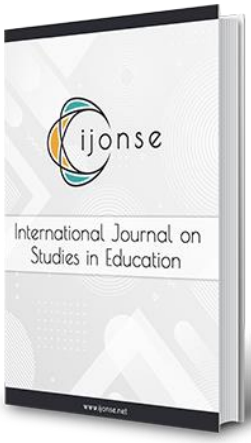

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To cite this article:

van Leeuwen, A., Post, L., Lockhorst, D., Admiraal, W., & Kester, L. (2024). A typology of teachers' self-reported use of student data from computer-based assessment programmes in secondary education. *International Journal on Studies in Education (IJonSE), 6*(3), 316-332. https://doi.org/10.46328/ijonse.208

International Journal on Studies in Education

2024, Vol. 6, No. 3, 316-332 https://doi.org/10.46328/ijonse.208

A Typology of Teachers' Self-reported Use of Student Data from Computer-Based Assessment Programmes in Secondary Education

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Article Info

Article History

Received:
13 January 2024
Accepted:
15 May 2024

Keywords

Secondary education
Teaching strategies
Learning analytics

Abstract

Teachers in secondary education have to deal with a growing diversity in student population, which asks for differentiation of their teaching. Computer-based assessments (CBA's) are educational software tools that, for a particular school subject, allow students to practice their knowledge or skills, leading to results about students' performance or ability level at that point in time. Information derived from CBA's (known as learning analytics) has the potential to support teachers to differentiate by informing them of each student's current level. In this study, our aim was to provide a typology of how and why teachers in secondary education use analytics, with the subsequent aim of providing recommendations for teacher professional development. Four profiles were found: high users, selective users, early stage users, and non-users. We provide recommendations for each of these profiles.

Introduction

Teachers in secondary education are increasingly expected to differentiate their teaching based on the needs of students (Tomlinson et al., 2003). To differentiate, among other things, teachers need information about their students' capabilities to make informed decisions about what activities and instructions to offer to which students. Computer-Based Assessment (CBA) can be applied as a means for teachers to obtain such information about their students to facilitate their differentiated teaching (Molenaar & Knoop-Van Campen, 2018). CBAs are educational software tools that, for a particular school subject, allow students to practice their knowledge or skills, leading to results about students' performance or ability level at that point in time. Information derived from CBAs, henceforth termed student data (SD), has the potential to support teachers to differentiate.

An increasing number of studies show the positive influence using SD may have on the quality of teachers' instruction. Yet, it is also apparent that using SD is a complex process (Keuning & van Geel, 2021) and that teachers differ in the extent to which they actually use SD in their teaching (Kester et al., 2018; Lomos et al., 2023). The aim of our study is to contribute to our understanding of how and why teachers in secondary education use CBAs and SD, with the subsequent aim of providing recommendations for teacher professional development. In the sections below, we provide background information on differentiated teaching, the role of SD, and the theory of planned behavior that we use for understanding teachers' current practices.

Differentiated Teaching and the Role of Student Data

Based on work demonstrating the superiority of individualized instruction over one-size-fits-all approaches, it is advocated that instruction should be differentiated by responding to differences between students (Vandewaetere, Desmet, & Clarebout, 2011). Teachers in secondary education are therefore increasingly expected to adapt their teaching to differences between students. Those differences may concern several aspects of learning, such as the cognitive, social, and affective level (Vandewaetere et al., 2011).

In this paper, we focus specifically on differentiated teaching on the cognitive level. Teachers may do so by adapting to student needs in the way content is presented (content), the way content is learned (process), or the way students respond to the content (product) (Dixon, Yssel, McConnell, & Hardin, 2014; Tomlinson et al., 2003). Differentiation occurs by choosing specific instructional activities at the classroom, small-group and individual level (Corno, 2008). To do so (Vogt & Rogalla, 2009), teachers need to be able to understand and identify student differences and use this knowledge to adapt their instruction or lesson plans to support learning for all students. Given that classrooms often contain 25 students or more, and that the teacher only has one pair of eyes to monitor those students, teachers do not always have time on a regular basis to obtain a detailed overview of the current level of understanding and needs for support of every student.

This is where CBAs can play a beneficial role. Educational technology that allows students to develop their knowledge or skills, results in a wealth of data about their current performance level, for example, in terms of test scores, details of provided answers, and time it took to complete a task (Van Leeuwen, 2019). These data are often used for supporting students in two ways (Molenaar & Knoop-van Campen, 2016): First, by having the CBA support the student directly, for example, by automatically selecting subsequent tasks to work on based on the students' current level Second, the collected data can be used to inform the teachers, who can use these student data (SD) to prepare their classroom instruction to support differentiated teaching (Farley-Ripple et al., 2019).

Using student information derived from CBAs to inform teachers can be seen as part of the research domain of learning analytics, which is defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens & Gasevic, 2012). SD obtained from CBAs provides teachers with an overview of student performance data which complements their own observations. This can help teachers understand the subsequent instructional needs of their students. Recent studies indeed show that SD is used by teachers at two levels of instructional planning. First, teachers use these data to plan the activities and the content they cover in subsequent lessons (Farley-Ripple et al., 2019; Van Geel, Keuning, Visscher, & Fox, 2016). Second, teachers use these data during real-time enactment of lessons when they have access to a teacher interface that is continuously updated (often called dashboards). Molenaar and Knoop-Van Campen (2018), for example, showed how teachers used different types of feedback in the classroom after they consulted a teacher dashboard with information about students' mathematical skills.

Findings from other studies suggest that the use of SD derived from CBAs for teaching in class is a dominant

factor that explains differences in student learning gains (Holstein, McLaren, & Aleven, 2018; Koedinger, McLaughlin, Hefferman, 2010; Ysseldyke & Bolt, 2007). Faber, Luyten and Visscher (2017) examined the effects of one of the most commonly used CBA in Dutch education, Snappet. Teachers were scored to what extent they used Snappet to differentiate their teaching, and this score was related to student achievement. This finding suggests that the effectiveness of Snappet for student learning depends on if, and how intensive, these systems are used by teachers in the classroom. As a result of the SD, teachers reported a better overview of the progress of lessons and of students' understanding of the assignments (Faber & Visscher, 2016). Furthermore, teachers reported that they were better able to respond quickly and purposefully to students' questions and learning needs. Holstein et al. (2018) compared students' learning gains in a condition when teachers had access to SD offered via smart glasses (glasses that allow the user to receive additional information displayed on top of reality) to a condition in which teachers did not, and found a positive impact on student learning for the condition with the smart glasses.

Similarly, Koedinger et al. (2010) examined effects of ASSISTments, which is a web-based CBA aimed at mathematics that includes an interface for teachers displaying SD. In a quasi-experimental study, these authors found an interaction effect of teacher and student use, which meant that increased teacher use was not only associated with learning gains by students who did use the CBA but also among those students with little or no use. This latter finding suggests that students who did not use CBAs, benefitted from teachers adapting their whole-class instruction based on what they learned from the SD available through ASSISTments.

Teachers' Use of Student Data in Class

In contrast to these studies that show teachers' successful use of CBAs and SD to realize differentiated instruction, there are also studies showing the difficulties teachers experience with regard to this process (Wayman & Jimerson, 2014). Kester and colleagues (2018) provided an overview of differentiation practices based on SD concerning Dutch teachers. They conclude that a large group of teachers struggled with correctly identifying students' needs based on SD generated by CBAs, indicating a need for developing the required data literacy to do so. In the context of higher education, Van Leeuwen (2019) showed that teacher are not always able to take the subsequent step of translating the interpretation of data to actual teaching strategies.

The use of CBAs and SD is a time-consuming process, with the result that teachers tend to focus on low-performing students and to a lesser extent to the needs of high-performing students (Datnow & Hubbard, 2015; Admiraal, Vermeulen, and Bulterman-Bos, 2020). In general, Keuning and Van Geel (2021), Wise and Yung (2019), as well as Mandinach and Beth (2016) stress that using SD for differentiated teaching is a challenging process involving a multitude of teacher competences. The study by Kippers, Wolterinck, Schildkamp, Poortman, and Visscher (2018) that focuses on teachers' use of data to inform instruction more broadly (so also concerning technology other than CBAs), reports that teachers use data for instruction in only 25%–50% of their lessons. From the interviews the authors conducted to gain more insight into these findings, it appeared that teachers often lacked the skills of how to translate the data into subsequent action. For example, concerning differentiation on the process dimension, teachers did not know how to adjust students' pacing of studying the materials, since the

teachers were tied to a schedule in which they teach particular content in particular weeks. Other teachers only reported ways of using data to criticize or reward students instead of increasing differentiated teaching.

There is thus variety in the extent to which teachers are able to use SD, and using SD is not yet common practice. Nevertheless, if teachers use SD for differentiated teaching, this seems to have a positive effect on students' learning (Deunk, Smale-Jacobse, de Boer, Doolaard, & Bosker, 2018; Holstein et al., 2018). More insight into differences between teachers in why they use CBAs and SD would therefore be useful as a starting point for professional development of teachers concerning the use of CBAs and SD to stimulate differentiated teaching (Datnow & Hubbard, 2015; Wayman & Jimerson, 2014).

The Present Paper: Studying Teachers' Reasons for Using CBAs and SD

A limitation of most studies on CBAs is that little to no information is available on how often and why teachers use evidence from CBAs to adapt their instruction for differentiated teaching. Thus, the purpose of the present paper is to examine that question by using teachers' questionnaire, logbook and interview data. As other researchers have indicated (i.e., Admiraal et al., 2017; Tondeur, Hermans, van Braak, & Valcke, 2008; Tubin, 2006), a useful way of mapping teachers' practices and underlying reasons for their practices is by creating a typology. Typologies of teachers (usually based on cluster analyses) provide a categorization of teachers into certain types, based on characteristics that are selected beforehand. In the present project, our aim is to create a typology of teachers concerning their self-reported use of CBAs and SD and reasons for doing so, to serve as a starting point for formulating goals for professional development.

For our typology, we will focus on teachers' self-reported use of CBAs and SD (in terms of whether and how it is used) and on teachers' reasons for doing so. To study teachers' reasons for using CBAs and SD, we use elements from the Integrative Model of Behavior Prediction (IMBP; Fishbein & Azjen, 2010). The IMBP is generally considered a suitable framework to study teachers' intentions of displaying certain behavior and has been applied in the context of teacher interaction with educational technology (i.e., Kreijns, Vermeulen, Kirschner, Van Buuren, & Van Acker, 2013; Prenger & Schildkamp, 2018). The IMBP states that three key constructs relate to a person's intention to display behavior (in this case the use of CBAs and SD), namely Attitude, Perceived Social Norm and Self-efficacy. Attitude is the extent to which teachers experience a sense of favorability for performing the behavior. Attitude is determined by the beliefs a teacher has about the likelihood that performing the behavior will have certain outcomes, which could be both positive and negative. Thus, when teachers, for example, believe that using CBAs and SD in their practice will have negative consequences (either for themselves or for their students), they are unlikely to do so.

Perceived social norms consist of the extent to which teachers experience support from their colleagues for displaying a certain behavior, to what extent their colleagues display the behavior, and whether teachers think the behavior is expected of them. When social norms are high, teachers will regard the use of CBAs and SD as being considered important and will be more likely to display this use themselves (Datnow, Park, & Kennedy-Lewis, 2012; Wayman, Jimerson, & Cho, 2012). Lastly, self-efficacy is the extent to which teachers perceive themselves

to be capable to display a certain behavior. Self-efficacy thus reflects the extent to which teachers think they possess the required skills to use CBAs and SD in their classroom. Thus, to summarize, we will create a typology based on teachers' self-reported use of CBAs and SD, and on teachers' self-reported attitude, perceived social norms and self-efficacy.

The current project was conducted by a research consortium consisting of five schools in secondary education and a team of researchers. Teachers from the consortium schools feel a growing need for professional development in transferring CBA generated SD into a more differentiated way of teaching, for both the whole class and individual students. To be able to do so, the schools need to know how their teachers currently use CBA and SD and what need they have for professional development. As it stands, existing studies do not always provide details on how and how often teachers use CBAs and SD and current studies are inconclusive about which interventions promote teachers' use of data (Marsh, 2012). Creating a typology of this use could therefore serve as a starting point for professional development by recommending specific steps for each profile (type), both for the consortium of this project as well as for other schools. The following research question was formulated:

> *What types of teacher profiles can be identified concerning how and why teachers use student data as a tool for differentiated teaching?*

Method

Design and Participants

This study reports on the results of a project with a consortium of schools that explicitly expressed their desire to increase the professional development of their teachers concerning the use of CBAs and SD. The study had a mixed design, in which the quantitative data had dominant status and the qualitative data was used as an additional source of information to understand the quantitative findings. Leech and Onwuegbuzie (2009) provide terminology to describe studies with a mixed methods design. Using their terminology, our study had a fully mixed concurrent dominant status design. This means that multiple data sources were used, which were collected around the same time (concurrently), and of which one had dominant status (the quantitative data).

For the quantitative part of the study, 42 teachers from five secondary schools in the Netherlands completed a questionnaire and a logbook. Their mean age was 43 years (M = 42.71, SD = 12.06; range 27-62) and they had on average 15 years of teaching experience (M = 15.14, SD = 11.69; range 3-41). Ten teachers who reported either a very high or very low use frequency of LA during the study were selected to participate in an interview.

Participants signed informed consent. The study design was approved by the ethics committee of Utrecht University under file number 19-043.

Data and Procedure

Teachers completed an online questionnaire at the beginning of the project. They were sent a link by one of the researchers to the online questionnaire, which took about 10 minutes to complete. Then they received a link to the

online logbook, once a week for a period of 20 weeks. The logbooks took about 5 minutes to complete. About halfway through this period, 10 teachers were invited for an interview via telephone. These interviews lasted about 20 to 30 minutes.

Questionnaire

A questionnaire was administered, in which a difference was made between the use of CBA and the use of SD, the first focusing on teachers' experience with administrating training and assessments through CBA's, and the second concerning the use of SD resulting from CBA's. The first part of the questionnaire contained questions about demographics and teachers' number of teaching hours. The second part of the questionnaire was based on the Teaching and Technology Questionnaire (see Admiraal et al., 2017) and measured teachers' self-efficacy (7 items, $\alpha = 0.74$), attitudes (6 items, $\alpha = 0.87$), and experienced social norms in the school (6 items, $\alpha = 0.74$) regarding the use of CBAs.

Table 1. Example Items for the Questionnaire.

Scale	Example item (translated from Dutch)
Self-efficacy CBA	I have sufficient knowledge to use CBA's in my courses.
Attitude CBA	I like to work with CBA's in my courses.
Social norms CBA	The use of CBA's in class is appreciated in this school.
Self-efficacy LA	I have sufficient knowledge to use student data from CBA's to differentiate my teaching.
Attitude LA	I like to differentiate my teaching, based on student data from CBA's.

Note. CBA = Computer-Based Assessment

Concerning the use of SD for the purpose of differentiated teaching, we measured teachers' self-efficacy (6 items, $\alpha = 0.86$) and attitudes (5 items, $\alpha = 0.83$). We did not measure social norms regarding use of SD, as we had expected this variable to be high for all participating consortium schools. All items were rated on a five-point-scale ranging from "totally disagree" to "totally agree".

Logbook

Additionally, teachers completed a weekly logbook in which they detailed how often they had employed CBAs in their classes (in hours per week), and how often they consulted the resulting SD (as a percentage of classes in which CBA was used). Teachers also reported how often they used SD during class and how often they used SD in-between classes. Teachers were also asked to indicate to what extent the SD influenced their teaching, which was measured by the number of ways teachers reported how they used SD. Teachers could choose from a list of options how they used SD, including whether SD shaped classroom instruction or interaction with a particular student (similar to the categories by Farley-Ripple et al., 2019).

Interview

Halfway through the data collection, short interviews were held with 10 teachers to get a better understanding of their experience with the use of SD – in terms of both frequency of use and their satisfaction –and their reasons for choosing to use SD. We selected teachers that stood out in terms of low or high use of SD. Before beginning the interviews, we prepared a summary of the logbooks the teachers had completed up to that point. The interviews were conducted by reading these summaries to the teachers, and asking them to respond and elaborate on the provided answers in the logbooks. The interviews took about 20 to 30 minutes. The first two authors created a summary of the conversation after each interview was conducted. The summaries were used to interpret the teacher profiles resulting from the quantitative analyses.

Analyses

The questionnaire and logbooks outlined above resulted in 10 variables, four of which concerned CBAs:

- use frequency: the proportion of hours of implementing CBA's of total teaching hours as reported in the logbooks
- self-efficacy: the average on the CBA self-efficacy scale in the questionnaire
- attitude: the average on the CBA attitude scale in the questionnaire
- social norms: the average on the CBA social norms scale in the questionnaire

and six of which concerned SD:

- use frequency: the proportion of CBA hours for which the teacher checked the resulting SD
- use during class: the proportion of times SD were checked during class
- use between classes: the proportion of times SD were checked between classes
- degree of implementation: the average number of ways of using SD (e.g., to adjust content, instruction, or feedback)
- self-efficacy: the average on the SD self-efficacy scale in the questionnaire
- attitude: the average on the SD social norms scale in the questionnaire

Using the standardized scores (Z-scores) on these ten variables as input, we performed hierarchical cluster analysis using SPSS for the 35 teachers who provided data on all 10 variables. We used the squared Euclidean distance as a measure of distance between cases. We considered all seven options that SPSS provides for hierarchical cluster analysis, using the Variance Ration Criterion (VRC, Calinski & Harabasz, 1974) to examine the ratio explained variance and total variance, corrected for the number of clusters and cases, and **Ω** for evaluating the difference between two outcomes of cluster analysis (**Ω**).

The combination of a relatively high VRC with a low **Ω** indicates the optimal number of clusters. In this case, the optimal number of clusters was found to be four (using Ward's method, VRC = 6.42; **Ω** = 0.92). After clustering, we determined in which cluster the interviewed teachers could be placed. The results from the interviews were used to describe teachers' experiences and considerations in the different clusters in more detail.

Results

Descriptive values for the whole sample for all variables are displayed in Table 2. Table 3 displays the four profiles that we obtained from the cluster analysis, with a brief label (first column) and the typical (standardized) values on the ten variables that were used to cluster the data. Analyses showed that the four profiles of teachers did not differ on variables such as age, gender, and teaching experience of the included teachers. We therefore do not report on those values in the descriptions of the profiles.

Table 2. Teachers' Use of CBA and LA

		N	**Mean**	***SD***
CBA	Proportion of hours per week (%)	40	30.27	24.05
	Self-efficacy (1-5)	41	3.98	0.71
	Attitude (1-5)	41	3.59	0.69
	Social norms (1-5)	41	3.98	0.55
Student data	Proportion of CBAs (%)	40	38.27	29.64
	During class (range 0/no – 1/yes)	37	0.85	0.27
	Between classes (range 0/no – 1/yes)	37	0.62	0.39
	Use of student data to inform practice (0-5)	37	2.12	1.10
	Self-efficacy	41	3.48	0.83
	Attitude	41	3.88	0.70

Note. CBA = Computer-Based Assessment, LA = learning analytics.

Profile 1: Engaged Users

In the smallest cluster, the engaged CBA and SD users (profile 1), teachers generally showed relatively high scores on all included variables except for one. These teachers frequently used CBAs during their lessons and they show average to high scores on their use of SD. When they used SD, it was mainly between lessons (as opposed to during class which shows a relatively low score).

The teachers in this cluster report an above average influence of the SD on their teaching (Table 2: 'Use of student data to inform practice'). Regarding CBAs, these teachers report above average scores on self-efficacy and average scores on attitude and social norms. With respect to SD, these teachers feel capable (average scores on self-efficacy) and positive towards the use of SD (above average scores on attitude), leading to high engagement for using SD.

Two of the interviewed teachers belonged to this cluster. Both reported that they mainly used SD between classes (as opposed to during classes) so that they could adjust their planning and instruction based on the SD. This way, their teaching method was adapted to the students' needs beforehand and they could focus their attention on the students during class.

Profile 2: Selective Users

The selective users (profile 2) make below average use of CBA (despite above average self-efficacy and average social norms in the school). When they did make use of CBAs, they frequently used the resulting SD, both during and between classes. These teachers report a relatively high influence of SD on their teaching and feel capable in using the resulting SD. These teachers report average scores on their attitude towards the use of CBAs and show a positive attitude towards the use of SD (above average scores). Two of the interviewed teachers belonged to this cluster.

Table 3. Teacher Profiles with Mean Scores on each Variable.

Profile (*N* = 35)	***n***	**Use of CBA**					**Use of student data**				
		Proportion of hours per week	Self-efficacy	Attitude	Social norms	Proportion view of CBA use	During class	Between classes	Use of student data to inform practice	Self-efficacy	Attitude
1. Engaged users	3	1.56 (1.24)	0.44 (0.30)	0.24 (0.62)	0.13 (1.42)	0.08 (0.78)	-2.26 (0.70)	1.05 (0.00)	0.55 (1.41)	0.22 (1.17)	0.53 (0.91)
2. Selective users	9	-0.33 (0.80)	0.64 (0.90)	0.37 (0.82)	-0.11 (0.45)	1.07 (0.97)	0.50 (0.24)	0.89 (0.31)	0.92 (1.01)	0.69 (0.67)	0.66 (0.50)
3. Early stage users	18	0.12 (0.91)	-0.29 (0.88)	0.18 (0.76)	0.38 (0.80)	-0.36 (0.74)	0.01 (0.90)	-0.32 (0.87)	-0.29 (0.66)	-0.28 (0.96)	0.02 (0.73)
4. Disengaged users	5	-0.75 (0.33)	-0.36 (1.40)	-1.45 (1.17)	-1.23 (1.35)	-0.68 (0.47)	0.43 (0.33)	-1.08 (0.74)	-0.92 (0.27)	-0.34 (1.19)	-1.57 (1.00)

Color indication	=<-1.00 low	-1.00 - -0.50	-0.50 - -0.25	-0.25 - 0.25 average	0.25 – 0.50	0.50-1.00	=>1.00 high

From the interviews, we gathered that the less frequent use of CBAs, compared with the engaged users in profile 1, may be caused by the fact that parts of the curriculum are not provided digitally. When they did use CBAs, they used SD during class to provide ad hoc support to individual students or for a plenary discussion of a certain task or question. One of the two teachers reported the use of SD between classes to adapt instruction for the following class.

Profile 3: Early-stage Users

Most teachers were categorized as early-stage users (profile 3). These teachers made average use of CBAs, and average to below average use of the resulting SD (less than profile 1 and 2, but more than profile 4). When they did make use of SD, this took place more often during class than between classes. They had a positive attitude towards using CBAs and SD (average scores), and using CBAs was valued highly in the school (above average scores), but they did not always feel capable in using CBAs and SD (below average scores). It is therefore no surprise that these teachers report a below average influence of LA on their teaching.

Six of the interviewed teachers belonged to this cluster. Five of them used SD to help particular students. One teacher used SD as a motivational tool: Students got extra credits for each successfully accomplished task. The teachers rarely used SD for differentiated teaching. One teacher indicated that he wanted to differentiate based on SD, but did not know how. This is in line with the below average self-efficacy scores.

Profile 4: Disengaged Users

Lastly, disengaged users (profile 4) generally scored low on all included variables. They did not use CBAs often and when they did, they did not often make use of the resulting SD. They had a negative attitude and below average self-efficacy regarding the use of both CBAs and SD, and they report low social norms within their school regarding CBAs, leading to disengagement. In the rare case that they used CBAs and SD, this is mostly done during class, not between classes, and LA use had little influence on their teaching. None of the interviewed teachers belonged to this cluster.

Discussion

CBAs and resulting SD have the potential to support differentiated teaching and this seems to have a positive effect on students' learning. However, research shows there is a lack of teacher knowledge and expertise to effectively use CBAs and SD for this purpose. This paper focused on providing a typology of how and why teachers in secondary education use CBAs and SD, which can be used to guide teacher professional development in this area. We employed a cluster analysis based on teachers' self-reports of using CBAs and SD, and their underlying reasons for doing so in terms of attitude, self-efficacy, and social norms within the school. Below, we discuss our findings and provide recommendations for teachers' professional development. It must be noted that due to the relatively small sample size of our study, caution should be exerted in interpreting the results and subsequent conclusions.

Findings and Implications

Our analysis pointed out four teacher profiles concerning the use of CBAs and SD: engaged users (profile 1), selective users (profile 2), early-stage users (profile 3), and disengaged users (profile 4). As the labels for the profiles indicate, we found a considerable variety in our sample of teachers concerning the use of CBA and SD, which is in line with previous literature concerning SD (Kippers et al., 2018) as well as other studies that created typologies concerning teachers' beliefs about and use of ICT in education (Mama & Hennesy, 2013; Prestridge, 2012; Tondeur, Hermans, van Braak, & Valcke, 2008).

The IMPB framework (Fishbein & Azjen, 2010) provided a useful tool to capture how these differences in frequency of use of CBA and SD could be related to underlying reasons. In general, the profiles confirm the demanding nature and diverse set of skills needed for using CBA and SD for differentiated teaching (Mandinach & Beth, 2016; Van Geel, Keuning, Frèrejean, Dolmans, Van Merriënboer, & Visscher, 2019; Wise & Yung; 2019). Below, we discuss what types of professional development the teachers in these different profiles might

benefit from.

Profile 1, The engaged users, score average to high on almost all included variables. Concerning their use of SD, as stated above, there is an interesting distinction between using SD between classes to prepare for subsequent lessons, on which these teachers score high, and using SD during classes to differentiate between students, on which these teachers score low. This could mean that these teachers might benefit from programs aimed at expanding their skill set for employing SD as a support tool for differentiated teaching, specifically concerning using SD during class to inform their real-time decision making.

The average self-efficacy scores seem to confirm there might be room for further professional development here. However, a search through the literature seems to indicate that teacher professional development programs are mostly focused on using SD for lesson planning, or in general, on differentiated teaching (outside the context of CBAs). Although multiple studies do describe the challenges of using SD for on-the-spot decision making (Asterhan & Schwarz, 2010; Wise & Yung, 2019), to the best of our knowledge, studies describing programs aimed at supporting teachers to handle these challenges are scarce if not non-existent. Using SD during class typically occurs under time pressure and requires teachers to combine information obtained from SD with observations of student behavior in the classroom. On-the-spot decisions based on SD during class may disrupt original plans for activities and instruction, and thus requires flexibility. This difference between using SD between and within classes is thus an interesting topic for future research, as these two aspects may also interact with each other. Teachers' prior use of student data between classes can potentially influence subsequent rounds of data use within classes.

Profile 2, The selective users, displayed low CBA but high SD use, and seem to be all-round performing teachers in terms of using SD during and between classes, and feeling capable and positive about doing so. The second lowest score for this profile is on social norms within the school regarding the use of CBAs. This suggests that teachers in this cluster would benefit more from interventions or programs aimed at the school level rather than programs regarding their own competences (Tezci, 2011). A school's transition to include technology as a fundamental element in realizing student-centered and differentiated teaching requires effective leadership (Wayman et al., 2012). It is essential to make sure the belief that technology is a fundamental element to reach these goals is widely adopted in the school in terms of changing social norms (Tearle, 2003). For example, Tondeur and colleagues (2008) report that when schools make their goals for teaching with technology explicit in school policy and involve teachers in creating this policy, social norms and the subsequent use of technology can be influenced. Working on establishing these social norms could ensure that the selective teachers in profile 2 are stimulated and supported to continue to use CBAs and SD (Kopcha, 2010).

Profile 3 consists of the early-stage users and contained the largest number of teachers in our sample. This profile shows opposite results from selective users (Profile 2): While selective users report a low experience of social norms, early stage users report above-average experience of social norms. Furthermore, whereas selective users feel competent and indeed often use SD, early-stage users do not. It thus appears that early-stage users could benefit more from programs at the level of teacher competences as opposed to programs aimed at social norms at

the school level. Since the self-efficacy scores for both CBA and SD are low, it could be wise to start with professional development aimed at developing CBA competencies and then SD competencies. For example, helping teachers understand when and how to use CBA in their lessons, and from there moving to interpreting the SD resulting from the CBAs and using the SD to move to differentiated teaching. Van Geel et al. (2016) implemented a 2-year training program for primary school teachers that followed such a design and found a considerable improvement in student learning. Additionally, interventions based on peer collaboration could be helpful for the moderate CBA and SD users. The engaged and selective users in Profiles 1 and 2, who scored higher on, for example, self-efficacy, could be excellent role models or partners for the early-stage users in Profile 3. Schipper, Goei, De Vries and Van Veen (2017) for example describe the positive effects of teacher collaboration in terms of observing and providing feedback on each other's classes on differentiated teaching.

Profile 4, The disengaged users, probably present the most challenging case in terms of teacher professional development. These teachers score low on attitude, self-efficacy and experienced social norms. It is not surprising that they rarely use CBAs and SD, given that they score low on all three factors that predict the intention to use them (Fishbein & Azjen, 2010). For these teachers, it would probably work best to first try to foster a positive attitude towards the use of CBAs and SD. This could, for example, be done by arranging for them to experience a successful lesson in which a CBA is used, and subsequently showing them the information that SD has to offer. As discussed above, this could also be done by having them observe the lesson of a colleague in which CBAs and SD are used (Schipper et al., 2017), so that these colleagues act as change agents (Fullan, 2009). In turn, being in contact with colleagues who already incorporate CBAs and SD into their practice could also increase the experienced social norms. These steps are essential to build the motivation to work on the required skills for performing these tasks without the help of a colleague, and thus to increase the level of self-efficacy. This implies an important role for school leaders, who should provide the conditions (time and opportunity) for peer learning.

Summary and Directions for Future Research

After discussing the four profiles separately, the question that remains to be discussed is what overarching lessons can be learned, especially given that within one school, all four profiles may be prevalent. Given the diversity between teachers, we would highly recommend school leaders to take this diversity into account. Similar to the differentiated teaching we aim to offer students, our results suggest that professional development based on different teacher needs would be the best approach to prepare teachers for using CBAs and SD. Our results lead to two further suggestions.

First, this study concerned a consortium of schools that explicitly expressed their desire to increase the professional development of their teachers concerning the use of CBAs and SD. It could thus be expected that social norms regarding the use of CBAs and SD would be high. However, the results show that social norms as experienced by teachers were sometimes average or even quite low. This result shows the importance of both the school and the teacher level in educational innovations. Even when a certain plan is articulated at the school management level, it takes effort to reach a situation in which this plan is generally accepted within the school by all teachers (Marsh & Farrell, 2014; Wayman et al., 2012). Profile 4, the disengaged users, are an example of

teachers who may be relatively isolated within the school, since they experience very low social norms in using CBA (and probably also in using SD). Thus, for all professional development options we discussed above, taking into account both the school and teacher level is necessary.

Second, one of the dimensions on which we categorized the profiles played a notable role, namely, whether SD are used either in-between classes to plan a subsequent class or during class to inform on-the-spot decision making. There were differences on this dimension between profiles (for example, engaged users versus selective users), but interesting findings also occurred within profiles on this dimension (for example the engaged users, where SD were more often used in-between classes than during class). These findings suggest that the different uses of SD may also have different underlying skills that are needed for that particular use. For example, using SD during class typically occurs under time pressure and requires teachers to balance classroom management and the integration of information obtained from the SD with observations of student behavior in the classroom. In contrast, using SD between classes requires teachers to relate information obtained from SD to the curriculum and lesson planning. In the current study, we did not distinguish between these different types of uses in our questionnaires for self-efficacy and attitudes regarding CBAs and SD. Thus, our typology could have been even more refined by measuring planned behavior for these usages separately.

Conclusion

To conclude, in this study we presented a typology of how and why teachers in secondary education use CBAs and SD. The results are of scientific relevance because they offer more insight into what distinguishes teachers with regard to this use. In terms of practical relevance, we offered a number of recommendations for intervention programs at school or teacher level to support teachers in the use of CBAs and SD.

Acknowledgements

This work was supported by the Netherlands Initiative for Educational Research (NRO) under Grant number 40.5.18540.134.

References

Admiraal, W., Louws, M., Lockhorst, D., Paas, T., Buynsters, M., Cviko, A., Nouwens, S., Janssen, C., Jonge, M., de, Post, L., Ven, F. van der, & Kester, L. (2017). Teachers in school-based technology innovations: A typology of their beliefs on teaching and technology. *Computers & Education*, *114*, 57-68. https://doi.org/10.1016/j.compedu.2017.06.013

Admiraal, W., Vermeulen, J., & Bulterman-Bos, J. (2020). Teaching with learning analytics: How to connect computer-based assessment data with classroom instruction? *Technology, Pedagogy and Education*, *29*(5), 577-591. https://doi.org/10.1080/1475939X.2020.1825992

Asterhan, C. S. C., & Schwarz, B. B. (2010). Online moderation of synchronous e-argumentation. *International*

Journal of Computer-Supported Collaborative Learning, *5*(3), 259–282. https://doi.org/10.1007/s11412-010-9088-2

Calinski, T., & Harabasz, J. (1974). A dendrite method for cluster analysis. *Communications in Statistics*, *3*, 1-27.

Corno, L. (2008). On teaching adaptively. *Educational Psychologist*, *43*, 161-173. https://doi.org/10.1080/00461520802178466

Datnow, A., & Hubard, L. (2015). Teachers' use of assessment data to inform instruction: Lessons from the past and prospects for the future. *Teachers College Record*, *117*(4), 1–26. https://doi.org/10.1177/016146811511700408

Datnow, A., Park, V., & Kennedy-Lewis, B. (2012). High School Teachers' Use of Data to Inform Instruction. *Journal of Education for Students Placed at Risk (JESPAR)*, *17*(4), 247–265. https://doi.org/10.1080/10824669.2012.718944

Deunk, M. I., Smale-Jacobse, A. E., de Boer, H., Doolaard, S., & Bosker, R. J. (2018). Effective differentiation practices: A systematic review and meta-analysis of studies on the cognitive effects of differentiation practices in primary education. *Educational Research Review*, *24*, 31-54. https://doi.org/10.1016/j.edurev.2018.02.002

Dixon, F. A., Yssel, N., McConnell, J. M., & Hardin, T. (2014). Differentiated instruction, professional development, and teacher efficacy. *Journal for the Education of the Gifted*, *37*(2), 111-127. https://doi.org/10.1177/0162353214529042

Faber, J. M., Luyten, H., & Visscher, A. J. (2017). The effects of a digital formative assessment tool on mathematics achievement and student motivation: Results of a randomized experiment. *Computers & Education*, *106*, 83-96. https://doi.org/10.1016/j.compedu.2016.12.001

Faber, J.M., & Visscher, A. J. (2016). *De effecten van Snappet. Effecten van een adaptief onderwijsplatform op leerresultaten en motivatie van leerlingen.* Enschede: Universiteit Twente.

Farley-Ripple, E. N., Jennings, A. S., & Buttram, J. (2019). Toward a Framework for Classifying Teachers' Use of Assessment Data. *AERA Open*, *5*(4), 1–18. https://doi.org/10.1177/2332858419883571

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach.* New York: Psychology Press.

Fullan, M. (2009). *The Challenge of Change: Start School Improvement Now!* Corwin Press.

Holstein, K., McLaren, B., & Aleven, V. (2018). Student learning benefits of a mixed-reality teacher awareness tool in AI-enhanced classrooms. In *Proceedings of the International Conference on Artificial Intelligence in Education*, 154–168. https://doi.org/10.1007/978-3-319-93843-1_12

Keuning, T., & van Geel, M. (2021). Differentiated Teaching With Adaptive Learning Systems and Teacher Dashboards: The Teacher Still Matters Most. *IEEE Transactions on Learning Technologies*, *14*(2), 201-210. https://doi.org/10.1109/TLT.2021.3072143

Kester, L., Cviko, A., Janssen, C., Jonge, M. De, Louws, M., Nouwens, S., … van der Ven, F. (2018). *Docent en leerling aan het stuur: Onderzoek naar leren op maat met ict. Landelijk onderzoek Doorbraak Onderwijs & ICT.*

Kippers, W. B., Wolterinck, C. H. D., Schildkamp, K., Poortman, C. L., & Visscher, A. J. (2018). Teachers' views on the use of assessment for learning and data-based decision making in classroom practice. *Teaching*

and Teacher Education, *75*, 199–213. https://doi.org/10.1016/j.tate.2018.06.015

Koedinger, K. R., McLaughlin, E. A., Heffernan, N. T. (2010). A quasi-experimental evaluation of an online formative assessmen and tutoring stsem. *Journal of Educational Computing Research*, *43*, 489-510. https://doi.org/10.2190/EC.43.4.d.

Kopcha, T. J. (2010). A systems-based approach to technology integration using mentoring and communities of practice. *Educational Technology Research and Development*, *58*(2), 175–190. https://doi.org/10.1007/s11423-008-9095-4

Kreijns, K., Vermeulen, M., Kirschner, P. A., van Buuren, H., & van Acker, F. (2013). Adopting the integrative model of behaviour prediction to explain teachers' willingness to use ICT: A perspective for research on teachers' ICT usage in pedagogical practices. *Technology, Pedagogy and Education*, *22*, 55-71. https://doi.org/10.1080/1475939X.2012.754371

Leech, N. L., & Onwuegbuzie, A. J. (2009). A typology of mixed methods research designs. *Quality and Quantity*, *43*(2), 265–275. https://doi.org/10.1007/s11135-007-9105-3

Lomos, C., Luyten, J. W., Kesting, F., & da Cunha, F. L.(2023). Explaining variation in teachers' use of ICT: a learning analytics approach. *Interactive Learning Environments*, https://doi.org/10.1080/10494820.2023.2170419

Mama, M., & Hennessy, S. (2013). Developing a typology of teacher beliefs and practices concerning classroom use of ICT. *Computers & Education*, *68*, 380-387. https://doi.org/10.1016/j.compedu.2013.05.022

Mandinach, E. B., & Beth, J. (2016). Teachers learning how to use data: A synthesis of the issues and what is known. *Teaching and Teacher Education*, *60*, 452–457. https://doi.org/10.1016/j.tate.2016.07.009

Marsh, J. A. (2012). Interventions promoting educators' use of data: Research insights and gaps. *Teachers College Record*, 114(11), 1-48. https://eric.ed.gov/?id=EJ1001992

Marsh, J.A., & Farrell, C.C. (2014). How leaders can support teachers with data-driven decision making: A framework for understanding capacity building. *Educational Management Administration & Leadership*, *43*(2), 269-289.

Molenaar, I., & Knoop-Van Campen, C. A. N. (2018). How teachers make dashboard information actionable. *IEEE Transactions on Learning Technologies*. https://doi.org/10.1109/TLT.2018.2851585

Molenaar, I., & Knoop-Van Campen, C. A. N. (2016). Learning analytics in practice: the effects of adaptive educational technology Snappet on students' arithmetic skills. In *Proceedings of the Sixth International Conference on Learning Analytics & Knowledge*, April 2016, 538–539. https://doi.org/10.1145/2883851.2883892

Prenger, R., & Schildkamp, K. (2018). Data-based decision making for teacher and student learning : a psychological perspective on the role of the teacher. *Educational Psychology*, *3410*, 1–19. https://doi.org/10.1080/01443410.2018.1426834

Prestridge, S. (2012). The beliefs behind the teacher that influences their ICT practices. *Computers & Education*, *58*, 449-458. https://doi.org/10.1016/j.compedu.2011.08.028

Schipper, T., Goei, S. L., de Vries, S., & van Veen, K. (2017). Professional growth in adaptive teaching competence as a result of Lesson Study. *Teaching and Teacher Education*, *68*, 289–303. https://doi.org/10.1016/j.tate.2017.09.015

Siemens, G., & Gasevic, D. (2012). Guest editorial- learning and knowledge analytics. *Educational Technology*

& Society, *15*(3), 1-2.

Tearle, P. (2003). ICT implementation: What makes the difference? *British Journal of Educational Technology*, *34*, 567–583. https://doi.org/10.1046/j.0007-1013.2003.00351.x

Tezci, E. (2011). Turkish primary school teachers' perceptions of school culture regarding ICT integration. *Educational Technology Research and Development, 59*, 429–443. https://doi.org/10.1007/s11423-011-9205-6

Tomlinson, C. A., Brighton, C., Hertberg, H., Callahan, C. M., Moon, T. R., Brimijoin, K., ... & Reynolds, T. (2003). Differentiating instruction in response to student readiness, interest, and learning profile in academically diverse classrooms: A review of literature. *Journal for the Education of the Gifted, 27*(2-3), 119-145. https://doi.org/10.1177/016235320302700203

Tondeur, J., van Keer, H., van Braak, J., & Valcke, M. (2008). ICT integration in the classroom: Challenging the potential of a school policy. *Computers & Education*, *51*, 212–223. https://doi.org/10.1016/j.compedu.2007.05.003

Tondeur, J., Hermans, R., van Braak, J., & Valcke, M. (2008). Exploring the link between teachers' educational belief profiles and different types of computer use in the classroom. *Computers in Human Behavior*, *24*, 2541-2553. https://doi.org/10.1016/j.chb.2008.02.020

Tubin, D. (2006). Typology of ICT implementation and technology applications. *Computers in the Schools*, *23*(1/2), 85-98. https://doi.org/10.1300/J025v23n01_08

Van Geel, M., Keuning, T., Frèrejean, J., Dolmans, D., van Merriënboer, J., & Visscher, A. J. (2019). Capturing the complexity of differentiated instruction. *School Effectiveness and School Improvement*, *30*(1), 51–67. https://doi.org/10.1080/09243453.2018.1539013

Van Geel, M., Keuning, T., Visscher, A. J., & Fox, J. P. (2016). Assessing the Effects of a School-Wide Data-Based Decision-Making Intervention on Student Achievement Growth in Primary Schools. *American Educational Research Journal*, *53*(2), 360–394. https://doi.org/10.3102/0002831216637346

Van Leeuwen, A. (2019). Teachers' perceptions of the usability of learning analytics reports in a flipped university course: when and how does information become actionable knowledge? *Educational Technology Research and Development*, *67*(5), 1043–1064. https://doi.org/10.1007/s11423-018-09639-y

Vandewaetere, M., Desmet, P., & Clarebout, G. (2011). The contribution of learner characteristics in the development of computer-based adaptive learning environments. *Computers in Human Behavior*, *27*(1), 118–130. https://doi.org/10.1016/j.chb.2010.07.038

Vogt, F., & Rogalla, M. (2009). Developing adaptive teaching competency through coaching. *Teaching and Teacher Education*, *25*(8), 1051–1060. https://doi.org/10.1016/j.tate.2009.04.002

Wayman, J. C., & Jimerson, J. B. (2014). Teacher needs for data-related professional learning. *Studies in Educational Evaluation*, *42*, 25–34. https://doi.org/10.1016/j.stueduc.2013.11.001

Wayman, J. C., Jimerson, J. B., & Cho, V. (2012). Organizational considerations in establishing the Data-Informed District. *School Effectiveness and School Improvement*, *23*(2), 159–178. https://doi.org/10.1080/09243453.2011.652124

Wise, A.F., & Jung, Y. (2019). Teaching with Analytics: Towards a Situated Model of Instructional Decision-Making. *Journal of Learning Analytics*, *6*(2), 53–69. https://doi.org/10.18608/jla.2019.62.4

Ysseldyke, J., & Bolt, D. M. (2007). Effect of technology-enhanced continuous progress monitoring on math

achievement. *School Psychology Review*, *36*, 453-467. https://eric.ed.gov/?id=EJ788347

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