Primary school teachers meet learning analytics dashboards: from dispositions to situation-specific digital competence in practice

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Abstract: This paper looks into the use of Learning Analytics Dashboards, visualization tools that present data regarding students' learning progress, by teachers in and out of lessons. Based on data of two studies conducted in Belgium and England, we discuss primary school teachers' prior experience with dashboards, their perceived value and self-efficacy towards dashboards and we take a more situated perspective presenting one case of how a dashboard is used in practice. We argue on the importance of looking into specific elements of teacher beliefs and competence in using such dashboards in their practice but also understanding the broader educational context and the teachers' goals. We conclude by suggesting further research into the relationship between teachers' dispositions and how they make sense of the information presented on dashboards in practice, to inform future dashboard design and teacher training opportunities.

Keywords: primary teachers, learning analytics dashboards, digital competence

Introduction

There is much hype about the use of learning analytics to inform classroom practice. This can be seen in the proliferation of digital learning environments that provide visualisations and other forms of information to support teachers' awareness and decision making based on summarised data that students leave in the respective digital tool. Commonly referred to as 'learning analytics dashboards' (LAD) these visualizations show aggregated data about learners, learning processes, and/or learning contexts (Schwendimann et al., 2017). LAD are promising because they can inform teachers' instructional behaviour (Connor, 2019), support real-time classroom orchestration (Mavrikis et al., 2019) or monitoring and reflection on behalf of the teacher (Molenaar & Knoop-van Campen, 2016). The use of dashboards has been shown to result in improved knowledge about the learner and adapted lesson plans involving individualised scaffolding (Aslan et al., 2019; Xhakaj et al., 2017). Furthermore, teachers might reflect on the impact of their instructions and implemented learning design. As such dashboards can improve teachers' reflection on their own practice and hence improve teaching quality (Ndukwe et al., 2020). Altogether, the aspiration is that LAD can support individualised learning experiences and improved student learning outcomes.

There has been a lot of research on the design and use of LAD in higher education (Rienties et al., 2018; Wise & Jung, 2019). Also, in primary education teachers increasingly use digital technology, a phenomenon that was accelerated by the distance and online education during the global pandemic (Kovanic et al., 2021). While research shows positive results of using dashboards for teachers (thus indirectly for learners) in primary education, there is a large variation in how teachers use these

dashboards in the classroom (Molenaar & Knoop-van Campen, 2016). For example, teachers' interactions with dashboards vary with regards to when they look at the dashboard (during versus after a lesson), how much they look at the dashboard and the kind of feedback (personal, meta-cognitive, social, etc.) they give to learners (Van Leeuwen et al., 2021). It is well understood that whether digital technologies, including dashboards, will lead to meaningful student learning is linked with teacher competence (Molenaar & Van Campen, 2016; Ndukwe et al., 2020) and particularly, digital competence including knowledge, skills, attitudes, abilities, strategies, and awareness that are required when using ICT" (Ferrarri, 2012, p. 30). Mathematics teachers' digital competence in particular has also been explored and presented as the combination of instrumental skills and knowledge (e.g., the ability to use digital tools), advanced skills and knowledge (e.g., the ability to apply digital tools to particular tasks), and attitudes of skills and knowledge application (Jasute & Dagiene, 2012). However, when looking into the research of dashboards in mathematics education, there is little understanding of how specific elements of teacher competence relate to effective dashboard use and how decision-making is influenced by the broader educational context.

Theoretical Background

One model that has been widely used in mathematics education research to investigate teacher competence is the competence model of Blömeke et al. (2015). They conceptualize teacher competence as a multifaceted concept consisting of dispositions, situation-specific skills and performance (Depaepe et al., 2020). First, dispositions refer to teachers' cognitive and affective-motivational traits. Cognitive traits necessary to interpret LAD incorporate data literacy skills, defined as "the ability to effectively engage with data and analytics to make better pedagogical decisions" (Ndukwe et al., 2020, p. 3). Affective-motivational traits include professional beliefs about the use of LAD. In relation to the use of data for instructional purposes in particular, previous studies have revealed the importance of teacher self-efficacy (i.e., teachers' beliefs in their own abilities to use learner data to enhance learner performance) and perceived usefulness (i.e., teachers' beliefs about the use of learner data to enhance learner performance) (Dunn et al., 2013; Reeves & Honig, 2015). Previous studies also documented the importance and interrelations of beliefs about teaching mathematics with technology, self-efficacy, and epistemological beliefs (e.g., Thurm et al., 2022). These dispositions are assumed to impact the second facet of professional competence, i.e., situation-specific skills including cognitive processes such as perception, interpretation and decision-making before, during and after actual classroom behaviour (Blömeke et al., 2015). In view of LAD, perception refers to the extent to which teachers get oriented and apply focused attention to what is presented on the dashboard (Van Leeuwen et al., 2021). Interpretation refers to how teachers filter, organize or analyse the perceived data from dashboards and combine this information with prior expertise and experiences with the learners (Van Leeuwen et al., 2021). Decision-making refers to the instructional actions teachers plan to undertake based on the data or the assessment of the effectiveness of these actions (Wise & Jung, 2019). Third, teachers' situation-specific skills are considered to impact their actual performance in a classroom (Van Leeuwen et al., 2021). Specific teacher actions can include selecting suitable instructional methods, prioritizing which content to teach or emphasize, reteaching and designing support for these learners in most need of them (Aslan et al., 2019).

However, there are some reasons why the implementation of LAD is not self-evident for primary education teachers. First, using LAD teachers often have limited opportunities to learn about analytics and how they can be useful for teaching. Due to a lack of emphasis on this topic in teacher training programmes, it can be expected that teachers' self-efficacy towards the use of data and the extent to which they perceive using data for instructional purposes valuable for their teaching practice, is rather low (Dunn et al., 2013; Reeves & Honig, 2015; Wise & Jung, 2019). For example, Vanlommel et al. (2020) observed that teachers greatly relied on intuitive processes rather than on data to decide about the transition of pupils during their last year of primary education. Second, primary education teachers are generalists and may lack data literacy skills which are necessary to interpret the many visualisations presented on dashboards (Merk et al., 2020; Van Leeuwen et al., 2021). For example, teachers reported to have difficulties with interpreting dashboards, making meaningful connections between the various data components and making instructional decisions about specific groups or whole classrooms (Molenaar & Knoop-van Campen, 2016). Third, using digital artefacts in real-time classroom practice is complex. Taking the perspective of the 'theory of instrumental orchestration' (Drijvers et al., 2014), a type of orchestration is required so that the use of LAD, an available artefact in the learning environment the teacher uses for a mathematical task, is exploited in such ways so that students are successfully guided towards achieving instrumental genesis (Trouche, 2004). Until now, it is unclear how the teacher's 'exploitation mode' for exploiting their arrangements and configuration of the LAD artefact benefit teachers' didactical situations (Drijvers et al., 2014). Fourth, research also pointed at limitations in teachers' ability to make data-driven decisions. Sun et al. (2016) conducted a systematic review on the use of learner assessment data. They found that teachers use data often to identify weaknesses and gaps in learners' knowledge and skills standards, but that teachers consider it difficult to adapt instruction accordingly.

Methods and Participants

The overarching question of this paper is what teachers' dispositions are towards the use of LAD and how this relates to how they use LAD in their teaching. We narrow the reporting here on two different cases from studies in Belgium and England by focusing on teachers' dispositions, situation-specific skills and how they use LAD in practice so as we can inform the development of dashboard design and further training.

In Belgium, a study was conducted to investigate teachers' dispositions towards LAD and their situation-specific skills to use dashboards. Participants were required to have at least one year teaching experience and were recruited by contacting schools in Flanders. In total, 45 (9 men, 36 woman) in-service primary education teachers of Flanders agreed. Teachers taught in different years of primary education (Year 1: $n=7$, Year 2: $n=9$, Year 3: $n=8$, Year 4: $n=14$, Year 5: $n=9$, Year 6: $n=15$). Their teaching experience varied from less than 5 years ($n=21$), between 5- and 20-years ($n=12$) to more than 20 years ($n=12$). A questionnaire was administered to assess teachers' 1) experience with dashboards, 2) purposes for which they used dashboards, 3) perceived value towards the use of data in the classroom, and 4) self-efficacy towards the use of LAD. For the scale that measured perceived value, we translated the Survey of Educator Data Use according to Wayman et al. (2009) into Dutch and adapted the items to the context of this study, regarding LAD. This instrument consists of nine items to be evaluated on a 4-point Likert scale: (1) strongly disagree, (2) disagree, (3) agree and (4) strongly agree. Internal consistency of the scale was good (Cronbach's

α=.75) (Field, 2017). Self-efficacy was investigated using the scale of Walker and colleagues (2018). The items were translated to Dutch and were adapted to the context of this study, specifically for LAD. The scale uses a 5-point Likert scale: (1) totally disagree, (2) disagree, (3) neither agree nor disagree, (4) agree and (5) totally agree. The internal consistency was very good (12 items; Cronbach's α=.83). Interviews were conducted with each teacher to assess their perception, interpretation and decision-making skills in particular situations but due to space limitations we do not report on this part in this paper.

In England, at the time of this writing, we are piloting a study with teachers who already use LAD in their teaching practice. Participants are identified from schools with three different LAD: a platform focusing specifically on daily times tables practice, an online tutoring service for primary mathematics, and a reading and spelling online resource. We piloted our instruments and interviews with two schools, and we are in the process of recruiting and training participants for the main study. Participants are given a short questionnaire on their profile and experience with educational technology in general, a diary to include their interactions, observed once a month in relevant planning and classroom sessions, and complete a semi-structured interview that focuses on the actual usage of LAD, reflect on their notes and focus on identifying how they relate the data presented in the dashboard with the decisions they are taking. In this paper, we hone in on one of our participants in the times tables practice platform: a Year 4 teacher at a state school with 12 years teaching experience with a year experience with using the specific platform and LAD in the classroom.

Teachers' experience with and dispositions towards dashboards in Belgium

All 45 teachers in Belgium indicated that they use digital learning tools in their classroom practice to train learning content with pupils. Regarding the availability of dashboards, 39 out of 45 teachers report that the digital learning tools they use contain a dashboard. When asking how familiar teachers are with these LAD, we get mixed responses. Almost half of the teachers (42.3 percent) report that they have not heard of LAD before they participated to the study, or they knew what LAD were but never have used them before. The other teachers used LAD less than once a month (17.8 percent), once or twice a month (17.8 percent), (almost) weekly (13.3 percent) or (almost) daily (8.9 percent).

The teachers that reported to use a dashboard did this for different purposes. Teachers use the data displayed on dashboards mostly to plan content to focus more on during the following lessons (42.2%). Teachers also use the data on dashboards to tailor instruction to individual students' needs (33.3 percent) or to form small groups of students for targeted instruction (31.1%). The data on dashboards is used less to ask for additional support in the classroom for certain learners (22.2%) or to discuss the data with the student, colleague or parent (24.4%). Most teachers use dashboards for 0 (12 respondents), 1 (12 respondents) or 2 reasons (12 respondents), far fewer teachers use them for more than 2 reasons. A significant positive relationship was observed between how much teachers use dashboards and the variety of purposes they use the dashboards for (0.37, $p = 0.012$).

Teachers' perceived value towards the use of data to inform classroom decisions was assessed on a Likert scale of 1 (strongly disagree) to 4 (strongly agree). The teachers' mean score was 2.86 ($SD = 0.54$) meaning that they rather agree towards the idea that data are useful to make informed classroom decisions. Similar results were found for teachers' self-efficacy towards how confident they are to use a dashboard in the classroom. The items measuring self-efficacy had to be scored on a Likert

scale of 1 (totally disagree) to 5 (totally agree). The teachers' mean score on this scale was 3.76 (*SD* = 0.80) showing that teachers rather feel competent to use dashboards in classroom practice.

A significant negative correlation between teachers' experience with dashboards and teachers' perceived value (-0.33, $p = 0.029$) was found. This implies that teachers who report higher use of dashboards in their practice, also tend to perceive them as less valuable for their practice compared to teachers who reported less frequent use of dashboards. No significant correlation was observed between teachers' experience with dashboards and their self-efficacy towards the use of dashboards.

The case of Lena in England: actual usage of LAD for a times tables platform

In this case study, Lena (not the teacher's real name), had no prior training in the dashboard from the times tables platform or prior training on possible dashboard purposes. She has been using the times table programme in a Year 4 classroom regularly (almost weekly) throughout the term and recommends to parents to access it at home too. According to her diary, the use of the dashboard is occasional (once every two weeks) and not necessarily systematic.

At a high-level, a key observation was that Lena approached the dashboard with an explicit objective that varied depending on the specific goals of the class for that week and what she had asked from parents at home. In particular, the times tables platform contains different game types and teachers encourage students to focus on one or another depending on their emphasis that week (e.g. learn a specific times table, practice several together as practice test, or whole-classroom games).

Similar to the purposes reported above for the Belgium teachers, Lena accessed the dashboard to plan which times table she should focus on the following lesson and to allocate specific times tables for specific students and to identify small groups of students for targeted instruction. Less frequently, the dashboard was used to tailor feedback to specific students and to provide specific recommendation to parents e.g., in parent meetings or with other colleagues. However, Lena reflected on the fact that there is not enough time in her workload to focus on the two last purposes so she mainly used the "average daily minutes over the last 7 days" as a proxy to prioritise which students to 'nudge' to use the platform more. This helped her implement the "little and often" principle that is key to times tables fluency and recall.

At this point, it is worth reflecting on the teacher's intentions and the overall context behind the use of the dashboard in this case. During the interview it became clear that two intertwined forces are shaping Lena's actions, revolving around the multiplication tables check (MTC) that is statutory for primary schools in England. According to the government, "the purpose of the MTC is to determine whether pupils can recall their times tables [2 to 12] fluently"[1]. The test adds significant pressure to some schools and teachers and some parents and students find it particularly stressful. Lena (like other teachers) is concerned that the test is encouraging rote learning and creates unnecessary time pressures, therefore possibly contributing to maths anxiety for some pupils. Driven by both the desire, on one hand, that the school does better on the test and on the other hand that the pupils are supported as much as possible. The first matters as in essence the results will be used to analyse school performance that plays a role in parental decisions for selecting a school. The emphasis on individual pupils, however, was also important for Lena not only to support them to master specific times tables

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[1] https://www.gov.uk/government/collections/multiplication-tables-check

but to use the data from the dashboard to help provide additional support wherever possible as it provided a diagnostic function that the MTC is not intended for. "The dashboard", Lena said, "helps me see exactly which times table they struggle with [..] and if I had more time or a teaching assistant help me target with precision".

Conclusion

We started this paper referring to the common rhetoric and aspiration in the field of Learning Analytics to design dashboards and other tools that support teachers so as, in turn, they can support students with their learning. The data from the case of Belgium demonstrate that although many teachers use tools that contain a LAD, most of them have not heard of LAD and do not report to use it regularly. Furthermore, teachers' perceived value and self-efficacy are moderate indicating a need for both better positioning of LAD and for including them in training to help improve teachers' dispositions. A possible explanation for the lack of extensive use of LAD, of course, is that teachers do not have time for this (as also mentioned in the in-depth interview of Lena in England). Another explanation, corroborated by the Belgium findings, revolves around the perceived value of LAD in that the information that is presented on current dashboards is not valuable enough for teachers to justify their use. Although there is a growing realization of advanced dashboards that can trigger interventions or even prescribe new pathways or strategies to improve student success (Kovanic et al., 2021), it is possible that the data presented on dashboards that are used at scale are rather limited and only present relatively simple descriptive information (such as accuracy, time). This endorses the view that one key challenge in this area is facilitating this journey from information to insight to action (Molenaar & Knoop-vanCampen, 2018)

In the case of Lena, we saw how the dashboard is beginning to be part of her practice – an instrument that is being exploited in several ways leading to specific actions. We also saw how this is shaped, if not motivated, by the overall schooling context and the national times tables test that creates additional pressure to her. Applying this lens reveals a complex interplay of factors that shape the use of the LAD in this case in practice. This in turn, shapes our future work as well, in that it becomes clear that a situated account of how and why LAD are used in practice is required, analogous to a situated action perspective (e.g, Suchman, 1987).

Research in the fields of mathematics education and teacher training has demonstrated by now that key aspect of teacher knowledge, and competence and their relationship to instructional quality is the enaction of this knowledge in practice (Tabach, 2021). Similar to Niss and Hojgaard (2011) who advocate that preparation for mathematics teachers requires not only acquiring mathematical mastery, or general pedagogical training but bringing "the mathematics competence into play with the issues regarding the teaching and learning of mathematics", we advocate for a focus on data literacy in combination with training in mathematical teaching competence in a way that makes visible their interplay through practice.

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