Tales of a Companion Teacher Analytics

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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.

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 explain 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 orchestration to be tracked. The analytical activity that the teacher can perform [Rebholz et al. 2012] leveraging *log-views* 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 describe below is based, mostly, on the SMALA toolset, described in [Rebholz et al. 2012]. SMALA provides an infrastructure for automatically tracking learning activities and recording the solutions and solutions steps taken by learners 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 problem types that were detected during the *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.

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 words and graphics the learning tools' representations and the course's concepts.

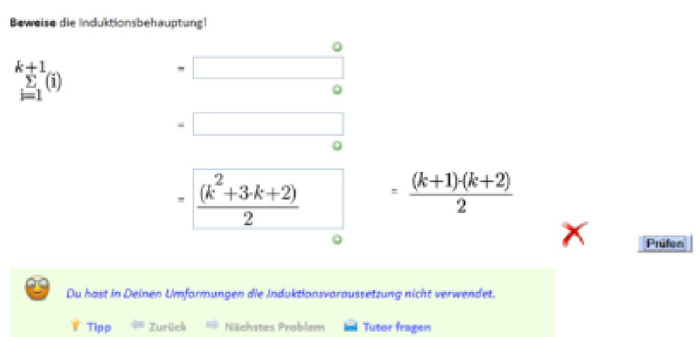
[1] This presentation, about another learning tool, is available at http://www.youtube.com/watch?v=jHBYtbdEic4

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 his 150 students have attempted, 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.

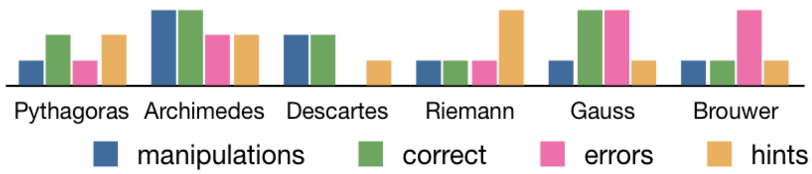
For the following exercise session, thus, a plan change is communicated so that students come with their laptops to the university. The objective of the teacher is to let the students go through as many of the ComIn-M exercises as possible in small groups in front of the laptops but keep eyes wide open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

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. 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.



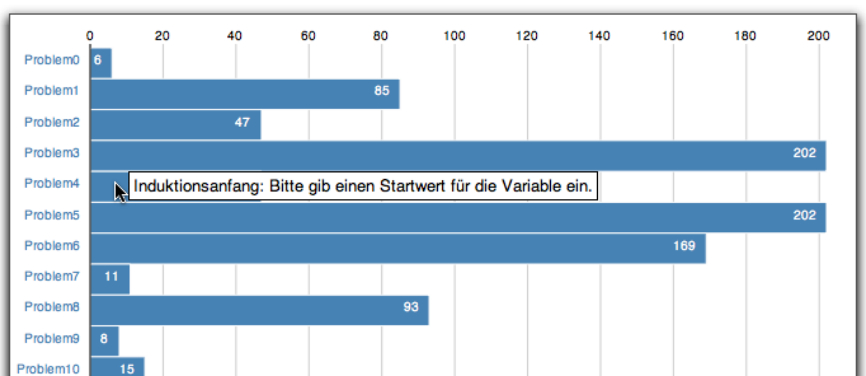
The decision to help can either be following a students' initiative or a teacher's observation. This observation can be over the shoulder or based on some analytics representations.

For example the prototype log-view below could be displayed on a screen that the teacher has in her pocket or her desk in a course where named logging is agreed upon such as a classroom usage. It indicates the amount of manipulations (buttons, clicks, in formulæ input and elsewhere,…), the amount 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.



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.

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 displays counts of error reports. Hovering the mouse on the individual errors indicates its text.



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.

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. 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 orchestration types in action.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.

Future work

The scenario that we have described essentially extends the Smala tool set [Rebholz et al. 2012]. From the current state of this tool[2], we see the following desirable features, which seem to go beyond the analytics tool until the learning tool:

- 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

[2] Smala is documented at http://sail-m.de/sail-m/SMALA_en

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.

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