PROGDASH: Lessons Learned From a Learning Dashboard in-the-wild

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Abstract: Teachers mixing in-class and remote online learning activities face numerous challenges in monitoring learners' online activity and progress, especially when preparing in-class interventions. We present a design study of PROGDASH, a dashboard enabling teachers to monitor learners' activity on an online grammar and spelling learning platform. We designed PROGDASH based on interviews with seven teachers to understand their needs, and we collaboratively iterated on design prototypes. We conducted a three-month field deployment with 17 teachers, collecting logs, diaries, and interview data to evaluate how PROGDASH informed their practices. Our findings extend prior work on teachers' practices using dashboards: teachers found PROGDASH actionable to devise informed pedagogical practices: monitoring, conducting assessments, planning interventions, sharing in-class, providing debriefing and feedback. Based on our findings, we suggest directions on how dashboards could effectively support teachers in schools using online learning platforms in authentic settings.

1 INTRODUCTION

Schools are increasingly integrating web-based learning environments with in-class learning activities (Technavio, 2016). Teachers leverage these platforms, to support in-class learning, help learners develop skill-sets that should already be mastered, or to provide personalized support to learners with specific needs, e.g., dyslexics.

Teachers mixing in-class and remote online learning activities face numerous challenges in monitoring learners' online activities, especially when informing their in-class interventions. Dashboards can be efficient tools for facilitating sense-making, reflection, and making informed decisions (Verbert et al., 2014). Prior work on virtual learning environments, used mainly in-class, has shown the potential of dashboards to support teachers, for instance, to improve their awareness of their classrooms (Holstein et al., 2018), to support their planning tasks and interventions (Xhakaj et al., 2017), to support learners with lesser abilities (Molenaar and van Campen, 2017), and to provide personalized support to learners in a timely fashion (Aslan et al., 2019).

However, with online learning, the individualized pacing of learners makes it difficult for teachers to monitor learners' progression before engaging in formative in class interventions. The way teachers leverage dashboards in the long run and how dashboards shape their pedagogical practices is still unclear. Two recent systematic reviews of more than 150 learning analytics dashboards emphasize the need for more longitudinal studies to investigate how a dashboard might inform and impact teachers' practices (Bodily et al., 2018; Schwendimann et al., 2017).

In this paper, we present a design study (Sedlmair et al., 2012) and a longitudinal field evaluation of PROGDASH, a dashboard to assist teachers in monitoring learners' progression on an online grammar and spelling learning platform. We designed PROGDASH based on interviews with seven teachers to understand their needs, and we collaboratively iterated on design prototypes (Dow et al., 2011). We implemented and integrated PROGDASH in a commercial online learning platform called PROJET-VOLTAIRE[1]. We then conducted a three-month field deployment with 17 teachers, collecting logs, diaries, and interview data to evaluate how PROGDASH informed and impacted their practices in blended learning. Our results show that most teachers reacted positively to the

[1] https://www.projet-voltaire.fr

dashboard. They found it actionable to inform several pedagogical practices: monitoring, conducting assessments, planning interventions, sharing in-class, providing debriefing and feedback. Our results further highlight a divide between teachers specialized in the concepts of the learning platform (i.e. French language) and those in disciplines requiring the skills (e.g. Marketing), even if both were concerned with achieving the same objectives, mainly helping learners master spelling and grammar. Based on our findings, we provide design implications aimed at improving dashboards to bridge online and in-class learning and foster learners' self-reflection.

The contributions of our work are (1) a design study of PROGDASH to support teachers in using a curriculum-integrated online learning platform, (2) a three-month "in-the-wild" field study of PROGDASH, which extends our understanding of how teachers integrate a dashboard in their practices to articulate remote and in-class learning, and (3) design implications for dashboards to bridge online and in-class learning and facilitate data-informed pedagogical practices.

2 RELATED WORK

This paper focuses specifically on how dashboards might inform teachers' practices in authentic settings.

2.1 Learning Analytics Dashboards

Early work on learning dashboards focused on supporting formative assessments to provide teachers with data-driven insights into learners' state of learning (Black and Wiliam, 1998). Follow-up research on learning dashboards focused on leveraging human judgment through robust reporting tools and visualizations (Siemens and Baker, 2012). Recently, a wide range of contributions has been introduced to instrument teachers using dashboards spanning a variety of aspects.

A great deal of research has been devoted to ensure the solid technical infrastructure of dashboards, such as standard ways to collect, store, and query learning traces with the associated context and content, implementation of interoperable architectures (Dyckhoff et al., 2012), development through toolkits (Kitto et al., 2015), and data aggregation from multiple learning platforms (Mottus et al., 2014). Besides, other dashboards' aspects have been investigated, such as enabling teachers to personalize the presentation of views (Dyckhoff et al., 2012; Mottus et al., 2014; Michel et al., 2017), or to specify what and how indicators are monitored to match learners' performance with regard to competences (Florian-Gaviria et al., 2013).

While these studies shed light on the importance of dashboards in assisting teachers, they mainly focus on evaluating the technical aspects of the underlying systems (Schwendimann et al., 2017). In fact, the aforementioned dashboards and many others focused mainly on "usability" (Chetlur et al., 2014; Dyckhoff et al., 2012; Ez-zaouia and Lavoué, 2017; Carrillo et al., 2017), "usefulness" (Florian-Gaviria et al., 2013; Dyckhoff et al., 2012), or "interoperability" (Dyckhoff et al., 2012), and in many cases the evaluation was conducted in controlled settings or even in the lab (Mazza and Dimitrova, 2007). Although these studies are useful for understanding the design and intelligibility of dashboards, they teach us little about the impact of dashboards on teachers' practices in-situ.

Very few studies have focused on teachers' routines surrounding such tools (Greiffenhagen, 2011), or on how they are can guide teachers' actions. And such studies are often conducted over short-term deployments. In contrast, we conducted a teacher-centered design process, leading to a longitudinal study, to investigate how a dashboard might impact teachers' pedagogical practices in a long term (Ez-zaouia, 2020; Zapata-Rivera and Katz, 2014).

2.2 Authentic Setting Studies

Research on teachers' data-informed practices using dashboards focuses mainly on how to support monitoring of learners' performance while they are using a learning environment in-class, such as errors, struggles, attempts, responses, and engagement indicators. Combining field observations and interviews, Molenaar and van Campen (2017) investigated how 38 teachers used a dashboard over one session (50 minutes) to conduct assessments both at class and learner levels (errors, progression, etc.), to provide motivational and formative instruction to learners, as well as to adjust both the learning material and the pace of the lesson. Although the results revealed a diversity of use (low, medium, high), three-quarters of teachers' dashboard consultations were followed by motivational feedback or formative instruction either directed to the class as a whole or to individual learners with medium or high ability. In a similar study, Holstein et al. (2018) investigated how 8 teachers used a virtual reality glass dashboard over a total of 18 courses (30 minutes each) to orchestrate the classroom. In contrast to (Molenaar and van Campen, 2017), the authors found that the dashboard tended to divert teachers' attention and time towards learners of lower prior ability.

Combining observations and interviews, Aslan et al. (2019) investigated how a teacher used indicators of learners' engagement shown on a dashboard

over two courses (80 minutes each) to support learners through different teachers' interventions: verbal warning, positive reinforcement, scaffolding, close monitoring. The authors observed a medium size-effect of the dashboard on teachers' scaffolding interventions and use for close monitoring, mainly in assisting the teacher with allocating time to learners who need most support without compromising the overall experience of the class. In a similar study, Martinez-Maldonado et al. (2015) investigated how three teachers used real-time notifications on learners' actions and their learning artifacts, shown on a dashboard. The dashboard was found to be helpful for teachers in orchestrating multi-tabletop learning environments and providing feedback to learners.

In a context similar to ours, Groba et al. (2014) proposed an analytics-based tool to help teachers assess learners' activity, and evaluated it with two teachers during a one-session course. The results showed that this tool reduced significantly assessment times and helped teachers understand the learning process of learners. Combining think-aloud and observations, Xhakaj et al. (2017) investigated how five teachers used a dashboard to plan and conduct lessons over eight courses (60 minutes each), where students used a virtual learning environment. The authors found that the provision of both positive and negative notifications on learners' status facilitated the dialog between a teacher and learners, and supported teachers in adjusting and orchestrating learning materials. The authors also observed that the dashboard helped teachers update (confirm, reject, and/or add new items) their knowledge about both the class as a whole and individual learners. In particular, the authors found that teachers mostly integrated the knowledge acquired concerning where learners' struggles in their lessons.

These studies show that dashboards, when they are well crafted, can successfully assist teachers in monitoring learners and conducting adapted interventions. In fact, the aforementioned dashboards are mostly used by teachers synchronously inside the classroom while learners are using the computer-based learning environment. Informed by the work of Ez-zaouia et al. (2020), we investigate how PROGDASH may inform teachers' practices in blended and remote online learning settings. We sought to understand what teachers actually *do* with dashboards "in-the-wild".

3 DESIGN STUDY PROCESS

We followed a teacher-centered design study process (Ez-zaouia, 2020) in four steps (Figure 1):

1. Understanding the domain: We discussed with PROJET-VOLTAIRE designers to understand the the platform, the exercises, the learning process, and its data (see Section 4). We gathered real data to prototype realistic visualizations.

2. Understanding teachers' needs: We interviewed seven teachers to identify their needs for monitoring/understanding learners' progression, and to explore design alternatives (see Section 5).

3. Design and implementation: We iteratively designed PROGDASH, which we then enhanced through several informal discussions with members of the company and teachers from our first interviews. We deployed a stable design of PROGDASH to the company's R&D team for usability feedback (see Section 6).

4. Field study: We conducted a three-month field study with 17 teachers to capture teachers' experience/perception of PROGDASH, and how it may assist them in informing their practices (see Section 7).

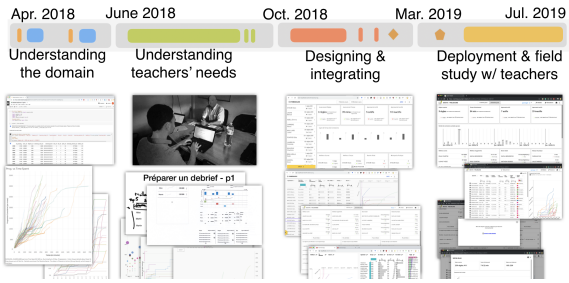

Figure 1: Key steps of PROGDASH design process.

4 PROJET-VOLTAIRE PLATFORM

We collaborated with PROJET-VOLTAIRE, an online platform for learning French vocabulary, grammar and spelling rules. The platform is widely used by French public and private schools (primary, middle, high school and university). It can be used autonomously or in-class, either projected on a whiteboard with class exercises, or on personal computers.

Learning Process: The platform centers around an exerciser that adapts to learners' skills in vocabulary, spelling, and grammar. Learning is structured around modules corresponding to a given level of expertise. Each module has a set of stages that learners must go through to master the level. A stage has a set of grammar/spelling rules, corresponding to the concepts that learners need to master. Each rule has a set of exercises. Figure 2 shows typical questions on PROJET-VOLTAIRE. Teachers can also set up class quizzes, i.e., short evaluations, typically carried out at the beginning or the end of a course. PROJET-VOLTAIRE collects the pertinent learning traces on learners (see Table 1), which we used to build PROGDASH.

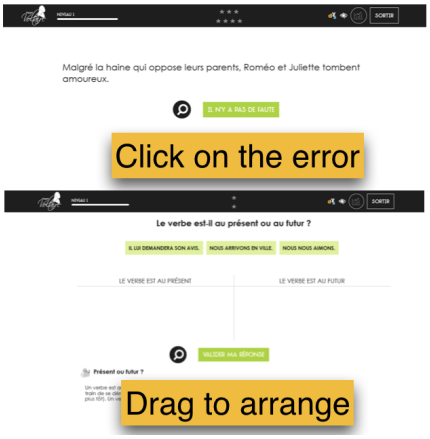

Figure 2: Example of exercises in PROJET-VOLTAIRE.

Table 1: PROJET-VOLTAIRE's collected logs.

Attribute	Description
Module	Learning module(s) a learner is enrolled in
Stage	level of difficulty of the module
Rules	to master in each module
Exercises	associated to a rule
Answers	exercises' answers (correct/incorrect)
Time-spent	Time-spent to answer each exercise of a rule

Learning Data: Prior to our study, teachers had access to a reporting table (see Figure 3). The table listed learners with a set of indicators split across multiple columns: time spent, score (%) of learner's mastery, initial level, scores and time spent on the programmed quizzes, last connection, and rules acquired. Teachers can also download a pdf report about each learner or export the entire table as a spreadsheet file.

Figure 3: Example of a class report table.

5 Teachers' Needs, and Design Goals

We conducted nine interviews with seven teachers to understand (1) how they use the learning platform, and (2) how they monitor learners' progression. We recruited teachers via the company's education customers' team, and they received a book on the French language as a thank-you gift. Interviews were audio-recorded, and later transcribed and analyzed by the main author to identify requirements in supporting teachers.

Context of use: We identified three ways of how teachers integrate PROJET-VOLTAIRE in their classrooms. First, as a *learning material*, they incorporate platform-based activities in their curriculum with a dedicated time-slot. Second, as a *support material*, where teachers push learners to use the platform alongside their course. And, finally, as a *personalized aid* for specific learners, such as learners with grammar-related disabilities, e.g., dyslexia, or with very poor grammar skills.

Learning progression: Teachers characterize learners' progression as (1) the *levels and modules* that learners have reached, (2) the *regularity* of their practice, and (3) how *skills* develop over a period of time. They highlighted the temporal nature of the learners' progression, this is "hidden" in the existing reporting table which displays only learners' current state. This causes learners' progression – in sense of, e.g., unique pathways, discrepancies, common strategies, similar struggles; to become difficult for teachers to grasp. Teachers reported relying on informal discussions with learners to infer their progression and regularity of using the platform.

Informed interventions: Teachers often conduct interventions in-class to congratulate, encourage, remind, or alert learners. They highlighted the complexity of using the existing reporting table to keep track of learners' online activity and to pinpoint gaps in learners' progression, which hindered engaging in informed interventions with learners, e.g., acquiring arguments for debriefs and feedback. Also, when preparing a French class, teachers expressed interest in knowing which grammar concepts were not mastered by learners or those that proved most tricky in order to tackle them in class.

We derived the following design requirements from our interviews:

R1: Offer at-a-glance indicators to facilitate monitoring of learners' activity at class level by providing summaries of learners' overall practice, engagement, and regularity in using the learning platform.

R2: Provide indicators about learners' practice to facilitate close monitoring at learner or group of learners' level. Teachers emphasized the need for practicable information enabling them to keep track of the status of learners' online activity on the platform.

R3: Incorporate indicators about skills, i.e., grammar concepts that are already mastered or prove challenging. In order to prepare class interventions or to help individual learners, teachers expressed the need to understand what they should focus their interventions on, based on learners' difficulties.

R4: Provide information about learners' progression over time. Teachers expressed the wish to grasp the progression and regularity of practice over time. Learners' progression is multifaceted and depends on how teachers and learners engage with the learning platform. Relevant indicators include grammar concepts mastered, time spent, and amount of exercises practiced.

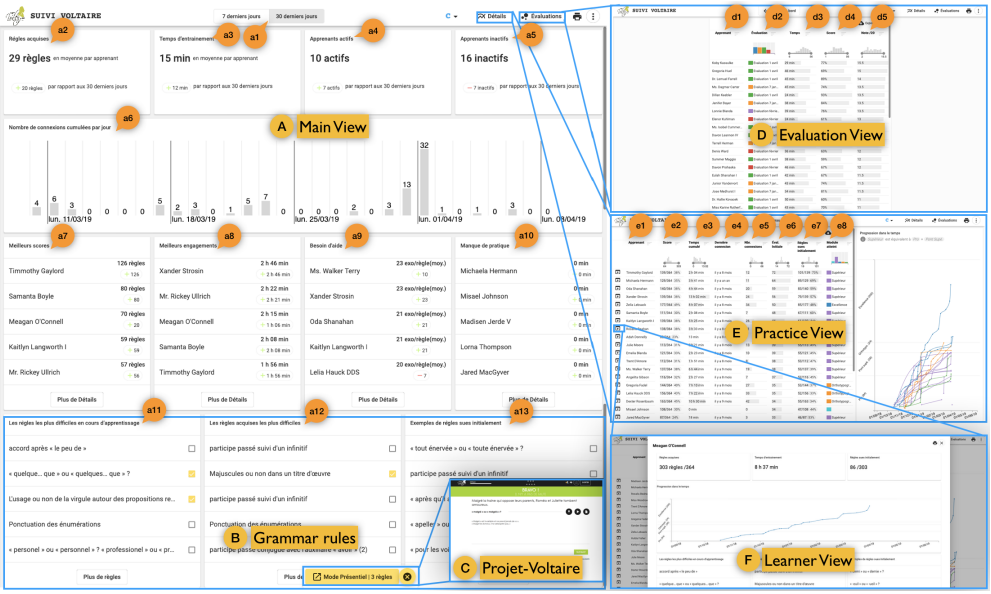

Figure 4: PROGDASH user interface.

6 PROGDASH User Interface

The main challenge in designing PROGDASH was to condense all the information required in a small visual space in order to clearly and directly inform teachers about the state of learners' progression. Following *"overview first, zoom and filter, then details on-demand"* (Shneiderman, 2003), we structured the information in four different views so that teachers can drill down for more information as needed. We adopted statistical and visual summarization techniques (Sarikaya et al., 2018) to present relevant indicators.

PROGDASH compiles metrics over the last 7 or the last 30 days, and teachers can pick between these two temporal windows. We combined textual, visual, and color encoding when designing the dashboard to facilitate glanceable reading of the indicators. We provided comparison and contextualization of PROGDASH's indicators by using bars to encode cells in tables and line-charts to visualize learners' progression paths. We also added histograms and bar-charts in the headers of tables' columns to facilitate filtering and searching. We provide supplementary online material about the dashboard in this link.

Main view: This view (Figure 4.A) presents overall information to monitor learners' activity at class level (**R1**). It presents 12 metrics in a grid compiled for the selected time window (7 or 30 last days, see Figure 4.a1). The grid is structured around three topics on learning regularity, learners' progression, and grammar rules acquisition (see Table 2). The first row of the grid provides the average number of acquired rules per learner, the time spent as well as the total number of active/inactive learners. The same widget is used to show the name, the value, and the associated (+/-) delta – change since the previous time window (7 or 30 days), of each metric. The second row shows a timeline bar-chart of learners' connections per day. The third row displays learners' related metrics: score, commitment, help, and dropout. The same widget is used to present the full name of the learner, as well as the associated value and (+/-) delta. The last row presents grammar rules related metrics: in focus (currently in learning by learners), acquired (already learned), and known (already known) (Figure 4.B). The rules are sorted by their level of difficulty exhibited by learners' practice. Teachers can select a set of rules and launch **Practice view** to practice them with learners live in-class (Figure 4.C) (**R3**).

Practice view: This view (Figure 4.E) enables close monitoring of the most important indicators on learners' activity at an individual and group level (**R2**). It displays the list of learners in the class with a set of associated metrics (learners' Fullname, Score, Time spent, Connections, Initial level score, Initial evaluation score, Reached module) arranged in a tabular form (see Table 3). The column headers are displayed either as a histogram or a bar-chart according to whether the column is categorical or nominal. Similarly, the cells are encoded using bars to support comparison between learners. Interaction with the headers through filtering and sorting is provided to support searching and to make scanning information easier. The table is

Table 2: **Main view**'s indicators within 7 or 30 days.

Attribute	Description
	Learning Regularity
Grammar Rules	Avg. number of mastered grammar rules per learner, with the associated (+/-) delta of the selected time (Figure 4.a2).
Time Spent	Avg. time spent learning per learner, with the associated (+/-) delta of the selected time window (Figure 4.a3).
Active Learners	Number of active learners, with the associated (+/-) delta. Learner is considered active if s/he makes at least one (in 7 last days) or 4 (in 30 last days) connections (Figure 4.a4).
Inactive Learners	Number of inactive learners, with the associated (+/-) delta. Learner is considered inactive if he/she makes zero (7 last days) or less than 4 (30 last days) connections window(Figure 4.a5).
Connections Timeline	Total some of unique connections per day (Figure 4.a6).
	Learners Progression
Score	Top five learners in grammar rules acquisition (Figure 4.a7).
Commitment	Top five learners in practicing on the platform (Figure 4.a8).
Help	Top five learners struggling the most (Figure 4.a9).
Dropout	Top five non-practicing the most (Figure 4.a10).
	Grammar Rules Acquisition
In Focus	Top five rules currently in acquisition, and leading to struggles to most learners (Figure 4.a11).
Acquired	Top five rules already acquired, although led to struggles to most learners (Figure 4.a12).
Known	Example of five rules already known by most learners (Figure 4.a13).

augmented with a line-chart of learners' learning progression pathways in a timeline of all learning modules in which learners may enroll (**R4**).

Evaluation view: This view (Figure 4.D) displays the list of learners' metrics related to their evaluations, i.e., quizzes programmed by teachers (**R2**), in the same tabular form as the Practice view. This includes the learner's name, the time spent on the evaluation, the score obtained, as well as a corresponding derived score on a scale of 20 (Figure 4.d1–5).

Learner view: This view (Figure 4.F) is shown as a dialog box that presents the main metrics of the learners in a grid form, in a similar way to the Main view. This includes the current score, the time spent, the total number of initially known rules, the learning progression line-chart, as well as grammar rules acquisition related metrics (top five rules in focus (currently in learning by learners), acquired (already learned) and known (already known) (**R2, R3**).

Implementation: PROGDASH user interface is built using Typescript and Angular. The visualizations are implemented using D3js. PROGDASH works in a client/server fashion over REST web services. We pull the data from the database and compile metrics of the different views, before serving back to the browser in JSON. For optimization purposes, data is cached on the client for 1h before refreshing.

Table 3: **Practice view**'s indicators.

Attribute	Description
Learner	Learner's full name (Figure 4.e1).
Score	Learner's current score, that is, the number of rules known + acquired over the total number of rules in his/her learning path, as both a percentage and a total number (Figure 4.e2).
Time Spent	Time spent practicing on the platform (Figure 4.e3).
Connections	Total number of connections on the platform (Figure 4.e4).
Last connection	Last connection, as: since x hour/day/month(s)(Figure 4.e5)
Initial level	Grammar rules that are initially known by a learner, as both a percentage and a total number (Figure 4.e6).
Initial Evaluation	Score at initial evaluation as a percentage of correct answers (Figure 4.e7).
Reached Module	Last module reached by learner in his/her learning path (Figure 4.e8).

7 Field Study Design

We deployed PROGDASH for three months between March and June 2019. We aimed at investigating how teachers used the dashboard to monitor learners' progression. Specifically, we sought to answer two main research questions:

- Does PROGDASH provide teachers with useful information about learning progression?
- How does PROGDASH inform teachers' practices in assessing learners' online learning and conducting formative interventions?

7.1 Procedure

Deployment lasted three months for each teacher, split into 3 phases: opening, deployment, and closing.

Participants: We recruited 17 teachers via the company's newsletter (gender: [F=10, M=7], age: [min=30, max=60], school: [Middle=6, High=4, Vocational=7]). They all used PROJET-VOLTAIRE with their learners. We informed teachers of the logging implemented on the dashboard and their ability to withdraw at any time. They gave us permission for collecting and analyzing data.

Opening: We started the study after we had recruited 11 participants. We continued to enroll participants for two weeks afterwards. In the first week, we set up a webinar as teachers resided in different locations. We explained the main objectives of the study as well as the different parts of PROGDASH to help them become familiar with it. The webinar was recorded and later shared, along with a pdf user guide, with all the participants when they joined our study.

Deployment: We informed the teachers that they could use PROGDASH for a three-month period using dedicated web instance. Teachers used their own devices to access the dashboard from their location.

Closing: At the end, we asked the participants to fill out a questionnaire to collect feedback about the usefulness and effectiveness of PROGDASH, as well as teachers' practices. Later, a member of our research team set up online semi-structured interviews with six teachers. The interviews lasted 30 to 50 minutes. The questionnaire and interviews focused on (1) teachers' overall experience and perception in using PROGDASH and (2) how teachers used the tool in practice.

7.2 Data Collection and Analysis

Logs: We captured teachers' actions on PROGDASH with the associated timestamps.

Questionnaires: During the opening, we asked the participants to fill out a profile questionnaire to collect demographics information. During the deployment phase, each week, we asked teachers to fill out a simple diary questionnaire, asking if they had used PROGDASH the week before, when and what for. We gathered 16 (out of 17) participants' responses to the profile questionnaire, a total of 76 diary entries where teachers reported whether or not they had checked PROGDASH during the week [many times = 24 entries, once = 15, no checks = 36], and 14 (out of 17) responses to the ending questionnaire.

Interviews: We audio-recorded the interviews and followed Braun and Clarke (2006) thematic analysis:

1. Familiarizing with data: We manually transcribed and pseudonymized the interviews. We then allocated notes to interesting excerpts.

2. Initial coding: We transferred excerpts to a spreadsheet and assigned them codes. We kept enough context to ensure proper understanding. We duplicated excerpts with multiple codes. We iterated on codes to converge towards coherent sets.

3. Identifying themes: We iteratively piled and organized codes into themes, resulting in 20 initial themes.

4. Reviewing themes: We created a theme map from the initial themes, which we discussed among co-authors as suggested by (McDonald et al., 2019). We decided to split some themes and to merge others, resulting in 6 main themes. We kept representative excerpts for each theme to ensure coherence.

5. Naming themes: We named and defined each theme by its set of code excerpts. We then reviewed coded excerpts to refine the reporting on each theme.

8 Field Study Results

8.1 Teachers' Overall Use

Participants' interaction with PROGDASH evolved over the course of the deployment. Our log data (Figure 5) shows less activity at the end than at the beginning of the experiment, with school holidays in April accounting for a lesser use for two weeks.

Table 4: Use of PROGDASH's views, as count (#).

View	Count	Min	Max	Avg	SD	Vocational	High	Middle
Main view	300	1	73	17.6	22.8	100	81	119
Practice view	309	1	72	19.3	23.1	112	77	120
Learner view	207	1	137	18.8	39.8	37	33	137
Evaluation view	150	1	60	11.5	16.6	55	63	32

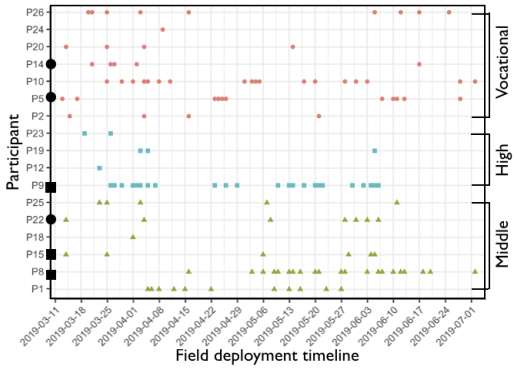

Figure 5: Teachers' sessions using PROGDASH. Interviewed teachers are marked with squares for French language teachers, and with dots for other teachers.

Connections. Log data showed that all teachers used PROGDASH at least once. The 17 participants used the tool 274 times in total [min=1, max=72, mean=16.1, sd=21.2] (identified as accessing the dashboard and selecting a class from the menu to explore AND counting only single login sessions). P1 asked to withdraw after using it 17 times, s/he explained that the dashboard did not suit her/his needs of dealing with 25 groups of learners, which s/he preferred to handle directly with spreadsheet exports. Three teachers used it only once (P12, P18, P24). Thirteen teachers used PROGDASH three or more times.

PROGDASH Views. Teachers used mostly the Main and Practice views, followed by the Learner view, than the Evaluation view (Table 4). Teachers in middle schools used the Learner view less than in high or vocational schools, mostly due to P9's and P10's extensive use of it. In the post-questionnaire (14 responses out of 17 participants), teachers expressed interest in all PROGDASH's views (Figure 6).

Teachers' Overall Experience. We asked teachers in the post-questionnaire: *"Would you like to continue using the dashboard?"*. All 14 out of the 17 who filled out the questionnaire responded *"Yes"*. Similarly, we asked participants *"Would you recommend the dashboard to a colleague already using* PROJET-VOLTAIRE*?"*, and their average rating (out of 14 responses) was above four on 5-point Likert scale. Overall, teachers were satisfied. They highlighted in their diaries different features of PROGDASH, such as the (1) visual aspect of the dashboard: *"I like the graphics"* (– P5), *"visual aspect of the class"* (– P20), (2) learners' progression: *"progression line-charts are very interesting"* (– P22), *"quick way to visualize learners' trajectories or their connection to the platform"* (– P12), and (3) grammar acquisition: *"ability to see easily the levels learners reached and the number of*

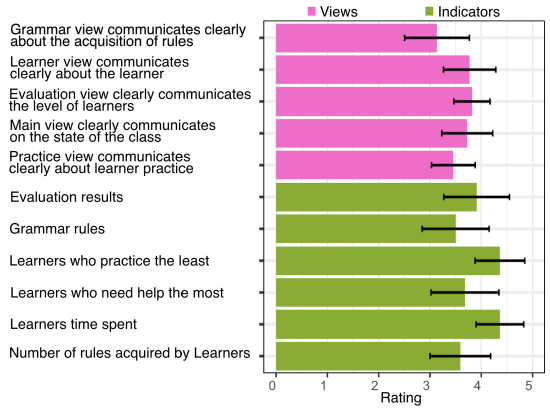

Figure 6: Teachers' interest in PROGDASH's views and indicators on a scale of 0 to 5 with the confidence interval.

concepts acquired by each learner" (– P1), *"many more details and vision about learners who do nothing to target them with exercises to do"* (– P15).

Teachers' Pain-points and Suggestions. In their diaries and interviews participants noted some usability issues and reported several suggestions. Teachers wanted to identify learners who missed an evaluation session. They had to look for blank cells in the table to find those learners, which became tedious with multiple evaluations per learner.

P22 stated that teachers must often cope with technical problems in the classroom, turning on the computer, connecting, setting up PROGDASH, or any other tool becoming too time-consuming. S/he suggested simplifying it by making two modes: *"a simple mode and an expert mode. The simple mode needs to be really ultra simple and ultra direct to track learners' results, and when you want to move on to something more advanced you can."* (– P22). S/he added by pointing out the need for an automated weekly report that could be sent by email to teachers as it might be more practical to access and to use on his/her mobile phone.

P14 highlighted his/her frustration with the design of the grammar acquisition view as s/he needed to be able to assign asynchronously specific concepts so that learners could practice those concepts when they launched the learning platform.

P8 and P9 disagreed with the sampling choice of indicators in the main view. For instance, P9 stated: *"top 5 is not enough because it needed to be balanced to 35 [number of learners in the class], it must be a top 10"*. Similarly, regarding the top 5 samplings of grammar concepts, P8 stated: *"I really like to be able to choose what I give to learners using* PROJET-VOLTAIRE *live in the classroom"*. Drawing a parallel with learners' progression line-charts, P8 and P22 requested a timeline for learners' time spent on the platform.

Table 5: Summary of teachers' pedagogical practices through the use of PROGDASH.

Teachers' practices along with illustrative quotes
Monitoring learners' progression
I really rely on the line-charts, I find them very telling [..] and immediately I see who dropped out or not, after I look at the numbers, but I start by looking at the line-charts. – P8
Often when I conduct my monitoring review, once a month, actually, I will dig deeper [..] I will rather be in the exploratory but regarding a particular learner. – P14
Formative, Summative Assessments
Now, when we have the detailed list of all the [grammar] concepts, we know precisely that if the learner no longer has this concept which is displayed – it means that it is acquired [..]. Before s/he [a learner] used PROJET-VOLTAIRE yes! but what value? does s/he learn no! we had to evaluate and conduct an evaluation. – P15
When we fill out learners' transcripts in the school, there is a criterion: the ability to ex-press oneself in writing with clarity and accuracy; of course, here we have objective elements [meaning using PROGDASH] to check the boxe. – P9
Planning, Adjusting Interventions
We had planned to work on the homophones "en" and "on" and when I saw that it was acquired by everybody, we did not do it. – P15
I use [PROGDASH] to adapt things when I realize that a language [grammar] element is not mastered at all, I will change my plan to incorporate it. – P8
Sharing PROGDASH In-class With Learners
They [Learners] were pleading to have such information, to see how they progress. – P8
I showed [PROGDASH] to learners [..] telling them that I could see everything that happened. And, when they knew it, it changed [learners' pace], because they didn't think we had access to it. – P15
Providing Feedback to Learners
It is rather to motivate them [learners], but it is also to sanction those who do not do their job. – P8
I didn't do a lot of close or individual monitoring with them [learners] except reminding them that they had to use the app. – P14

8.2 Teachers' Pedagogical Practices

Table 5 provides an overview of the pedagogical practices teachers developed with PROGDASH, and considered helpful.

Monitoring Learners' Progression. According to log data, 13 (out of 17) teachers checked the dashboard three or more times to monitor learners' activity on the learning platform (see Figure 5). Overall, in their diary reporting, those teachers reported a total of 35 checks of PROGDASH before a class [min=1, max=8, mean=3.18, sd=2.08]. They reported doing so to check learners' status and to look for outliers, either to encourage those practicing most or to talk to those not practicing enough. Teachers used such a strategy to provide the whole class with feedback . In post-interviews, P8 stated: *"I start by looking at the line-charts, and I see who is doing very well – to be able to congratulate and encourage them and who is not doing too well. It allows me to talk to them the next day when I see them"*.

Eight teachers reported in their diaries that they checked PROGDASH during a class a total of 27 times [min=1, max=8, mean=3.37, sd=2.26]. In post-interviews, two French teachers (P9, P15) emphasized checking the dashboard during a class, while learners were working on the learning platform, to check dis-

crepancies between learners' progression in grammar concept acquisition. P9 stated: *"during the class when they are in training, at a given time, I tell everyone to stop where they are. I now have the goal to harmonize the progression of the class, so I point to the gaps between learners"*.

Additionally, 13 teachers reported in their diaries checking PROGDASH after a class for a total of 26 times [min=1, max=5, mean=2.00, sd=1.29]. Teachers did so to inform follow-up debriefs with learners, or just to check if learners were progressing as expected. In post-interviews, P15 stated looking at the dashboard to check whether a learner had practiced a list of grammar concepts using the platform: *"I check the next week, if s/he still has the same list [of grammar concepts], then we will talk"*. Teachers looked at different dashboard indicators depending on the type of interventions they anticipated. Learners' time spent on the platform was one of the most important indicators for all teachers (see Figure 6). French teachers who teach material related to grammar concepts or who even use the learning platform in class, were interested in monitoring a combination of indicators about learners' progression, namely, the time spent on the platform, the regularity of learning, pacing, and skills development (P8, P9, P15).

Furthermore, teachers relied primarily on the line-chart timeline to conduct overall monitoring first before drilling down for more details. In post-interviews, four (out of six) teachers (P8, P5, P14, P22) highlighted the effectiveness of the line-charts in comparing learners' progression and identifying extreme learners: *"the line-charts representation is interesting because in the blink of an eye we can have the progression of learners compared to each other"* (– P14). Three teachers (P8, P5, P14) stated that they started their monitoring from the line-charts and then looked at the numbers: *"I really rely on the line-charts, I find them very telling [..] and immediately I see who dropped out or not, after I look at the numbers, but I start by looking at the line-charts"* (– P8). Finally, two teachers (P14, P22) stated in post- interviews that they conduct exploratory analyses using the dashboard. P22 stated that s/he did so to explore out of curiosity: *"it was mostly to see and do some monitoring, not remediation. It was mostly to see [*PROGDASH*] out of curiosity"*. P14 stated that s/he often drilled down regarding a specific learner: *"often when I conduct my monitoring review, once a month, actually, I will dig deeper [..] I will rather be in the exploratory but regarding a particular learner"*.

Formative, Summative Assessments. The dashboard was instrumental to teachers as it provided ongoing feedback about learners' online activity. This, in part, supported teachers in conducting quick formative assessments about learners' progression. In post-interviews, P8 stated comparing without and with the dashboard: *"when I land on the dashboard, I see the [grammar] concepts that are the most challenging for learners [..] before I had to infer it, as learners were the ones who informed me [during discussions]. Now I have it directly on the dashboard: s/he [a learner] doesn't need to explain, and I see which concepts s/he is struggling with"*. Similarly, P15 stated: *"[before* PROGDASH*] we did not have the impression that we have a value [from using* PROJET-VOLTAIRE*]. Now, when we have the detailed list of all the [grammar] concepts, we know precisely that if the learner no longer has this concept which is displayed – it means that it is acquired [..]. Before s/he [a learner] used* PROJET-VOLTAIRE *yes! but what value? does s/he learn [grammar concepts] no! we had to evaluate and conduct an evaluation"*.

Additionally, the dashboard supported teachers in conducting summative assessments of learners' progression at the end of the school year at the end of some instructional unit. P9 described how the dashboard provided objective facts for filling out evaluation reports: *"when we fill out learners' transcripts in the school, there is a criterion: the ability to express oneself in writing with clarity and accuracy; of course, here we have objective elements [meaning using* PROGDASH*] to check the boxes"*. Similarly, P8 stated using the dashboard to prepare a class council meeting: *"at the time of preparing the class council, it allowed me to see [learners' progression] in the blink of an eye. It is a great tool to see whether learners' work is steady over time, where s/he managed to progress, where s/he didn't"*. On a class level, P15 reported using PROGDASH to evaluate grammar fundamentals among classes: *"all the bottom part [of the Main view] about [grammar] concepts [..], especially the concepts that are already known [by learners], enabled us to see which classes had good fundamentals, and that was interesting"*.

Planning, Adjusting Interventions. Teachers used the dashboard to inform their in-class activities. Among the 13 teachers who checked PROGDASH periodically (three or more times), seven reported in their diaries that they checked the dashboard to prepare a debrief. They also used it to adjust their teaching plans, assign work, or structure their classroom activities (e.g., peer-tutoring).

In post-interviews, all the French teachers stated that they used PROGDASH to adjust their lectures. P14 stated: *"we had planned to work on the homophones "en" and "on" and when I saw that it was acquired by everybody, we did not do it"*. Similarly, P8 stated: *"I*

*use [*PROGDASH*] to adapt things when I realize that a language [grammar] element is not mastered at all, I will change my plan to incorporate it"*. Only two teachers (P15, P25) reported in diaries that they used PROGDASH to prepare lesson content.

Teachers also used PROGDASH to target groups of learners based on their difficulties. In fact, among teachers who checked PROGDASH frequently (three or more times), eight teachers stated that they look at the dashboard to check the status of individual (or groups of) learners. For instance, P14 stated: *"what we found interesting is having real information to know that this learner has a problem with this rule, to be able to reuse them in more individualized exercises in personalized aid"*. P9 stated *"I will note on our digital working space in bold characters, to tell them: 'I warn you, I checked the dashboard'. And, I will mark with a 56 font-size: 'work on* PROJET-VOLTAIRE*'."*

In the post-interview, only P15 explained using PROGDASH to set up peer-tutoring sessions: *"I take active learners [..] and I pick one learner with difficulties and ask Paul [active one] to work with Pierre [struggling], to show and explain"*.

Sharing PROGDASH in-class. The six teachers who participated in post-interviews, stated that they used PROGDASH to facilitate in-class debriefs, by showing it to individuals or to the class. Two teachers (P8, P9) stated that they shared the dashboard in-class to tell learners about their indicators, and to enable them to see their progression, as learners did not have access to such information. P8 and P9 further reported that learners *"were pleading to have such information, to see how they progress"* (– P8) and they *"ask to see their line-charts"* (– P9).

In post-interviews, five teachers (P8, P9, P15, P14, P5) explained that they aimed at improving learners' pacing by showing that they had indicators on their practice on the learning platform. P15 stated: *"I showed [*PROGDASH*] to learners [..] telling them that I could see everything that happened. And, when they knew it, it changed [learners' pace], because they didn't think we had access to it"*.

Additionally, in post-interviews, all teachers reported that they shared PROGDASH in-class to facilitate motivational debriefs with learners. Teachers described different strategies to ensure that learners maintain a steady practice. One was simply to allow learners to see their names among the top 5, or bottom 5 learners, which, in part, helped stimulate learners' self-reflection and motivate them to practice more. Similarly, P9 stated that showing the table in the Practice view ordered by learners' time spent online, *"triggered some sort of challenge, and they [learners] worked harder"*. Moreover, in post-interviews, all teachers stated that they showed the progression of line-charts to motivate learners. Its main role was in *"demonstrating the correlation"* (P9, P22) between practicing on a regular basis and learners' progression. Hence, showing progression over time was important to emphasize the longitudinal nature of the learning process. However, one teacher decided not to display the information to the whole class, and preferred to provide one-to-one debriefs with learners, as s/he thought that showing PROGDASH to the whole class would stigmatize learners: *"[*PROGDASH*] is something I keep for myself. I have to show it individually [..] it stigmatizes learners, and right away they would mock each other."* (– P5).

We did not anticipate that teachers would share the dashboard live in-class. We discuss the ethical implications of such a practice in the discussion section.

Providing Feedback to Learners. We identified different feedback strategies building on PROGDASH, both at individual and class level. All the teachers stated in the post-interviews that they reminded learners of the need to practice, often lecturing them briefly about the importance of practicing on a regular basis to maintain steady progress. Teachers either checked learners' status using PROGDASH before or during a class to congratulate learners who were practicing and provide public or private reminders to others who were not. Moreover, French teachers in particular, conducted individual debriefs with learners. For instance, P9 stated: *"I have split-classes, so I can do individual debriefs. Learners come at the end of the class and ask to see their line-charts"*. Besides, feedback also took the form of guidance regarding how to best use the learning platform. P5 stated: *"I tell them, take your time [to read and understand grammar concepts], we give you the concepts and examples so you can train on short sentences, and after you can try again"*.

In the post-interviews, teachers who did not teach French (P14, P5, P22), reported that it was the learners responsibility to practice. They mostly provided feedback regarding the efforts made by learners online on the platform, e.g., time spent, and the number of connections. Also, they often reminded learners of the importance of mastering the language for their future, or as stated by P14: *"I explain to them their [future] job, I train them to be assistant managers, so: 'you will have to write letters, emails [..]' they will have a lot of written production"*. Non-French teachers used the learning platform in addition to their classes, e.g., marketing and management. They stated having little time to provide formative feedback, and also that they did not feel competent in providing formative feedback to learners regarding grammar concepts, as they are not specialized in French grammar. For instance, P14

stated: *"I do not feel qualified to explain a [grammar] concept, or other things, because I do not necessarily master it myself"*.

Limitations and Future Work. Although we aimed at including in the study teachers from different disciplines, and levels, e.g., middle, high, and vocational schools, to gather realistic insights into teachers' practices in using web-based online learning platforms, teachers were self-selected to participate in this study. Therefore, the results may reflect practices of motivated profiles of teachers. Additionally, we asked teachers to fill out a diary by sending them a weekly email, which may have pushed teachers to check the dashboard. Finally, our study is exploratory in nature, as the learning platform we collaborated with has a diverse *context of use* in schools, thus making it difficult to derive representative pedagogical practices of teachers in their use of the dashboard. The next step would be, for instance, to conduct a study centered around each profile of teachers with respect to their context of use of the learning platform. Further work is needed to understand: how our results may generalize to other online learning platforms, what is the impact of the dashboard on learners, and investigate the design of dashboards that connect teachers, learners, and others.

9 Discussion and Design Implications

In this section, we discuss our findings in relation to previous work. We also suggest design implications for dashboards in online learning settings.

Providing Insights into Learning Progression. Our findings show that PROGDASH was instrumental to teachers in accomplishing different tasks. First, in terms of monitoring, the dashboard surfaced information previously invisible, and confirmed teachers' intuitions about learners' online progression that they built from formal or informal discussions with learners in the classroom. This corroborates prior results, particularly in improving teacher *"visibility"* of (Groba et al., 2014) and *"knowledge"* about (Xhakaj et al., 2017) learners' online learning.

Additionally, the dashboard supported teachers in conducting formative and summative assessments of learners' activity both during and at the end of instructional units, which suggests that dashboards may help reduce assessment time as found in (Groba et al., 2014; Govaerts et al., 2011). PROGDASH particularly supported French teachers in identifying those grammar concepts where learners struggle most, and in adjusting learning materials accordingly as found in (Xhakaj et al., 2017; Molenaar and van Campen, 2017).

Understanding Individual and Group Progression. PROGDASH highlighted the large variability of learners' progression in the classroom, enabled by indicators that categorize learners (e.g., top learners) and by temporal visualizations (e.g., line-charts), which highlight patterns of tendencies among learners. Also, this corroborates prior results on dashboards as enablers to identify trends, for instance in forum discussions (Mazza and Dimitrova, 2007), learners' notebooks (Yuan et al., 2008), and learners' regulation in a social network (Groba et al., 2014).

Additionally, teachers emphasized the effectiveness of line-charts in understanding the temporal progression of learners, which supported the identification of outliers, as in (Mazza and Dimitrova, 2007; Molenaar and van Campen, 2017). Importantly, line-charts enabled teachers to grasp and understand the unique progression of each learner. Teachers started their exploration of the dashboard by looking at line-charts and then at numbers, as reported in post-interviews. Line-charts also supported the comparison between learners' progression (P8, P5, P14, P22).

Supporting Effective Data-informed Practices. Our study underlines critical implications of use of teachers' dashboards in contexts like ours, namely, specialized online learning platforms. That is, even if all teachers in this study used PROJET-VOLTAIRE to help learners improve their grammar skills with associated grades, there was a divide in PROGDASH use. Teachers who used the platform in their French language courses, relied on different indicators of learners' progression, including grammar concept acquisition, and conducted different informed pedagogical interventions: debriefing, feedback, peer-tutoring, and lessons. On the other hand, teachers who used the platform while teaching other disciplines, relied mainly on indicators about learners' efforts, such as the amount of time invested online and the number of connections. They were reluctant to provide formative feedback to learners, e.g., related to grammar concepts, and thus mainly lectured and reminded learners to use the learning platform on their own.

As a result, for instance, the type of feedback given by teachers could have a *mixed-effect* on learners. That is, in post-interviews, all teachers emphasized that they "congratulate" top learners, while all non-French teachers relied mainly on "timespent" to devise their feedback. For example, praising learners for task performance is shown to be ineffective as *"it contains such little learning-related information"* (Hattie and Timperley, 2007). In part, this suggests the need to train teachers to better support the intended use of such learning platforms through dashboards. Also, in part, it suggests the need for dashboards to facilitate finding teachable elements so that a teacher can provide

effective and actionable feedback about learners' progression. In fact, teachers' feedback is more likely to work when it is supportive, timely, and, importantly, specific to the learning activity (Shute, 2008).

Anticipating, Facilitating in-class Use. PROGDASH supported teachers in engaging in informed debriefs, e.g., *"positive reinforcement"*, *"verbal warning"* to push learners to do their best, as was found in (Aslan et al., 2019). Importantly, teachers shared the dashboard with the whole class to support their debriefs for three main reasons: *transparency*, to share information with learners as they do not have access to such dashboards (P9, P8); *control*, to let learners know that teachers have precise indicators about their progression and pacing (P8, P9, P15, P14, P5); and for *motivation*, to foster self-reflection and stimulate challenge by showing learners' indicators about their progression. This is very important as the dashboard fostered the dialog between teachers and learners in both directions, as in some classes, learners asked teachers to debrief them regarding charts on the dashboard. Such dialog improved the learning experience in the classroom, which would be lost if, for instance, the dashboard was designed only for learners (Martinez-Maldonado et al., 2015), or if the feedback was automated, e.g., programmed to learners, a practice found to be ineffective (Hattie and Timperley, 2007). However, we did not anticipate that teachers would show the dashboard in-class for debriefing with learners, or show information on all learners to the whole class, and PROGDASH was not designed for this purpose. This raises design and ethical concerns, especially regarding showing full names, rankings and learning data of all learners.

Additionally, in post-interviews, teachers emphasized their use of the dashboard in-class to foster learners' motivation and self-reflection. This is very important as most teacher-facing dashboards, even those designed to be used in classrooms (e.g., synchronous), are not designed to be shared with learners to support debriefs or feedback, even though dashboards can have a positive effect on learners, as was found in (Aslan et al., 2019; Holstein et al., 2018). Besides, although we did not intend to support self-reflection by design through PROGDASH, this observation is in-line with the impact model of learning dashboards proposed by Verbert et al. (2014).

These findings suggest the need for dashboards to support in-class sharing with individuals and groups, or for focused teaching interventions. However, dashboards need to be carefully designed to anticipate this kind of emerging teachers' practices.

10 Conclusion

We presented a design study of a dashboard to support teachers in monitoring learners' progression on an online grammar and spelling learning platform. We iteratively designed the dashboard with teachers, and we integrated it on a widely used platform. The result of this work is PROGDASH.

We presented the results of a 3-month field study of a dashboard in-the-wild, with 17 teachers, from different schools. Our results show that teachers used the dashboard at different times (before, during and after a course) and for different purposes: monitoring, formative, summative assessments, and planning interventions. Teachers shared the dashboard with learners for transparency, control, and motivational purposes, to support debriefs and in-class interventions. Teachers used PROGDASH to provide feedback to learners at both class and individual level. Our results highlight a divide between the practices of teachers teaching French language and those using the platform for extra-curricular learning. Based on our findings, we suggest directions on how teachers' dashboards could better bridge online and in-class learning.

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