The teacher in the loop: customizing MMLA in blended CSCL scenarios

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Abstract. In across-spaces learning scenarios, evidence needs to be gathered from different spaces to obtain a more complete view of the teaching and learning processes. Multimodal learning analytics (MMLA) enables us to gather data from physical spaces, enriching the evidence coming from digital ones. However, blended learning scenarios are heterogeneous, and the varying data sources available in each particular context can condition the accuracy, relevance, and actionability of the analyses. To avoid this problem, in this paper we propose to involve teachers in customizing the LA solution they will use, adapting it to their particular blended learning context (e.g., identifying relevant data sources and metrics). Preliminary results from two studies in blended CSCL settings show an improvement in the accuracy of the resulting MMLA solution. Although this kind of approach requires additional time from teachers, participants reported increased levels of relevance, novelty, understanding and actionability of the results.

Keywords: Multimodal Learning Analytics, across-spaces Learning Analytics, blended learning, computer-supported collaborative learning, customization

1 Introduction

Blended learning is often defined as the combination of face-to-face and technology-mediated interactions. However, considering current trends in technology-enhanced learning (TEL), blended learning could be understood in a broader sense covering a blend of spaces, activity types, and technologies [17]. Thus, applying Learning Analytics (LA) to blended learning scenarios requires gathering evidence about face-to-face and computer-mediated interactions and productions, in order to obtain an integrated view of the learning situation [20, 13].

Although LA in blended learning has mainly focused on computer-mediated interactions and productions, the increasing affordability and pervasiveness of sensors facilitates capturing evidence from the physical world too [20]. Indeed, recent work in multimodal learning analytics (MMLA) provides the opportunity to gather data from different sources, collecting evidence from physical and digital spaces [15]. However, the heterogeneity of blended learning scenarios and the variability of data sources available in each particular context may condition the accuracy, relevancy, and actionability of the analyses.

Even though users (e.g., teacher, students) could help to adapt the MMLA solutions to their specific context of use, their involvement in the configuration of MMLA solutions currently is rather minimal (as it is in other LA areas). Besides, this limited involvement also impacts the interpretation and contextualization of the results, trust and agency [1, 21]: users are often not aware of how the results apply to the specific learning context, the accuracy of the results, and therefore what can be done with such information.

In this paper, we propose an "a priori" reflection process for implementations of MMLA across spaces, which involves users in the customization of the analyses, taking decisions about what should be analyzed, when, and how. We hypothesize that, by reflecting on these aspects, users will be: better informed about the trustworthiness of the results, able to adapt the learning context to obtain more relevant and accurate data, able to better understand the analyses and to make decisions based on the results. We have applied this reflection process in 2 studies carried out in blended computer-supported collaborative learning (CSCL) settings, with promising preliminary results regarding to teacher satisfaction and accuracy. As an open issue for discussion at the workshop, we also propose a method to measure the added value of MMLA across spaces, illustrating how it would apply to the aforementioned studies.

2 Related work

Multiple conceptual models have been proposed to describe the LA cycle [3, 5, 4]. Despite the different conceptualizations, we could argue that a common denominator among them is that it spans from data gathering to decision making. In this loop, often the role of the users is just to provide data and get the results of the analyses (and, hopefully, act upon them), without paying attention to the specificities of each particular context, local user needs, and ethical consequences of not involving users [1, 8, 21, 19]. There is, hence, a need to adopt a *personalized LA* approach that engages end users, to better tailor solutions to their needs [14].

Taking a cue from current teacher observation processes (either for professional development or classroom orchestration), the common protocol that guides the process requires certain teacher decisions in advance, namely defining the areas of focus, the indicators to be obtained in order to illuminate such areas, and the specific events to be observed [9]. Then, the evidence gathered is analyzed and interpreted according to those initial decisions. In contrast, current MMLA solutions do not offer such configurability, and often require researcher mediation and/or complex technical setup. Yet, there exist examples in the literature that show the benefits of enabling personalized solutions, e.g., where teachers integrate different data to be analysed [16, 6], or even define concrete indicators, datasets, and visualization techniques [14].

Besides, the learning context itself may pose additional challenges when applying (multimodal) LA. For instance, ubiquitous learning environments such as blended CSCL require gathering evidence across spaces in order to have an holistic view of the teaching/learning process [18, 11, 13]. Thus, there is also a need for *identifying data sources suitable for the different spaces* involved.

3 MMLA Customization Process

In order to ameliorate the aforementioned problems -interpretation, contextualization, trust and agency- we propose to include teachers in the design of the MMLA solution they will use for a particular blended learning scenario (or at least, in its customization). Our purpose is to guide teachers in the reflection on those design aspects that affect monitoring and adapt the monitoring process to the teacher's needs. To achieve that purpose, we propose a 4-phase customization process where teachers describe the learning scenario, and then reflect on the analyses to be done, the evidence available and the potential refinements. These phases are:

1. *Definition of the (across-spaces/blended) learning scenario*. Such definition includes the usual elements in the formalization of a learning design, including participants, resources, activities, spaces, and interaction. This step is often carried out by the teacher (e.g., using a learning design authoring tool), or co-created by the teacher and the researcher.
2. *Selection of relevant metrics*. An initial reflection is done about what actions and interactions (or lack thereof) can pose a risk to the success of the scenario, and how such events could be detected using the systems and tools involved in the design (e.g., the fact that no student has opened the background material for an activity is detectable by the platform being used, and can be an indicator of students not engaging with the activities as expected). Again, this step is best performed by the teacher and the researcher, to exploit teachers' deep contextual knowledge and researchers' knowledge of the affordances of the technologies involved.
3. *Feedback about the evidence available* in the scenario and the capability to provide (actionable) warnings about the chosen metrics. In certain cases, especially due to the blended nature of the scenario (e.g., interactions occurring face-to-face not being registered by the technological tools), the data gathered may be insufficient to understand what is going on, and what intervention is appropriate. The researcher will provide this kind of feedback on the current design, point out spaces or activities that may not be covered by the MMLA solution, as configured so far.
4. *Refinement of the (across-spaces/blended) scenario and customization of the MMLA solution*. On the basis of the provided feedback, teacher and researcher refine the design of the activities and/or the data gathering and analyses, including additional data sources (e.g., introducing a new tool that may provide more data, alternative points of data gathering, additional informants like students themselves, etc.), modifying the constraints of the scenario (what constitutes a risk to be warned about or not), when to run which analyses and receive reports, etc.

As a result of this customization process, we expect to keep teachers aware of the impact that their decisions have on the monitorable data, avoiding undesired negative effects on the later monitoring [12, 8, 21, 19]. Furthermore, we foresee that involving teachers in the configuration of the monitoring process will contribute to adapt it to their needs, as different authors have already envisioned [2, 18, 14].

4 Preliminary results

The proposed MMLA customization process was evaluated in two authentic scenarios with a common profile [18]: blended CSCL scenarios spanning 3-4 weeks were carried out, supported by distributed learning environments (i.e., a virtual learning environment complemented with additional web 2.0 tools). The first scenario involved a non-expert teacher whose main challenge was to cope with the high number of students and learning resources (165 and 316, respectively). The second scenario was led by a CSCL expert teacher, who proposed a complex design with many interrelated activities occurring in a short period of time with a group of 15 students, hence demanding much attention from the teacher to avoid problems that could jeopardize the scenario down the road. Regarding the MMLA solution, in both studies the teachers used a design-aware monitoring solution (GLIMPSE) that enabled them to detect deviation between the learning design and the current status of the learning activities [18].

For the evaluation, we used mixed methods [7], combining multiple informants (2 teachers, 1 researcher, 180 students, and the ICT tools of the corresponding distributed learning environments), and a variety of quantitative and qualitative data sources and gathering techniques (teacher interviews, learning designs, researcher observations, student questionnaires, logs, and student learning artifacts). All these elements provided multiple perspectives and allowed for triangulated data analyses [10].

In both cases, we proceeded in the same way. At design-time, we provided the teachers with worksheets and forms that guided them throughout the customization process and helped them specify the information required to guide the data analyses. The design of the learning scenario consisted of two sessions, where the phases presented in Section 3 were covered. In the first session, the teachers, guided by the worksheet, designed the learning scenario and filled out the activity forms with the monitoring configuration, selecting data sources and metrics. Then, the researcher analysed the constraints of the design and introduced them in the activity forms. With this information, in the second session, the teacher faced included new data gathering and monitoring support activities in the scenario. Figure 2 shows an example of activity form and feedback provided about the evidence available.

Even though the customization tasks were not mandatory, the teachers went through them, introducing changes in their original designs (e.g., the selection of tools to be used in the scenario was influenced by their catalog of monitorable actions, and the design was modified to include new monitoring data to be gathered from teachers and students).

Then, we used a number of technologies to create a computational representation of the CSCL script (WebCollage[4]), deploy the design into the selected learning environment (GLUE!-PS[5]), and integrate the third-party tools into the VLE (GLUE![6]). During the enactment, the learning designs were put into practice and, throughout the different activities, teachers were provided with monitoring reports to help the awareness and later regulation of the learning scenarios (see 2). These reports were obtained following

[4] https://www.gsic.uva.es/webcollage/

[5] https://www.gsic.uva.es/glueps/

[6] https://www.gsic.uva.es/glue/

GENERAL ACTIVITY DESCRIPTION			
Activity name:	Improvement of the proposals		
Phase name or number:	3 (Level-3)	**Sequence order:**	3.5
Beginning: (YYYY-MM-DD hh:mm:ss)	~~2013-05-17 16:00:00~~ 2013-05-18 00:30:00	**End:** (YYYY-MM-DD hh:mm:ss)	~~2013-05-21 12:00:00~~ 2013-05-22 12:00:00
Enable monitoring: (yes / no)	yes	**Monitoring dates:** (YYYY-MM-DD hh:mm:ss)	~~2013-05-21 12:10:00~~ 2013-05-22 12:10:00
Learning mode: (Face-to-face / Distance / Blended)	Blended	**People involved in the activity:** (Number of students, teachers, observers, others)	15 students 1 teacher
Participation: (Optional / Mandatory for individuals / Mandatory for groups)	Mandatory for individuals	**Social level:** (Individual / By groups / Whole class)	By groups
Technological support for the learning tasks: (Total / Partial /No support)	Partial	**Interaction type:** (Face-to-face / Computer mediated / Blended)	Blended

GROUP FORMATION			
Does this group formation join groups from a previous activity because interaction should happen? (yes / no)			no
If there's any dependence with groups conformed in a previous activity, specify which activity:			
Group name:	Super group 1	**Participants:**	Student1, Student2, Student3, Student4, Student5
Group name:	Super group 2	**Participants:**	Student6, Student7, Student8, Student9, Student10
Group name:	Super group 3	**Participants:**	Student11, Student12, Student13, Student14, Student15

ICT TOOLS & ADDITIONAL DATA SOURCES						
Resource name	**Tool name**	**Resource reused from previous activities**		**Expected use from participants**		**Actions to be monitored** (see attached table)
		(yes / no)	If reused from which activities	(optional / mandatory)	(individual / by groups)	
Activity description	Web Content	no	--	optional	individual	Users' accesses
Research proposal & plan	Gdocs	yes	4	mandatory	individual	User's accesses and group's editions
Teachers' observations	*Teacher's observations*	--	--	--	--	*Student's attendance to the lab sessions and other comments*
Workgroup report	*Students' feedback*	*no*	--	*mandatory*	*by groups*	*User's accesses and students' participation percentage*

Monitorable data available for each constraint after the first design cycle
V = Relevant evidence P = Partial evidence X = No evidence

Activity constraints: (Derived from the analysis of the activity features)	1. *Individual participation:* all participants must be involved in the activity	P
	2. *Social level:* there must be collaboration between group members	P
	3. *Expected use of resources:* every group member must use the resource "Research proposal & plan"	V
Flow constraints: (group dependences, reused resources, etc,)	4. *Resource reuse:* the resource "Research proposal & plan" will be reused in Activity 4.1	V
Warnings related to the constraints to be monitored	1. *Individual participation:* students participation is mandatory, and they can participate face-to-face and or by means of the technological support. However, the current configuration of the activity only provides evidence of computer mediated interactions. 2. *Social level:* in every group, there must be at least two participants involved in the activity to ensure collaboration, and they can interact face-to-face and or by means of the technological support. However, the current configuration of the activity only provides evidence of computer mediated interactions. 3. – 4. --	
How to enhance monitoring:	- **Additional data sources:** The data sources used for monitoring this activity are reduced to part of the technological support (MediaWiki, WebContent and GDocs). If you need additional information, you could obtain it from the people involved in the activity (students and teacher). - **Learning mode and Students interactions:** This activity is carried out partially face-to-face during class session, combining face-to-face and computer mediated interactions. However the evidence gathered from the learning scenario come exclusively from the technological support. Gathering evidence from face-to-face interactions may contribute to more significant monitoring results.	

Monitorable data available for each constraint after the second design cycle
V = Relevant evidence P = Partial evidence X = No evidence

Activity constraints: (Derived from the analysis of the activity features)	1. *Individual participation:* all participants must be involved in the activity	V
	2. *Social level:* there must be collaboration between group members	V
	3. *Expected use of resources:* every group member must use the resource "Research proposal & plan"	V
	4. *Expected use of resources:* every group must use the resource "Workgroup report"	V
Flow constraints: (group dependences, reused resources, etc,)	5. *Resource reuse:* the resource "Research proposal & plan" will be reused in Activity 4.1	V
Warnings related to the constraints to be monitored		
How to enhance monitoring:		

Fig. 1. Example of activity form completed by the teachers during the design process (left) and feedback given to them (right). More concretely, it shows the design of *Activity 3.5 Improvement of the proposals* which belongs to the second study. Red text in italics represents the changes included by the teacher for the refinement of the scenario and customization of the MMLA solution.

a script-aware monitoring process and an architecture to automate the data gathering, integration and analysis tasks (both the process and software architectures used are described in [18]). The LA process, in this case, consisted mainly on detecting potential activity/interaction problems that could jeopardize the accomplishment of the CSCL scenario.

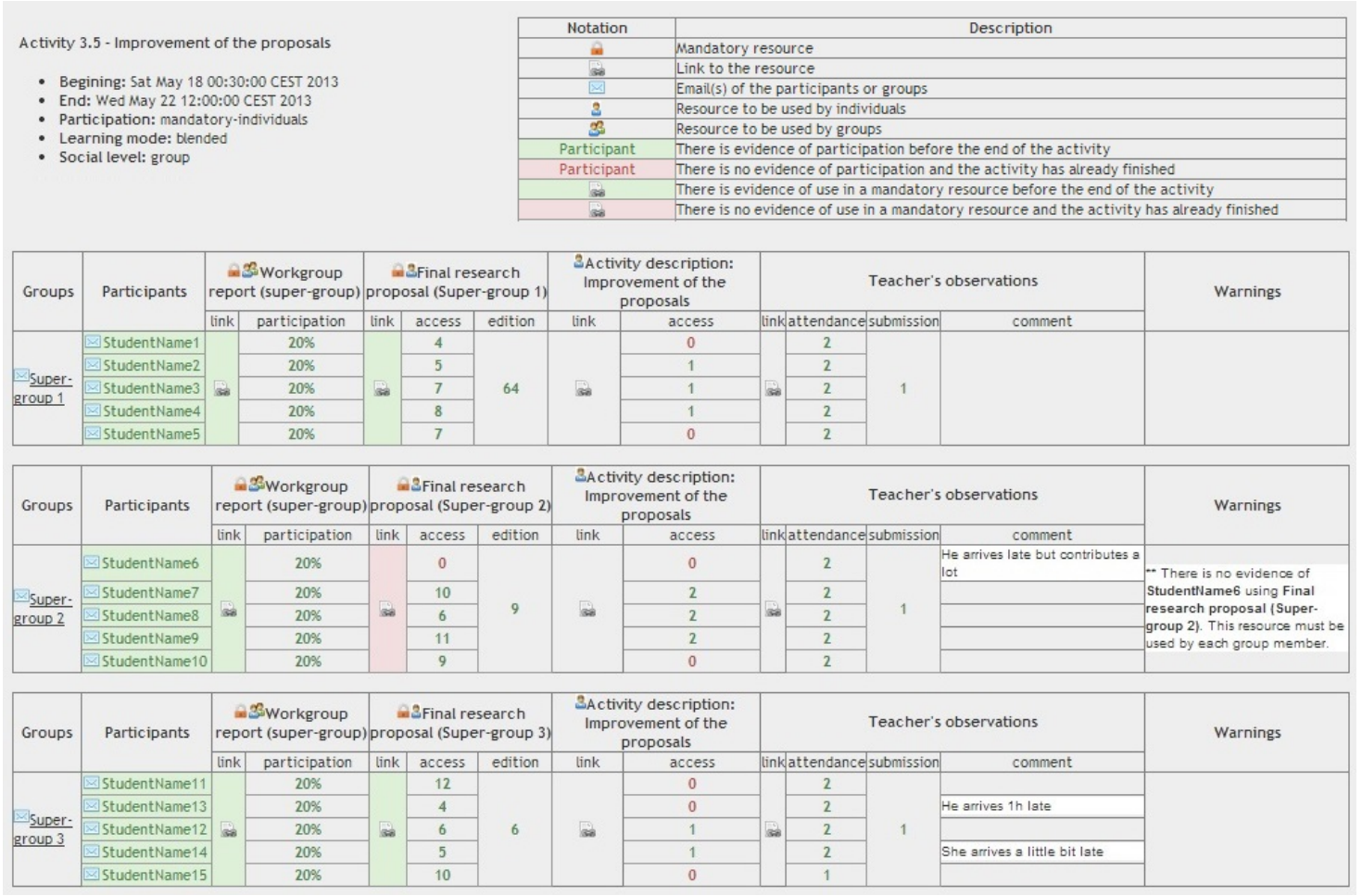
In order to validate whether the monitoring reports provided an accurate view of the situation, we compared the LA results obtained versus the complementary teacher observations, the student comments, the researcher observations, and the learning outcomes as reflected in the tools used by students. Taking the piece of report shown in Figure 2 as an example, 27 conditions were verified (the individual participation of the 15 students, the evidence of collaboration in each of the 3 groups, the usage of the 3 workgroup reports and the 3 improved proposals by the corresponding group, and whether the lack of usage of the 3 improved proposals may have an impact on the activities scheduled afterwards). Out of 27 conditions, 25 results were accurate and 2 were false positives (i.e., warnings that did not match any problematic situation).

From the analyses of the two studies, we concluded that the monitoring reports presented an error rate of 0,33% (4 out of 1217 evaluated conditions were not correctly detected by the LA system) in the first study, and 2,17% (6 out of 276) in the second study. In the first case, the errors were two undetected problems and two false positives. In the second study, there were 6 false positives. It is noteworthy that, although the teachers had a certain idea of what was happening based on the face-to-face sessions and students actively contacting them, in many cases (98,44% and 62,41% in the first and second study, respectively) the teachers were not aware of the status of the situations before being showed the monitoring reports.

The teachers pointed out that the customization process did not increase significantly the effort devoted to implementing the scenario, as the main effort was to design the learning situation in advance. Both agreed that such customization is worth the effort, considering the benefits obtained: improvement of the learning design, increase of their awareness of potential eventualities and the impact that they could have on the learning situation, better coverage of the monitoring needs (which led to saved time during the enactment), or having more evidence about the students' work for assessment purposes.

5 Open issue: quantifying the added value of MMLA

As we analyze the customization process followed in the aforementioned case studies (and several others performed during the same research), we face the question of trying to measure the added value of the different decisions taken during the process (e.g., adding or removing data sources, what actions to monitor, what to consider optional or mandatory). This should then be weighed against the additional effort involved in designing, gathering (during enactment), analyzing and visualizing data. We anticipate the adoption of MMLA in the "real world" will be greatly conditioned by teachers and/or institutions performing this kind of appraisals (i.e., 'is it worth the hassle?') in their own contexts, and we believe that clear measurements of such added value are an important issue to be tackled by our community.



Activity 3.5 - Improvement of the proposals

- **Begining:** Sat May 18 00:30:00 CEST 2013
- **End:** Wed May 22 12:00:00 CEST 2013
- **Participation:** mandatory-individuals
- **Learning mode:** blended
- **Social level:** group

Notation	Description
	Mandatory resource
	Link to the resource
	Email(s) of the participants or groups
	Resource to be used by individuals
	Resource to be used by groups
Participant	There is evidence of participation before the end of the activity
Participant	There is no evidence of participation and the activity has already finished
	There is evidence of use in a mandatory resource before the end of the activity
	There is no evidence of use in a mandatory resource and the activity has already finished

Groups	Participants	Workgroup report (super-group)		Final research proposal (Super-group 1)			Activity description: Improvement of the proposals		Teacher's observations				Warnings
		link	participation	link	access	edition	link	access	link	attendance	submission	comment	
Super-group 1	StudentName1		20%		4	64		0		2	1		
	StudentName2		20%		5			1		2			
	StudentName3		20%		7			1		2			
	StudentName4		20%		8			1		2			
	StudentName5		20%		7			0		2			

Groups	Participants	Workgroup report (super-group)		Final research proposal (Super-group 2)			Activity description: Improvement of the proposals		Teacher's observations				Warnings
		link	participation	link	access	edition	link	access	link	attendance	submission	comment	
Super-group 2	StudentName6		20%		0	9		0		2	1	He arrives late but contributes a lot	** There is no evidence of **StudentName6** using **Final research proposal (Super-group 2)**. This resource must be used by each group member.
	StudentName7		20%		10			2		2			
	StudentName8		20%		6			2		2			
	StudentName9		20%		11			2		2			
	StudentName10		20%		9			0		2			

Groups	Participants	Workgroup report (super-group)		Final research proposal (Super-group 3)			Activity description: Improvement of the proposals		Teacher's observations				Warnings
		link	participation	link	access	edition	link	access	link	attendance	submission	comment	
Super-group 3	StudentName11		20%		12	6		0		2	1		
	StudentName13		20%		4			0		2		He arrives 1h late	
	StudentName12		20%		6			1		2			
	StudentName14		20%		5			1		2		She arrives a little bit late	
	StudentName15		20%		10			0		1			

Fig. 2. Example of monitoring report sent to the teachers at the end of each learning activity. This anonymised version corresponds to one of the learning activities of the second scenario.

To illustrate the issue, we can briefly describe our current thinking about how to quantify such added value (in this case, the value of having the teacher in the loop, customizing the MMLA solution). Our approach basically consists of gathering data about the problems that actually occurred during enactment, what the teacher already knew about the progress of the scenario *before* the MMLA reports are visualized, as well as the problems detectable by each of the available data sources. This enables us to build multiple hypothetical "MMLA detectors":

- What the teacher knew without the aid of specific MMLA technology
- The initial MMLA solution using the data sources defined in the initial learning design (phase 1 in section 3)
- The different MMLA solutions that would result from each of the customization decisions (phase 4 in section 3)
- The finalized MMLA solution that was used during the scenario

By comparing the detected problems, false positives, and false negatives of each of these "detectors" with the actual problems that occurred during the enactment, we can build performance metrics like accuracy, precision, recall, F1, etc. Comparing such metrics with estimations of the time and effort that each of these additional data sources requires from the users, can be a first step to establish the added value, not only of the MMLA solution as a whole, but also of each of the data sources, so that teachers (and researchers) can make informed decisions about what flavor of MMLA most suits their needs.

6 Conclusions

In order to get a realistic view of blended teaching and learning processes through LA solutions, it is necessary to gather and integrate evidence from digital and physical spaces, resulting in multimodal datasets and/or requiring multimodal analyses. So far, MMLA has focused on solutions mainly configured by researchers. However, to promote the generation of relevant results in practice, there is a need for including users in the MMLA loop, allowing them to be aware of the limitations that the solutions have in their particular learning context, and giving them the chance to customize the solutions to their needs.

In this paper, we have presented a reflection process that allows teachers customize the MMLA solutions and fosters the user involvement in the data gathering. Preliminary results from 2 studies with 2 teachers in blended CSCL scenarios show a positive impact on the accuracy, novelty and relevance of the analyses as well as on the teacher ability to interpret and react according to the analyses. However, the application of this approach, especially in MMLA, is still in its infancy: in our case studies, multiple different supporting tools were in place, most of them requiring a researcher to be present or to perform certain steps of the process (i.e., teachers were not really autonomous). Also, the kind of LA being performed (basically, an early warning system for the teacher) were admittedly quite basic.

Nevertheless, we believe this line of work increasing the involvement of teachers in the LA process has enormous potential. We are currently performing more in-depth

analyses of the impact that the different user decisions had on the accuracy of the results (as outlined in section 5), but measuring the added value of the different elements of an MMLA solution is still an open problem for us. We hope to discuss this issue, as well as how to generalize it to other MMLA efforts, during the workshop.

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