Picturing student progress : teachers' comprehension of curriculum-based measurement progress graphs

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SUMMARY AND GENERAL DISCUSSION

CHAPTER 6

SUMMARY AND GENERAL DISCUSSION

This dissertation focused on teachers' comprehension of student progress graphs from a progress-monitoring system called curriculum-based measurement (CBM; continue voortgangsmonitoring [CVM] in Dutch). CBM is a progress-monitoring system designed for teachers to use to monitor the progress of students with learning disabilities and to evaluate the effectiveness of the instruction for these students (Deno, 1985, 2003).

Within CBM, short and simple measures are administered to students frequently, and the scores on those measures are depicted in individual progress graphs. Teachers inspect the graphs to evaluate student progress and the effects of instruction. Research demonstrates that when teachers use CBM to monitor student progress *and* when they respond to the data by making instructional and goal changes, student achievement improves (see Stecker, Fuchs, & Fuchs, 2005, for a review). However, research also demonstrates that teachers often *do not* respond to the data; that is, they collect the data but do not use the data for instructional decision-making (Stecker et al., 2005). Yet, it is only when the data are used to make instructional decisions that student achievement improves (Stecker et al., 2005).

One potential reason for teachers' non-use of the data might be that teachers have difficulty reading and interpreting CBM progress graphs. For example, teachers may not recognize that a student is making inadequate progress and, thus, may not realize that the instruction needs to be changed.

This dissertation focused on teachers' ability to read and interpret – that is, to *comprehend* – CBM progress graphs. The research presented in this dissertation built on two early, explorative studies of teachers' CBM graph comprehension (Espin, Wayman, Deno, McMaster, & de Rooij, 2017; Wagner, Hammerschmidt-Snidarich, Espin, Seifert, & McMaster, 2017). The results of these initial studies revealed that both inservice (Espin et al., 2017) and preservice (Wagner et al., 2017) teachers had difficulties with CBM graph comprehension, that years of experience implementing CBM was not related to CBM graph comprehension (Espin et al., 2017), and that preservice teachers comprehended CBM progress graphs less well than CBM experts (Wagner, et al., 2017).

These two initial studies were limited in that they had relatively small sample sizes, focused primarily on the most basic level of graph comprehension (i.e., reading the data), and did not compare CBM graph comprehension of inservice teachers to CBM experts. Moreover, it was not clear from the studies whether difficulties with CBM graph comprehension were unique to teachers – that is, whether the difficulties were due to the fact that teachers are not good at CBM graph comprehension – or whether it was that case that CBM graphs were difficult to read and interpret – that is, that others also would comprehend CBM graphs less well than CBM experts.

The research presented in this dissertation replicated and extended the studies of Espin et al. (2017) and Wagner et al. (2017). There were two specific goals. The first was to deepen and extend our knowledge about teachers' comprehension of CBM progress graphs, and the second was to examine methods for improving teachers' comprehension of CBM progress graphs. To address the first goal, we employed think-aloud and eye-tracking methodologies to examine how teachers described (Chapter 3) and visually inspected (Chapter 4) CBM progress graphs. To address the second goal, we employed a randomized control design to compare the effectiveness of three instructional approaches for improving teachers' CBM graph comprehension (Chapter 5).

In the following sections, the main findings of the studies described in Chapters 3, 4, and 5 are summarized, integrated, and discussed. An outline of the limitations of the research and directions for future research are then provided, followed by implications for practice.

Teachers' Comprehension of CBM Progress Graphs

To further deepen and extend our knowledge about teachers' CBM graph comprehension we employed think-aloud and eye-tracking methodologies. Twenty-three teachers were asked to describe CBM progress graphs and to "think out loud" while doing so. As teachers described the graphs, their eye movements were registered. Via the think-aloud data, we examined teachers' ability to read, interpret, and link CBM data to instruction. Via the eye-tracking data, we examined teachers' CBM graph-inspection patterns, that is, how long teachers inspected the various elements of the CBM graphs, and whether they inspected those elements in a logical sequence. In addition, we collected data from "gold standard" experts, that is, general-, education-, and/or CBM graph-reading experts. Data from the gold-standard experts provided a frame of reference for interpreting the teachers' data, and provided insight into whether CBM graph comprehension difficulties were unique to teachers.

Results related to the think-aloud data were reported in **Chapter 3** and are referred to as the think-aloud study. Results related to the eye-tracking data were reported in **Chapter 4** and are referred to as the eye-tracking study. The main findings across the think-aloud and eye-tracking studies were that (1) teachers had difficulties with comprehension of CBM progress graphs, and these difficulties were evident both in how teachers described the graphs and how they inspected the graphs, (2) CBM graph comprehension difficulties were not unique to teachers, and (3) teachers' CBM graph comprehension difficulties were not limited to researcher-made graphs.

Teachers had difficulties with CBM graph comprehension

The think-aloud study revealed that teachers were not as good at describing CBM progress graphs as were CBM experts. That is, as a group, teachers were less complete and less sequentially coherent in their think-alouds, and made fewer data-to-data comparisons, data-to-goal comparisons, and data-to-instruction links than the CBM experts. However, there was variability among teachers. That is, some teachers had more difficulties than others with reading, interpreting, and linking CBM data to instruction. Findings related to differences in completeness and sequential coherence between the teachers and the CBM experts replicated the findings of Wagner et al. (2017), who found that preservice teachers were less complete and sequentially coherent in their think-alouds than were CBM experts. Neither Wagner et al. nor Espin et al. (2017) examined the *data-to* comparisons/links in their research.

Although in general teachers performed more poorly than the CBM experts, some aspects of CBM graph comprehension appeared to be easier for teachers than other aspects. For example, most teachers were reasonably proficient at reading the data, but nearly all teachers had difficulties with interpreting and linking the data to instruction. That is, on average, teachers made few data-to-data-comparisons, data-to-goal comparisons, and data-to-instruction links. Some teachers even did not make such comparisons or links at all; from the 23 teachers, three did not make any data-to-data comparisons, four did not make any data-to-goal comparisons, and twelve teachers did not make any data-to-instruction links. These findings fit well with research on general graph comprehension, and with Curcio's (1987) and Friel, Curcio, and Bright's (2001) assertion that reading between and beyond the data are the most difficult aspects of graph comprehension. In addition, the findings are similar to the results of a study by Zeuch, Förster, and Souvignier (2017) who found that teachers often did not spontaneously pay attention to reading beyond the data when interpreting CBM-like progress graphs.

Teachers' difficulties with reading, interpreting, and linking CBM data to instruction were also reflected in the ways in which they inspected the graphs. Similar to the think-aloud study, the eye-tracking study revealed that teachers inspected CBM graphs differently than the CBM expert. As a group, teachers devoted *less* visual attention to the most relevant aspects of CBM graphs (the data in the instructional phases), and *more* visual attention to the least relevant aspects of CBM graphs (the incorrect choices), than did the CBM expert. In addition, teachers inspected the graph elements in a less logical sequence than the CBM expert, and looked back and forth between adjacent instructional phases less often than the CBM expert. Again, there was variability among the teachers. Teachers with high-quality think-alouds were more similar to the CBM expert in their CBM graph-inspection patterns than teachers with low-quality think-alouds. That is, teachers with better think-alouds devoted more visual attention to the most relevant aspects of CBM graphs and inspected the graph elements in a more logical sequence than teachers with poorer think-alouds.

The differences in CBM graph-inspection patterns between the teachers and the CBM expert are in line with the results from other eye-tracking studies that involve inspection of visual stimuli. This research reveals that experts focus more on task-relevant aspects of a visual stimulus than do novices, and that experts are more systematic and goal-directed in completing a visual task than are novices (e.g., Al-Moteri, Symmons, Plummer, & Cooper, 2017; Canham & Hegarty, 2010; Gegenfurthner, Lehtinen, & Säljo, 2011; Jarodzka, Scheiter, Gerjets, & van Gog, 2010; Vonder Embse, 1987).

The finding that teachers inspected the various graph elements in a less logical sequence than the CBM expert, and that they looked back and forth between adjacent instructional phases less often than the CBM expert, also fit well with the results of the think-aloud study. That is, in their think-alouds, teachers described the CBM graphs in a less logical, sequential manner than the CBM experts, and compared student data across adjacent instructional phases (data-to-data comparisons) less often than the CBM experts.

Taken together, the think-aloud and eye-tracking studies suggested that teachers have difficulties comprehending CBM graphs. But were these difficulties unique to teachers?

CBM graph comprehension difficulties were not unique to teachers

In the think-aloud study, data were collected not only from CBM experts, but also from general- and education graph-reading experts. Comparing the teachers' think-aloud data to the data from these other experts revealed that CBM graph comprehension difficulties were not unique to teachers. Scores for the general- and the education-graph reading experts were also lower than scores for the CBM experts. Moreover, for five specific aspects of CBM graph comprehension (i.e., accuracy, completeness, sequential coherence, comparing the data to the goal/goal line, and linking the data to instruction), teachers' scores were similar to, or higher than, scores of the general graph-reading experts. In addition, for two specific aspects (i.e., sequential coherence and comparing the data to the goal/goal line), teachers' scores were similar to, or higher than, scores of the education graph-reading experts.

In general, these data revealed that teachers were not the only ones who had difficulties with CBM graph comprehension, indicating that CBM graphs can be difficult to read and interpret. This finding fits with the other graph-comprehension research that demonstrates that graphs often are difficult to read and interpret (see Friel et al. 2001; Glazer, 2011; Shah & Hoeffner, 2002, for reviews). It also fits with single-subject design graph-interpretation research that demonstrates that graphs with "simple" A-B designs are difficult to analyze and interpret (see Kratochwill, Levin, Horner, & Swoboda, 2014, for a review).

Teachers' CBM graph comprehension difficulties were not limited to researcher-made graphs

It was possible that teachers' difficulties with CBM graph comprehension were in part due to the fact that they were inspecting and describing researcher-made graphs with fictitious student data that were not directly relevant to the teachers. We anticipated that teachers might be more likely to make data-to-goal comparisons and data-to-instruction links when describing graphs of their own students because they could bring to bear background knowledge about the students and about the students' instruction. However, this anticipation was not supported by our results. The think-aloud data revealed that teachers also made few data-to-goal comparisons and data-to-instruction links for the student graphs. Especially data-to-instruction links were rarely made. Only six (out of 23) teachers made at least one such link for the student graphs. These findings are of concern because it are precisely such comparisons/links that guide the teachers' instructional decision-making. In other words, when teachers compare the student's progress to the goal/goal line and see that students' actual rate of growth is less than the expected/desired rate of growth, the teachers should link the data to instruction and conclude that the instruction is ineffective and thus needs to be modified or changed. Only via such data-based instructional decision-making does CBM implementation lead to improvements in student achievement (Stecker et al., 2005).

Taken together, the results of the think-aloud and eye-tracking studies demonstrated that teachers had difficulties with inspecting CBM progress graphs, and with reading, interpreting, and linking the data to instruction. The results further demonstrated that such difficulties were not unique to teachers, suggesting that comprehension of CBM graphs requires specific, directed instruction in CBM graph comprehension. Given that teachers' difficulties were primarily related to interpreting and linking CBM data to instruction, instruction in these areas seems especially warranted.

Improving Teachers' Comprehension of CBM Progress Graphs

To address the second goal of the research presented in this dissertation – that is, to examine methods for improving teachers' comprehension of CBM graphs – we employed a randomized control design. One hundred sixty-four teachers were randomly assigned to one of three CBM instructional conditions (the BASIC condition, the INTERPRETATION condition, and the INTERPRETATION + LINKING condition) or to a control condition. (Recall that the three instructional conditions differed in the extent to which they emphasized reading the data, interpreting the data, and linking the data to instruction.) CBM instruction was delivered via instructional videos.

Via the randomized control study, we examined the effects of the three CBM instructional approaches on teachers' CBM graph comprehension, that is, how they read, interpret, and link CBM data to instruction. Building upon the earlier studies, teachers' CBM graph comprehension was measured via a think-aloud-like task; however, in this study, teachers were asked to describe a CBM graph as if they were describing it to the student's parent. Teachers described the graphs prior to and following the intervention. Teachers also evaluated the CBM instructional videos and CBM.

The data from the randomized control study (referred to as the intervention study) were reported in **Chapter 5**. The main findings of the study were that (1) teachers' CBM graph comprehension, and in particular their ability to interpret and link the data to instruction, was improved via CBM instruction, (2) the additional interactive instruction and practice provided in the second and third instructional approaches led to greater improvement for interpreting the data, but not for linking the data to instruction, than the basic instructional approach, and (3) teachers evaluated the CBM instructional videos and CBM positively.

Teachers' CBM graph comprehension was improved via CBM instruction

Results of the intervention study revealed that teachers in the three instructional groups improved more in CBM graph comprehension than teachers in the control group. This finding is perhaps not so surprising given that one would expect (and hope) that CBM instruction would lead to improved CBM graph comprehension, but it is important to verify that teachers' CBM graph comprehension can be improved via instruction. More notable, perhaps, is the fact that teachers' comprehension was improved with a 25-45 min instructional video, implying that improvements can be obtained in a relatively short time and within a digital context.

Interestingly, and importantly, teachers' abilities to interpret CBM data and link it to instruction were the primary areas that improved via the instructional videos. These were the aspects of CBM graph comprehension that were the most difficult for teachers in the think-aloud study. It should be noted, however, that for interpreting the data, improvements were found only for the number of data-to-goal comparisons, not for the number of data-to-data comparisons made by teachers. The finding that teachers did not make more data-to-data comparisons following CBM instruction was somewhat disappointing, and supports to the idea that interpreting the data, and especially comparing data across instructional phases (i.e., making data-to-data comparisons), is a difficult skill for teachers. What was also somewhat disappointing was that teachers did not improve more with regard to describing the CBM graphs in a logical and coherent manner (i.e., sequential coherence).

Additional interactive instruction and practice led to greater improvement for interpreting the data

Although it was positive that CBM instruction led to improved CBM graph comprehension for teachers, and in particular to increases in the number of data-to-goal comparisons and data-to-instruction links made by teachers, our primary focus was on whether differences between the three CBM instructional approaches would be found.

As mentioned earlier, each approach differed in the extent to which reading the data, interpreting the data, and linking the data to instruction were emphasized. In the BASIC condition, teachers were told how to interpret and link the data to instruction, and were given examples of how that should be done. In both the INTERPRETATION and INTERPRETATION + LINKING conditions, teachers were provided with the same information given in the BASIC condition, but also were provided with additional, interactive instruction and practice on these skills. We anticipated that additional interactive instruction and practice would result in greater improvement than explanation and modeling only; however, effects were seen only for interpreting the data, and only for data-to-goal comparisons. That is, teachers in both the INTERPRETATION and INTERPRETATION + LINKING conditions experienced a greater increase in the number of data-to-goal comparisons than did teachers in the BASIC condition. The INTERPRETATION and INTERPRETATION + LINKING CBM instructional approaches, thus, led to greater improvements in one aspect of CBM graph comprehension (i.e., comparing student' progress to the goal/goal line) than the BASIC CBM instructional approach.

Teachers evaluated the CBM instructional videos and CBM positively

Teachers evaluated the CBM instructional videos positively, with an average rating across teachers of 8 out of 10. Teachers' ratings of the specific characteristics of the videos revealed that teachers thought the videos were clear, interesting, useful, and informative. Mean ratings were similar across the CBM instructional videos, meaning that the three videos were evaluated equally positive by the teachers. These findings fit well with results from a study of Kennedy et al. (2016) on improving preservice teachers' knowledge of CBM, that showed that preservice teachers were positive about CBM multimedia instruction and were motivated to learn about CBM via multimedia instruction.

The teachers in our intervention study were not only positive about the CBM instructional videos; they also evaluated CBM itself positively. Teachers' ratings of CBM revealed that, after watching the instructional videos, they understood what CBM was, they felt they could interpret the graphs and were sufficiently trained to use CBM in their class, and they felt that CBM would be helpful for instructional decision-making and that they would like to use CBM in their class for individual students with reading difficulties. These findings are line with the findings of Foegen, Espin, Allinder, and Markell (2001), who found that preservice teachers were positive about CBM's utility after watching a videotaped presentation about CBM.

Taken together, it was encouraging that teachers who were not familiar with CBM developed a positive attitude about CBM via the CBM instructional videos, and were positive about the videos itself. This was especially encouraging given the fact that educators' attitudes towards data-based decision-making are related to the effects of data-based decision making on student progress (Keuning, van Geel, & Visscher, 2017).

Limitations and Directions for Future Research

Link between CBM graph comprehension and CBM data use

Perhaps the major limitation of the research presented in this dissertation is that the link between teachers' comprehension of CBM progress graphs and teachers' actual CBM implementation was not examined. Although one might assume that CBM graph comprehension contributes to improved CBM implementation – especially as it relates to using the data for instructional decision-making – and that improved implementation leads to improved student achievement, such relations must be directly tested in future research.

It will be important in such research to include samples sizes large enough to examine the moderating/mediating effects of other factors both on teachers' CBM graph comprehension and on their CBM data use. For example, general graph literacy might influence the comprehension of particular graphs (e.g., see Chapter 3 of this dissertation; see Friel et al., 2001; Glazer, 2011; Shah & Hoeffman, 2002, for reviews). Given that in the think-aloud study results regarding the relation between graph literacy and CBM graph comprehension were mixed, this relation must be examined again with a larger sample, and with a graph-literacy test that does not produce a ceiling in scores.

In addition, the effects of content/pedagogical knowledge, for example, knowledge of reading and reading instruction, should be examined. Knowledge of the content presented in a graph influences comprehension of that graph (e.g., Friel et al., 2001; Glazer, 2011; Shah, 2002), and the use of data from progress-monitoring systems to tailor instruction to the needs of students requires knowledge of the subject matter and knowledge of differentiating instruction (Staman, Visscher, & Luyten, 2014). As related to CBM progress-monitoring, this suggests that teachers with more content/ pedagogical knowledge may better comprehend CBM progress graphs and may be more likely to respond to the data with instructional changes, than teachers with less content/pedagogical knowledge.

Finally, the role of teacher efficacy should be examined. Teacher efficacy refers to teachers' beliefs in their ability to affect student performance (e.g., Gibson & Dembo, 1984; Tschannen-Moran & Woolfolk Hoy, 2001), and teacher efficacy "affects the effort teachers invest in teaching, the goals they set, and their level of aspiration" (Tschannen-Moran & Woolfolk Hoy, 2001, p. 783). As related to CBM progress monitoring in reading, it would be important to examine teachers' sense of efficacy in reading as it relates to teachers' use of the data. If teachers believe that they can affect change in a student's performance, they may be more likely to respond to the data with instructional changes.

It is possible that CBM graph comprehension not only affects CBM implementation but that CBM implementation also affects CBM graph comprehension. That is, it may be the case that CBM implementation over the course of an entire academic year leads to improved CBM graph comprehension. Although Espin et al. (2017) found no relation between experience with CBM implementation and CBM graph comprehension, their sample was very small, experience was measured via self-report questions, and the study did not explore the moderating/mediating effects of general graph literacy or content/pedagogical knowledge.

There is a need to examine the link between CBM graph comprehension and CBM implementation, and in particular CBM data use, more closely with a large enough sample size and in an actual classroom setting. In addition, in such research teachers' comprehension of students graphs should be examined again based on graphs of students that teachers have monitored over the entire academic year (instead of a period of only 10-12 weeks). Finally, it would be good in such research to use the more "authentic" prompt used in the intervention study, where teachers were asked to describe a CBM graph as if they were describing it to the student's parent. Related to this point, it would be interesting to actually examine to what extent teachers' are able to describe CBM progress graphs to parents in an actual parent meeting or to colleagues in an actual team meeting.

Effects of CBM instructional approaches on CBM data use

A second limitation of the research, and one that relates to the first limitation, is that we did not examine the effects of the CBM instructional videos on teachers' actual CBM implementation and their use of CBM data for instructional decision-making, and the subsequent effects on student achievement. In our intervention study, results revealed few differences between the three instructional approaches on teachers' CBM graph comprehension; however, it is possible that the three instructional approaches would lead to differences in actual CBM data use. It will be important in future research to examine the effects of the different instructional approaches on actual CBM implementation and data use.

A related issue is the extent to which the "BASIC" instructional approach represented typical CBM training. Our results imply that the basic instructional approach was nearly as effective as the two longer, more intensive instructional approaches with respect to CBM graph comprehension. However, it is not clear whether the type and amount of information provided in the basic instructional approach were typical of the information provided in CBM trainings. Currently, we are conducting a study to examine what proportion of CBM training materials is devoted to interpreting the data and linking it to instruction.

Although the link between CBM graph comprehension and CBM data use, and the effects of the instructional approaches on CBM data use were not examined in this dissertation, the research presented here does provide a foundation for future research and development. The think-aloud and eye-tracking methodologies developed for this research can be used in future studies to gauge teachers' CBM graph comprehension, and to examine the influence on actual CBM implementation and data use. Further, the CBM instructional videos can be used for further exploration of the effects of CBM instruction not only on CBM graph comprehension, but also on CBM implementation and data use. Such instructional videos might eventually be developed into digital courses that can be made widely available via Massive Online Open Courses (MOOCS) or Small Private Online Courses (SPOCS).

Importance of and Need for CBM Graph Comprehension

Before describing the implications of the research for practice, we wish to return to and briefly expand upon a topic raised in the limitations section: To what extent is CBM graph comprehension necessary for CBM implementation and data use? In research and articles about data-based instructional decision-making, analyzing and interpreting the data are often seen as essential prerequisites for the optimal use of the data in the classroom (e.g., Mandinach, 2012; Schildkamp & Kuiper, 2010; van der Kleij & Eggen, 2013). One could, however, argue that teachers do not actually need to comprehend CBM graphs in order to use the data to make instructional decisions. For example, computer technology could be used to prompt teachers to make instructional or goal changes, and to provide teachers with recommendations for what type of changes to make.

Indeed the work by Fuchs, Fuchs, and colleagues (see L. S. Fuchs & Fuchs, 1989; L. S. Fuchs & Fuchs, 2002; Stecker et al., 2005, for reviews) indicates that providing teachers with such prompts and feedback can significantly improve teachers' use of CBM data for decision-making, and, subsequently, students' achievement. What is not known from this previous research is whether, and to what extent, CBM graph comprehension contributes to CBM data use in the presence of technological supports. However, we would posit that there are reasons to believe that CBM graph comprehension is an important factor, and should be included in future research on CBM implementation and data use.

First, teachers' active involvement in graph inspection and interpretation may be an important factor in eventual data use. L. S. Fuchs and Fuchs (L. S. Fuchs, 1988; L. S. Fuchs & Fuchs, 1989) argued that computer technology might serve to distance teachers from the data, and that it is important for teachers to be actively involved with interpreting the data in order to make effective data-based instructional decisions. This argument was supported by a study that demonstrated that enhancing teacher involvement in formulating instructional decisions based on CBM data led to improvements in the timing of goal and instructional changes (L. S. Fuchs, Fuchs, & Hamlett, 1989a).

Second, teachers may be more likely to respond to the data with instructional changes if they understand and "believe" the graphed data. Previous research has demonstrated that preservice and inservice teachers do not necessarily believe in or trust CBM data (Foegen et al., 2001; Landrum, Cook, Tankersly, & Fitzgerald, 2007). Better comprehension of the data might improve their belief in the data, their trust in the computer-generated recommendations, and, ultimately, their willingness to use the data to make instructional decisions such as implementing instructional or goal changes.

In sum, it seems worthwhile to consider teachers' comprehension of CBM graphs in future research, and to examine the role of comprehension on data use in the presence of technological aids. In such research, the relative contribution of various factors on teachers' CBM graph comprehension and on teachers' use of the data should be examined as well.

Implications for Practice

Comprehending CBM progress graphs

Probably the most obvious implication from the research presented in this dissertation is that one cannot take as self-evident that teachers will comprehend or understand CBM progress graphs. This implication is especially vital in the sense of sharing data from CBM graphs with others. That is, CBM graphs can be used to foster communication about student progress and the effectiveness of instruction, and teachers are often expected to describe the graphs to parents in parent meetings or to colleagues or other professionals in team meetings (Deno, 2013). Yet if teachers have difficulties with comprehending the CBM graphs, sharing the data with others will be problematic.

Thus, if teachers are expected to describe CBM graphs to others to communicate about student progress and instructional effectiveness (and to make instructional decisions based on the data), they must comprehend the graphs and should be equipped to inspect the graphs, and to read, interpret, and link the data to instruction.

A second implication is that instruction in CBM graph comprehension provided via 25-45 min CBM instructional videos can improve teachers' CBM graph comprehension. The idea that CBM instruction can be provided via videos is interestingly and valuable because videos can easily be incorporated into online CBM progress-monitoring systems or, as mentioned earlier, can be offered as stand-alone online courses to reach a large number of teachers in an efficient way. However, it may be necessary to revise or enhance the CBM instructional videos to be more effective. Not all aspects of CBM graph comprehension improved, or improved as much as desired, in the intervention study. Teachers may need more instruction on how to make data-to-data comparisons than was provided in the videos.

In addition, given the importance of sharing CBM data with others (Deno, 2013), teachers might benefit from supplementary instruction on how to effectively communicate CBM data. For example, teachers might be provided with the ideal sequence (i.e., the sequence in which the data are used for CBM instructional decision-making), and be instructed to inspect and describe the data in this sequence. When providing such instruction, it would be helpful to point to or highlight the elements that are explained. Providing teachers with examples of good descriptions of CBM graphs while teaching teachers how to communicate CBM data might also be worthwhile.

Comprehending Cito progress graphs

In the Netherlands, CBM is not (yet) in widespread use. Here, many elementary schools implement a progress-monitoring system in which nationally-normed standardized tests (Cito toetsen) are used to collect student data. Students are typically tested once or twice a year, and individual as well as class-wide data are provided to teachers in the form of tables and graphs.

The results of the research presented in this dissertation fit well with the results of studies on teachers' interpretation of data from the various types of Cito score reports (Ledoux, Blok, Boogaard, & Krüger, 2009; Meijer, Ledoux, & Eslhof, 2011; van der Kleij & Eggen, 2013), that suggest that teachers have difficulty interpreting these data. For example, van der Kleij and Eggen (2013) administered a questionnaire with closed-answer items to teachers, lead teachers, and principals that measures their interpretation ability of individual and class-wide Cito score reports. Results revealed that teachers only answered 62% of the items correctly, which was below the standard of 85% that was set by experts as the minimum expected score. Moreover it was found that, from the three participant groups, teachers had the lowest scores, indicating that they struggled the most with interpreting the reports.

In addition, the results of the intervention study presented in this dissertation fit well with the results of a study on the effects of professional development on school staff's attitudes, knowledge, and skills for data-based decision-making (Staman et al., 2014), that demonstrates that training in data-based decision-making using Cito data resulted in improved data interpretation scores for teachers. That is, at posttest teachers answered a higher percentage of multiple-choice items about interpreting various types of Cito score reports correctly than at pretest; however, despite this substantial growth in teachers' interpretation ability there was still room for improvement.

One aspect of teachers' comprehension of Cito data, and in particular of their comprehension of Cito progress graphs of individual students, that has not yet been addressed is the aspect of linking the data to instruction. Given the results of the research presented in this dissertation one might hypothesize that linking Cito data to instruction would be difficult for teachers and requires training. Currently, we are conducting a small study to examine how teachers' read, interpret, and link data from Cito progress graphs to instruction.

Implementing CBM in the Netherlands?

Since the enactment of the law *Passend Onderwijs* in 2014, teachers are confronted with more and more students with learning and/or behavioral difficulties in their general classrooms, and teachers are supposed to meet the educational needs of these students and to provide them with tailor-made education (Nationaal Regieorgaan Onderwijsonderzoek, 2014). As illustrated by the case study of Mr. Kees and Sander (see Chapter 2), CBM could be used – alongside a current progress-monitoring system such as the Cito system – to closely monitor the academic progress of, and evaluate the instruction for, students with learning difficulties, with the purpose of addressing the student's educational needs by providing tailor-made education.

The use of CBM to monitor and evaluate student progress to make data-based instructional decisions would be in line with the governments' call for elementary schools to adopt a data-based instructional approach to improve student achievement (referred to as *Opbrengstgericht werken*; Ministerie van Onderwijs, Cultuur en Wetenschap, 2007, 2011). However, to make Passend Onderwijs and the adoption of a data-based instructional approach successful, school personnel would need to be provided with resources (i.e., the knowledge, skills, expertise, and time) to collect, interpret, and use data for instructional decision-making. As illustrated by the case study of Mr. Kees and Sander (see Chapter 2), the school psychologist ("orthopedagoog" in Dutch) and the lead teacher ("intern begeleider" in Dutch) can play an essential role in the implementation of a data-based instructional approach (see Deno, 1986, for more information on this role of the school psychologist).

Conclusion

In conclusion, the results of the studies presented in this dissertation revealed that teachers experience difficulties with inspecting CBM progress graphs, and with reading, interpreting, and linking CBM data to instruction, but that teachers' comprehension of CBM graphs can be improved via relatively short CBM instructional videos. Future studies should examine whether teachers' CBM graph comprehension is related to, and whether the three CBM instructional approaches affect, teachers' actual implementation of CBM and their use of the data for instructional decision-making.