Orchestrating institutionalisation in card-matching lessons: The use of 'big cards'

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This paper reports on one aspect of the FaSMEd project in South Africa. In the project, teachers trialled lessons, at the heart of which small cards were used in activities involving matching or classifying mathematical objects. While the success of this kind of task is generally well recognised in terms of challenging and engaging students, it also seems to be the case that bringing the lesson to a close tends to be more problematic. To address this, as an experiment, big versions of the small cards were provided for the teachers. The research investigated whether, and how, the teachers used the cards. The findings suggest that teachers use the cards in a variety of ways, some of which appear to be more effective than others; it appears that teachers need more support in thinking through the decisions that need to be made in planning effective discussions when finishing a lesson.

Whole-class discussion, institutionalisation, teacher choices, card matching

Introduction and background

The Formative Assessment in Science and Mathematics Education (FaSMEd) research project which took place in 2014, 2015 and 2016, involved eight European partner institutions and one in South Africa. This paper reports on one aspect of the South African research.

Ten secondary schools, and twenty teachers, were involved in the project. The teachers were asked to commit to teaching three 'FaSMEd' lessons and most managed to do so. In these lessons, students worked in pairs on a card-matching or card-sorting activity. They were given sets of small cards and a large sheet of paper; they were asked to group or sort the cards, and then to stick the groups onto the large sheet of paper. These lessons were intended as 'active learning' lessons which would provide multiple opportunities for formative assessment.

The way of working was as follows: the researchers worked with each teacher to select and plan a lesson; the teacher taught the lesson observed by the researchers who interviewed the teacher after the lesson and then wrote a report on the lesson and the interview and shared it with the teacher; the researchers and teacher considered ways to improve the lesson; and once in each cycle of lessons all teachers attended a 'cluster meeting' organised and run by the researchers but with selected teachers contributing a so-called 'cameo slot' at each meeting.

One of the issues arising in the planning of the first cycle of lessons and in the cluster meeting that followed was how to end the lesson. The FaSMEd researchers developed the idea of using big versions of the small cards the students used; this paper reports on research into how the teachers chose to use the big cards in the final phase of the lesson.

The institutionalisation phase: whole class discussions

Mathematics lessons usually, and some argue *should*, (Cobb & Yackel, 1998; Swan, 2006) end with a 'wrapping up' or institutionalisation phase, during which the teacher closes the gap between the knowledge the students have constructed for themselves and the intended mathematical knowledge (Brousseau, 1997).

Teachers' views on the role of, and approaches to orchestrating, the phase of institutionalisation are clearly likely to vary (Jones & Tanner, 2002). Some teachers invite students to share their answers and explain their thinking; they appear, however, to believe that they should not provide mathematical guidance (for example, see Chazan & Ball, 1999). This approach is sometimes referred to as 'first generation' (Stein, Engle, Smith, & Hughes, 2008); and is seen as problematic in that firstly, students tend not to be interested in their peers' solutions and therefore do not engage (Silver, Ghousseini, Gosen, Charalambous, & Strawhun, 2005) and secondly, the expected institutionalisation of knowledge does not occur because the discussion does not move beyond 'show and tell' (Stein et al., 2008). So-called 'second generation' practice, however, aims to use student thinking as a springboard for discussion of powerful mathematical ideas and hence to close the gap described by Brousseau. Clearly, a second generation approach is seen as more effective but it is also recognised as being difficult (Stein et al., 2008).

In all cases, however, the teacher has to decide how to orchestrate the sharing of the students' thinking. This includes making decisions about what exactly will be discussed in a whole class discussion, by whom, and when. These teacher decisions are the subject of this paper.

What we did

As discussed above, this research took place in the context of lessons involving the use of small cards which students matched or sorted according to some criterion. For example, in one lesson students were given sets of cards with 'real life' situations (e.g. I bought two bananas) and equations (e.g. $b=2$). In another they were given sets of exponent expressions (e.g. $2^2 \times 3^2$) and single exponents (e.g. 6^2).

Generally teachers were given the big versions of these small cards and they decided how to use them. All chose to stick the big cards on the board at the front of the classroom and to involve students by somehow assigning cards to them to be stuck up. They usually held a whole class discussion about the card matching. The analysis of what they decided to do, presented in this paper, is framed by four questions: how the big cards were assigned to students, who explained the reasoning, when discussions were held and what was discussed.

Findings

Although all twenty teachers taking part in the research used the big cards, here three teachers' choices are discussed. All three teachers are experienced teachers of mathematics but for all of them the 'FaSMEd lessons' represented a significant shift in their practice. In each subsection below, the teachers are briefly introduced and an account is given of the ways in which the big cards were used.

MacDonald

MacDonald, originally from Zimbabwe, teaches in a non fee-paying, government, township school in which all the learners are Xhosa-speaking, although the medium of instruction is English. His class was a Grade 10 class of learners who had chosen to take mathematics and physical science for their final examination, the National Senior Certificate. This implies that they were able mathematicians.

MacDonald used the big cards in three lessons. In the first, students had matched one or more single exponents (e.g. 6^2) with one or more expressions (e.g. 2^2 x 3^2 and $3^2 + 3^3$). MacDonald had told the students that they should aim to get ten groups of cards. Towards the end of the lesson, he stuck the expression cards on one side of the board and the single exponent cards on the other. He did not say anything to the students, but very soon they began to come to the board and move the cards into groups. Some students moved cards that had already been placed, apparently disagreeing with the original placement. No explanation was given. By the time all cards were matched, it was time for the end of the lesson. MacDonald counted the groups of cards, and said that there were ten groups and congratulated the class, saying that he was sure they were hungry and their food was ready (their lunch is served and eaten in classroom).

In the second lesson, students matched four sets of cards relating to algebraic relationships (functions and non-functions) such as linear, quadratic, exponential. The four sets of cards were: graphs, equations, tables of values (ordered pairs) and the rule in words. Once most students had done the matches, MacDonald placed the big graph cards along the top of the board and lay the other cards on empty desks at the front of the classroom. He invited students to come and choose a card and stick it under the appropriate graph. After some hesitation, and with encouragement from MacDonald, the students came to the front of the room and placed cards, and once again some students moved cards that had already been placed to different positions. When the students had finished, some card sets were incomplete and some cards were placed incorrectly. MacDonald held a discussion about those cards sets that appeared to have caused difficulty.

MacDonald's third lesson involved matching sets of cards representing six investments, each of which grows using simple and compound interest (description in words, formula, table of values and graphs). Four further cards make comparisons between the investments (e.g. This investment is the best one over ten years.) As the students were completing their card matching, MacDonald handed out the big cards to the students, explaining (to the researchers) that he did not want a repeat of the hesitation the class had demonstrated in the previous lesson. The students placed the cards, and again there some were moved to different places. Once all the cards had been placed, MacDonald brought to their attention two cards that were placed in the wrong group and asked the students where they should go. Some students came to the board and moved three cards so that all were correct. MacDonald confirmed that the matches were correct and dismissed the class.

Susan

Susan teaches in a school in one of the wealthier suburbs of Cape Town. The school is a government, but fee-charging, school. The fees are seen as high; too high for the majority of the population to afford. She was also teaching a Grade 10 class, and most

learners spoke English at home. Again, the students in this class had chosen to take mathematics and physical science.

Susan also taught three lessons involving big cards. The first was the exponents lesson MacDonald had also taught. Her approach, in the final part of the lesson, was to ask learners to tell her all the cards in one of their groups, and then she stuck these big cards on the board. In most cases she asked if the class agreed, and moved on. Sometimes she pointed out where she had noticed that students had difficulties.

In the second lesson, students matched three sets of cards related to time-distance graphs: graphs, tables of values and a description. In preparation for the whole class discussion at the end of the lesson, Susan handed out the description cards, one to each group of students (it was coincidence that the number of cards matched the number of groups). She then held up the other cards, called out the code on the card, and asked the students to ask for it if it matched their description card. She asked who had description 1, and said they should come up to the front of the class and explain, saying "Now, you listen please to one another's reasoning." Each group presented their matches, explaining briefly. Susan interjected from time to time with a question.

In the third lesson, students matched one or more statements (e.g. "$g(x) - 2 = f(x)$ when $x = -1$", "$g(x)$ is always decreasing") with graphs of two functions on one set of axes. As the students were finishing their matches, she stuck the big graph cards on the board and handed out one or more statement card to the students. She requested the student who had Statement 1 to come to the board and paste it under the appropriate graph. The student did this and explained briefly, on Susan's request. This was repeated for all statements, and there was some teacher-led discussion about the few matches that were not agreed by the whole class.

Wynoma

Wynoma also teaches in a government fee-paying school, but her school's fees are significantly lower than those in Susan's school. Her research class was Grade 8, the first year of secondary school. Most learners spoke English or Afrikaans at home, and the language of instruction was English. In this school classes were set, and her class was seen as a high-achieving class.

Wynoma taught one card-matching lesson, in which students were given definitions of variables (e.g. b is the number of bananas I bought, y is the cost of one banana in Rands) and two sets of cards, one with statements (e.g. I bought two bananas) and one with equations (e.g. $b = 2$). She stuck the big versions of all the small cards on the board, and explained that they would go through the matches as a class. She said she would be asking groups to show the class their matches and that she would try to give as many groups as possible a 'chance'. She chose one of the statement cards; "I bought 2 bananas", stuck it on a different part of the board and asked who wanted to volunteer a match; from the volunteers, she chose one student. The student came to the board and found the matching card and stuck in under the statement card. Wynoma asked if everyone agreed; they did and she said she was happy. She then chose another statement card ("Bananas cost twice as much as apples"), saying that she had noticed that some of the groups had found this one interesting, and asked for a volunteer. She asked the student to explain and then she explained again. The class went through all the cards in this way, with Wynoma

choosing a statement card, a student finding an equation card to match and some combination of student and teacher explanation and discussion.

Comparing and contrasting

The three teachers used the cards in quite different ways. Whereas for MacDonald, the focus appeared to be on the overall 'solution' in all three lessons, for Susan the focus was perhaps more on providing all students with the opportunity to share their thinking (mainly in the second and third lessons) and for Wynoma it was on emphasising the mathematical ideas underpinning the card matching activity.

This focus could be seen to determine in some ways the decisions the teachers made in terms of assigning the cards and discussion of the card matches: who discusses, when the discussions take place and what is discussed.

In MacDonald's classroom, all cards had to be stuck on the board and the way he achieved this was, in the first two lessons, to ask the students to volunteer and in the third, to hand cards out to students. Susan's approach was similar to the one used in MacDonald's third lesson; she handed out one set of cards, ensuring that each small group of students had at least one card, and then students asked for the others they needed. This ensured that each group had a set of big cards and would have the opportunity to share their thinking about this set of cards. Wynoma, on the other hand, chose a specific card and appeared to be deliberate regarding which students to choose to find the matching card(s).

In MacDonald's classroom the discussion, which took place after all the cards had been matched, was about correcting mistakes in the whole set of card matches and only those that had been problematic were discussed. MacDonald did most of the talking. In Susan's classroom discussion took place one match at a time, and was about each match in an order determined by the numbering of the cards; so everything was discussed. The students did most of the talking, although Susan asked some questions. Wynoma, while also discussing each match, appeared to decide in which order to look at the matches so that she could emphasise the mathematics she wanted her students to learn. In some cases the students explained their thinking and in some cases she explained.

Conclusions

As can be seen, the three teachers used the cards for different purposes and in different ways. In unpicking what they did, using the four-question framework developed for the analysis, we have highlighted some of the many decisions teachers have to make, even in a relatively short phase of a lesson. These decisions are informed perhaps, by their views on the role of institutionalisation as discussed above: for example, do they tend to use 'first' or 'second generation' practices in their classrooms? Decisions will also, however, be informed by very many other factors such as the mathematical content of the lesson and the students' confidence in the mathematics; the teacher's experience in teaching a card-matching lesson; time; and, importantly, the culture of the specific classroom. For example, while Susan's students were confident about the mathematics they were discussing and were, to some extent at least, enculturated into listening to one another's explanations, MacDonald's students were less confident in the mathematics (in the second and third lessons) and were not used to listening to one another's explanations. This would mean that Susan's approach might be possible with her class but would not work with MacDonald's class.

We did not always think the teachers used the big cards in the most effective ways and to some extent this is to be expected, as they had not used big cards previously. So, whereas the tasks we asked them to use with their students were very carefully designed and the way they might teach the class using these tasks was discussed with them in detail, perhaps not enough attention was given to the ending of the lesson by either the teachers or ourselves, as researchers. The research presented in this paper provides us and other researchers with insights into how many seemingly small, but probably important, decisions need to be made in order to get the most out of the institutionalisation phase of a card-matching lesson; and from this we can develop our approaches to working with teachers in future similar research.

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