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How mini-whiteboards can help teachers raise their level of communication in whole class plenary talks

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This study investigates if using mini-whiteboards can change communication practices in a classroom using a before-and-after approach. Change in teaching practices was analysed using a framework described by Brendefur and Frykholm (2000). The data for this paper were collected on a lesson before the introduction of the mini-whiteboards, and a lesson three months after the introduction of the tools. The second lesson is part of the shared data within TWG19 for CERME13. Using turn-by-turn analysis, the teachers' statements in the whole class plenary talks were analysed against the framework. The findings show no significant improvement in the teacher's guidance of the whole class plenary talks within Brendefur and Frykholm's (2000) framework, but there are some changes worth reporting on. These changes were twofold. The first change was that the teacher used less of the codes yes and no questions and guess what the teacher is thinking questions. The second change was that the mini-whiteboards created opportunities to raise the communication to reflective.

Keywords: Discourse, instructional development, enactment.

Introduction

Multiple theories exist about what improvements a teacher can do to enhance their teaching practices, such as Smith and Stein's (2018) 5 practices, or Kazemi and Hintz's (2014) talk moves. The question is, how do we get the teacher to use these practices or talk moves, that we know work? One way is by using the development framework Mastering Ambitious Mathematics (MAM), which Mosvold and Waage (2022) wrote about in CERME12 where they described how the method works. Another common way to develop teacher practice is lesson study, which Ming Cheung and Yee Wong (2014) showed in their systematic review gave beneficial outcomes to student learning. Both methods make the teacher look systematically at teaching, and how it can be improved. The problem with these methods is that they are resource demanding. They demand multiple cycles of reflection and planning, which is time-consuming. Fauskanger's (2019) study on lower secondary school teachers' views on lesson study found that most participants put forward time consumption as the most challenging.

The goal of this study is to test the possibility to make a change to a teacher's practice with a small intervention, that does not take too much time out of their daily tasks. Bjerkeli (2017) wrote in her master's thesis about a well-regarded teacher, who, among other things, used individual mini-whiteboards for each student to facilitate the whole class plenary talk. Based on this, a colleague and I found specific ways the teacher could use the mini-whiteboards in the whole class plenary talk to facilitate students' participation in the whole class plenary talk. Such as giving the teacher and other students easy access to all the different solutions in the class, as well as making it easier for the student to explain their strategies when they had their thinking illustrated on the mini-whiteboard (Eidissen et al., 2019). The research question hence is, "How will the introduction of mini-whiteboards in the whole class plenary talks influence the teacher's level of communication in mathematics?"

Theory

Brendefur and Frykholm (2000) provide a framework for analysing classroom communication, which has four hierarchical categories, where each successive level assume characteristics of its predecessor. First we have *uni-directional* communication, followed by *contributive* communication, *reflective* communication, and lastly *instructive* communication. These four constructs are wide and varied enough in their description to cover most classroom communication. The authors note that teachers will naturally engage in different levels of communication during a single lesson, but each level is distinctive in its description, which will be detailed hereafter.

The first of these four levels is *uni-directional* communication. It is described as the most common in mathematics classrooms and is often associated with traditional teaching practices. Brendefur and Frykholm (2000) describe this level of communication as a classroom where the teacher is the authority on mathematics and must explain it to the students. In these classrooms, the teacher typically dominates the discourse, asking closed questions, and allowing the students few opportunities to share their strategies, ideas, and thinking. Franke et al. (2007) describes a standard classroom discourse using the term IRE, where the teacher initiates, the students respond, and the teacher then evaluates the response. This description fits a teaching practice that uses *uni-directional* communication, as in a typical IRE pattern the teacher dominates the communication in a classroom and is then the authority of what is correct mathematics and decides by what is initiated what the class is looking at. Funnelling is a concept presented by Wood (1998) where the teacher asks a series of explicit questions until the student provides the correct answer. This can be seen as an attempt to get the students to share with the class, but it still is teacher dominated, and the teacher might reject correct strategies if they are looking for one specific answer. This can be seen in relation to Brendefur and Frykholm (2000, s. 126) who write that teachers on this level are “asking closed questions and allowing few opportunities for students to communicate their strategies, ideas and thinking”. Since funnelling is about the teacher asking leading and closed questions to get to a specific point, the students do not get to share their ideas but are a mouthpiece for the teacher's agenda.

The second level in Brendefur and Frykholm's (2000) framework is *contributive* communication. This level of communication is more focused on the interactions in the classroom, mainly between the teacher and students, but also between students. These interactions are usually limited to assistance or sharing and often include little or no deep thought. Even though the students are given more opportunities to share their strategies, ideas, and thoughts, *contributive* communication still fits the description of IRE, since the teacher asks the questions and evaluates the answers. The main difference is in the student's response as it now has more leeway in contrast to *uni-directional* communication, where there usually is only one correct answer. This can be seen as what Kazemi and Stipek (2001) describe as low-pressure exchanges, where the teacher has the students share their thinking, but do not press for details or look closer at inadequate solutions. This is similar to Brendefur and Frykholm (2000) description of this level as sharing with little to no deep thought required by the student. They also point out that conversations on this level often are corrective, although the students are allowed to articulate solution strategies in *contributive* communications, the teacher is still the mathematical authority. On this level, the students are contributing to the discourse, but not altering

it. The teacher is always in control and has a plan for where they are going to end up with the discourse.

The third level in Brendefur and Frykholm's (2000) framework is reflective communication, and they point out that there is a clear and important step between the second and third levels. On the surface, this level looks a lot like *contributive* communication, in that the students get to share their strategies, ideas, and thinking with the class. But on the second level that is all they do, on the third level, the teacher uses sharing to invite the students to a deeper investigation and exploration of the subject in question. This can, according to Wood (1998), be done by using focusing, where the teacher focuses on an important or interesting part of a student's strategy and invites other students to reflect on it. Later Wood (1998) says that by creating situations that allow the students to explain and give a reason for their thinking, the teacher can ask clarifying questions to get a deeper understanding of their thinking and make the strategy clear for the other students. Brendefur and Frykholm (2000) also note that teaching on this level includes providing the students with the opportunity to reflect on the relationship within the mathematical topics. For example, by having the students focus on other strategies than their own and look at differences or resemblances between them. It is the teacher's responsibility to make the students aware of the opportunity and teach them to grab them when they arrive. This can be done by establishing what Yackel and Cobb's (1996) describes as sociomathematical norms, which are different than social norms. Where the expectation that students are to share solutions and strategies is a social norm, that students are to compare strategies is a sociomathematical norm. Yackel and Cobb (1996) point out that a teacher must show the students how to compare these strategies and make it clear to them what constitutes a mathematically different solution, which is a contribution to the discourse. Then over time, the students will learn to see the differences themselves and be more proactive in sharing their ideas, to be able to look at the differences. In the previous two levels, the sociomathematical norms are more about what kind of answers the teacher will find acceptable. If the students are unsure about what is acceptable, it will most likely result in a less participatory whole class plenary discourse. The third level in Brendefur and Frykholm's (2000) framework no longer fits the IRE term (Franke et al. 2007), because the teacher does not have to do the evaluation and initiation every time. As noted by Brendefur and Frykholm (2000), the teacher must only provide the opportunity, not necessarily lead the students through it.

The final level in Brendefur and Frykholm (2000) framework is *instructive* communication. At its core, this level is about altering the path of a lesson plan or the structure of lessons. On this level, the students have such a deep conversation that the teacher can and will alter the course of the lesson based on what the student bring forth in their discussion. Brendefur and Frykholm (2000) write that the primary work of the teacher is still to pose situations and encourage reflection among the students, but the act of modifying the situation and/or reflections of the student to lead the discussion in new directions is what defines this level of communication. On this level, Yackel and Cobb's (1996) sociomathematical norms have to be clear on that the students have to know what constitutes a different mathematical solution so that they can contribute to the conversation without the teacher telling them to. One method for how to work on this level is to use Smith and Steins (2018) 5 practices. These are 1) anticipating, 2) monitoring, 3) selecting, 4) sequencing, and 5) connecting.

Practices 3 and 4 are about letting students' strategies direct the rest of the lesson. The teacher chooses which strategies to bring forth, and in which sequence, but not what strategies are present. This can be a great way to get the students used to what solutions are important to share. One of the differences between the last level and the third is that here the teacher is less of an authority and lets the student's reasoning and reflections influence the lesson.

Method

This article reports on a teacher's practices in whole class plenary talks after the introduction of mini-whiteboards. To look for development, a colleague and I filmed this teacher's practice before the introductions of the mini-whiteboards, and three months after. The second video is a part of the shared data within TWG19 for CERME 13, called Drageset (Whiteboards). The plan for the study was to show this teacher how this tool could be used, but because of covid restrictions, we were not allowed to come and meet the students. Instead, we met with the teacher for about an hour, brought the mini-whiteboards, and presented how they could be used in the whole class plenary discourse. For example, by asking a student to explain their thinking, while showing their mini-whiteboard, or by having another student explain that solution. In this way, the teacher can get the student to engage with each other's thinking.

Since the aim of the article is to see if there was a difference in the level of discourse the teacher had with the students, the analysis is based on a turn-by-turn analysis, which was done with the software NVivo. By using deductive coding, I categorized all the teacher interactions in the whole class plenary talk against the framework by Brendefur and Frykholm (2000), where the teacher's statements in the whole class plenary talks were coded based on the description in the framework, see Table 1.

During the analysing process, there were distinct differences within the categories in the framework. Therefore, I chose to do an inductive analysis based on the data within the given categories. There I developed codes that are partly based on characteristics from Brandefur and Frykholm (2000), and partly based on what became apparent in the data, which is presented in Table 2 and Table 3.

Findings

Table 1: Distribution of classroom communication level before and after

Level	Uni-directional	Contributive	Reflective	Instructive
Before	59 (69%)	26 (31%)		
After	38 (60%)	24 (38%)	1 (2%)	

There was no significant difference between the before and the after lesson (Table 1), though the teacher made small changes to their practice. I therefore looked closer at the different categories to see if there were changes that were not as apparent. In the following sections, I will present the codes used within each of the communication levels used during the lessons and show how the data was coded.

Uni-directional

Table 2: Distribution within the uni-directional communication level before and after

Code	Guess what the teacher is thinking	Yes and no questions	Evaluations	Explanations	Short answers
Before	21	24	19	13	10
After	4	7	10	10	17

Though there was little change in the use of the categories between the lessons given before and after the introduction of the tool, there were some clear changes in some of these codes. Changes were made mainly in the use of *yes or no questions* and *guess what the teacher is thinking* questions.

The *yes or no questions* were recognized from the form they had and are often shorter questions that do not demand a lot of thinking from the student. This communication is often seen as a way for the teacher to get confirmation on if they understood the student's thinking correctly. Such as asking, “*so you took a hundred away from five hundred?*” or “*This was what you thought?*”.

The *guess what the teacher is thinking* part of the code became apparent in running dialog, for example from how the teacher reacts to the student's answer, and the teacher's response to an answer that is not the one they had in mind.

- Teacher: Hundredths yes. And then it was actually quite fun what we did yesterday when we converted between percentage, fractions, and decimals. But what is the point of percentage? When, when do you need it? When do we see it in our daily life? Percentage. What's the point? Why should we learn about this? Student B, why do we need to know anything about this?
- Student B: Erm, if there is any percentage reduction on something.
- Teacher: Percentage reduction is usual on some things. Another word that also is used, not only reduction, is that one use to say that one can get a certain percentage. What then, Student C?
- Student C: Fee
- Teacher: Yes, it can be a fee, which one has to pay extra, but there is also another word that means reduction. Do you know?
- Student D: Discount.
- Teacher: Discount yes...

Here we can see that though the teacher acknowledged each student's contribution, it is obvious that they are looking for a specific answer, which in this case is “discount”. We can see in the transcripts that when the “correct” answer finally appears, the teacher then stops asking for more different answers since they finally got what they wanted and can present the next assignment.

According to Wood (1998), a funnelling pattern is characterized by the teacher asking questions until the right answer is mentioned. In this quote, we see the teacher doing just that, asking a variation of the same question until “discount” is said. The IRE pattern Franke et al. (2007) presents is also presented here. The teacher asks a question, a student answers, and then the teacher evaluates, before asking again.

Contributive communication

Table 3: Distribution within the contributive communication level before and after

Code	Why	Access and share
Before	4	22
After	3	21

Within this *contributive* communication, there was less variation found. We can see that the teacher did not change their practice much. The first code “why” is seen when the teacher pressed for the students reasoning a few times in the data set. Where they asked such as “yes, why?” or “because?” directly after a student had explained something, a strategy, or an idea. This fits in the framework as Brendefur and Frykholm (2000) write that when a teacher is moving from *uni-directional* to *contributive*, the teacher begins to encourage students to share. As in all the quotes under *why* where the teacher got the student to give a reason for their strategy but did not go into the details. Since there are so few of these kinds of questions, it paints a picture of the teacher not showing an interest in the students meaning behind their thinking.

In the second code, *access and share*, the teacher focused on getting access to and sharing the students’ strategies, ideas, and thinking, by asking “*What did you find out?*” and “*Tell us, Student G, how you were thinking.*” In the after-lesson, we can see that the teacher uses the mini-whiteboards as a medium to get the students to show their thinking, by asking “*You can look at Student J’s whiteboard, which is very clear, and then you can talk while we look at it.*”. Here the teacher is bringing the other student’s attention to Student J’s work so that they can follow her explanation.

This communication still fits with the IRE pattern (Franke et al., 2007), but here the teacher gives the students more freedom in what they respond with since it is their strategy. In comparison to *yes or no questions* and *guess what the teacher is thinking*, where the students know that the teacher is looking for one specific answer, as shown above.

We can see a marked reduction in some of the question types found in the sub-analyses, *yes and no questions* and *guess what the teacher is thinking* questions. By having the students share their work on the mini whiteboards there was no longer a need for the teacher to ask, *yes or no questions*, as often. In the data it was mostly asked to clarify an explanation a student had given, or to the student to show their own understanding. This clarification is no longer necessary when the teacher can see what the student has written.

Regarding the *guess what the teachers thinking* questions it is easier for the teacher to use what the student had on their mini-whiteboards and use that to lead them to a specific point if that point was apparent on the whiteboards. Since the teacher had easy access to all available strategies in the classroom, they had in theory an easier time getting to the point they had in mind. Therefore, the teacher could use the student’s work to get their point across.

Reflective

This level of communication only apparent once, in the after lesson.

Teacher: Okay. So you used the fact that you know twenty percent is one-fifth. Erm, Student F, how did you find your answer? Please show your whiteboard. If you all look at Student F's whiteboard, then you see that it looks completely different from Student E's. How did you think?

Here we can see that the teacher asks the students to look at Student F's whiteboard and notice that it is totally different than Student E's. The teacher points out to the students that there is a difference that they should pay attention to, and as described earlier, Brendefur and Frykholm (2000) wrote that the main difference between levels 2 and 3 is just this. That the teacher points to the difference and asks the students to notice it, which falls in line with the framework. Then the teacher asks the student with the different mini-whiteboard to share their thought, with that, stopping the comparison.

Though the teacher gives the students an opportunity to reflect on the differences in the answers given, this sharing does not lead to a deeper investigation or exploration of the subject, which Brendefur and Frykholm (2000) were clear on, is the difference between *contributive* and *reflective* communication.

As shown in Table 1, there was only one instance of *reflective* communication. However, there were some instances that were close, where the teacher only had to make small changes to the practice to raise it to *reflective* communication.

Teacher: Okay, then we have, erm... several ways to do this, that is amazing... Student J, tell us how you were thinking. You can look at Student J's whiteboard, which is very clear, and then you can talk while we look at it.

Then the teacher talks with the students and makes sure that Student J's strategy is shared. Then ...

Teacher: Then we must... get one hundred and ninety-five. Student K and Student L have, erm, another solution. Show your whiteboard so we can see it, erm, that one I didn't see any other place. Tell us, Student K, how you were thinking.

Here we see that the teacher points out that there are multiple ways of doing it, but do not ask the students to notice the difference or compare it. In the second example, we again see the teacher pointing out that there is an alternative solution and even making it clear that it was the only one of that kind. If the teacher had asked the students to explore and reflect on the difference in what was brought forth, it would raise the level of the discourse to *reflective* communication.

Conclusion

Regarding the research question, there was no significant influence to see in the framework based on Brendefur and Frykholm's (2000) four categories. However, there appeared some differences regarding the codes in *uni-directional* communication. Especially regarding *yes or no* questions and *guess what the teacher is thinking* questions. Even though there was little *reflective* communication there still seemed to be a few opportunities to raise the communication to a *reflective* level with only a few tweaks in the discourse. This shows that there is potential in this tool. If the teacher had been given the opportunity to observe us use the mini-whiteboards or maybe been guided on the use. It could have brought the teacher to have more *reflective* communication in their classroom.

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