachers. In: Journal of Educational Technology & Society, Vol. 15/3, 58-76.

**[Libbrecht al. 2012]** Libbrecht, Paul, Rebholz, Sandra, , Herding, Daniel, Müller, Wolfgang, and Tscheulin, Felix *Understanding the Learners' Actions when using Mathematics Learning Tools* in Intelligent Computer Mathematics, Proceedings of CICM 2012, Bremen, Germany, July 8-13, 2012, Lecture Notes in Computer Science, Vol. 7362, Jeuring, J.; Campbell, J.; Carette, J.; Dos Reis, G.; Sojka, P.; Wenzel, M.; Sorge, V. (Eds.) , 2012-07.

**[Rebholz et al. 2012]** Rebholz, Sandra, Libbrecht, Paul, and Müller, Wolfgang, *Learning analytics as an investigation tool for teaching practicioners* Towards Theory and Practice of Teaching Analytics 2012, Proceedings of TaPTA 2012, CEUR-WS Volume 894, Ravi Vatrapu, Wolfgang Halb, Susan Bull (eds). , 2012-09-18. Available from `http://ceur-ws.org/Vol-894/` .

**[Rebholz & Zimmermann 2011]** : Rebholz, Sandra & Zimmermann, Marc: *Applying Computer-Aided Intelligent Assessment in the Context of Mathematical Induction* . In: eLearning Baltics 2011: Proceedings of the 4th International eLBa Conference, pages 43-51, Stuttgart: Fraunhofer Verlag.

**[Govaerts et al. 2011]** Govaerts, S., Verbert, K. & Duval, E. (2011): Evaluating the student activity meter: two case studies. In: Proceedings of the 9th

International Conference on Advances in Web-based Learning - ICWL 2011, volume 7048, pages 188-197, Springer.

**[Trouche 2005]** Trouche, Luc, (2005), An instrumental approach to mathematics learning, in K. Ruth- ven, D. Guin and L. Trouche (eds.) *The Didactical Challenge of Symbolic Calcula- tors,* 137-162. Springer

**[Tabach 2013]** Tabach, Michal, *Developing a General Framework For Instrumental Orchestration* , in Conference on European Research on Mathematics Education, CERME8. Jana Trgalova and Hans-Georg Weigand (editors). Available from `http://cerme8.metu.edu.tr/wgpapers/wg15_papers.html`

**[Vatrapu et al. 2011]** Vatrapu, R., Teplovs, C., Fujita, N., & Bull, S. (2011): *Towards Visual Analytics for Teachers' Dynamic Diagnostic Pedagogical Decision-Making* . In: LAK '11 Proceedings of the 1st International Conference on Learning Analytics and Knowledge, 93-98. ACM, New York, NY, USA.