SCAFFOLDING DATA CONVERSATIONS IN A PRIMARY CLASSROOM

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In statistical inquiry students collaboratively address complex, ambiguous tasks that require negotiation and statistical evidence. Working collaboratively requires students to engage in intellectual risk taking as they propose and defend ideas, provide constructive feedback and defend the solution using statistical reasoning. Taking intellectual risks can be challenging for students who are more familiar with mathematics classrooms that focus predominantly on memorisation and reproduction of processes. This exploratory study aims to understand ways that 9 year old children can more confidently engage in data conversations that have the potential to improve the thinking, evidence and inquiry conclusion. Results suggest that by using scaffolding frameworks and establishing inquiry norms, students develop their capacity to reason statistically as they engage in student centered data conversations.

INTRODUCTION

In inquiry classrooms, students explain and justify solutions, make sense of explanations by peers, indicate agreement/disagreement, and query alternatives (Cobb, 1999, p. 7) as they contribute to advancement of knowledge in the classroom. Researchers have raised concerns about collaborative learning situations that provide insufficient teacher guidance (Bakker, 2018). This paper reports on an exploratory Australian study aimed to understand how students learned to engage in data conversations with increasing independence. The teacher introduced scaffolding frameworks (e.g. posters) and modelled classroom talk (see Makar et al, 2015 for a fuller discussion of the scaffolds). We explored the teacher's role in questioning and supporting students to assume responsibility, specifically her use of prompts, contrasting classroom episodes from the beginning and end of the year. The research question was: *How can a teacher's use of prompts scaffold the development of data conversations in a primary inquiry classroom?*

LITERATURE

Inquiry is a process of collaboratively addressing complex, ambiguous tasks using evidence to connect the question, evidence and conclusion. Evidence that includes the solution pathway as part of the solution defence is crucial for students to convince peers their solution is valid (Makar et al, 2015). Webb (2014) reported greater achievement gains when students engaged with others' ideas. Engaging collaboratively in inquiry involves not just contributing and explaining ideas but engaging with others' ideas: e.g. building on ideas, challenging respectfully, questioning/clarifying, and providing substantive feedback. Engaging with others' ideas is not typical in mathematics classrooms. Goos (2004) argued that in order for students to engage in mathematical thinking, the teacher can support them by acknowledging the intellectual risk involved in moving from passive to active listening, and modelling sense-making in developing justified solutions. Whole class scaffolding is critical to explicitly teach students how and when to share ideas (Yackel & Cobb, 1996). This type of scaffolding communicates that all children are sense makers and orients them to one another and their mathematical ideas (and goals). These are principles that Kazemi and Hintz (2014) suggest to engage all students meaningfully in classroom discussions (such as data conversations). Herrenkohl et al. (1999) explored whole class scaffolding that supported students to adopt audience roles in questioning, commenting and critiquing as they engaged in student-centered conversations. With the goal of scaffolding being the gradual withdrawing of support to handing over of independence to students (Van de Pol et al., 2010), students can develop argumentation-based inquiry norms and a conceptual understanding of key statistical ideas to feel confident to uptake the responsibility of student- centered data conversations that develop their statistical learning.

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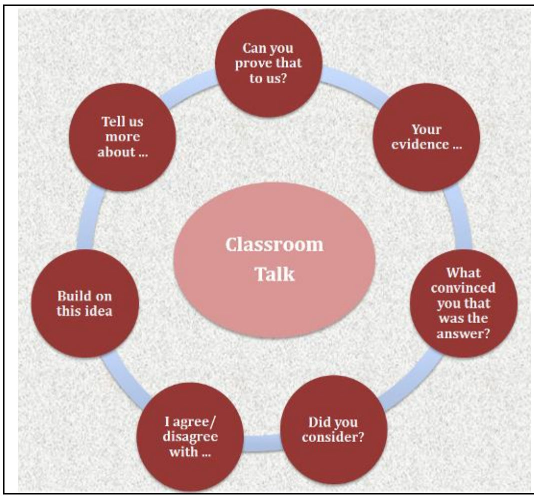
METHOD

This study used exploratory action research to investigate how a teacher developed students' data conversations over a year. Participants were 26 children (age 9) representing a diversity of achievement levels in a government school in Australia. The teacher (first author) had many years of experience teaching statistics with inquiry; she designed four units to strengthen inquiry norms and classroom talk over the year, discussing ideas with a researcher (second author, who collected and analysed the data) during and/or between lessons. Data consisted of classroom videos, teacher planning, student work samples and teacher interviews. Data were analysed using a process adapted from Powell et al (2003): video logs were created, key sections identified and transcribed that exemplified scaffolds for data conversations, transcripts annotated to summarise how prompts were used, videos re-watched, a storyline developed and narrative written.

Because most students had limited experience explaining and justifying solutions and critiquing explanations of others, Unit 1 consisted of short problem solving activities to introduce students to the concept of evidence. The aim of these activities was to develop skills in articulating and documenting reasoning and working effectively with peers. To facilitate students in initial attempts to make sense of and respond constructively to solutions explained by others, the class was provided with prompts as references to help them formulate questions to presenting groups (Figure 1, left). These prompts were explained and modelled with the class with examples and expectations for their use. Groups of 2-4 students were paired to practice both using the prompts in their role as audience, and responding to the prompts in their role as presenter.

In Units 2, 3 and 4, inquiries were designed to help students to make their reasoning explicit in linking *question-evidence-conclusion* (Fielding-Wells, 2010) and to address specific statistical goals (e.g. introducing students to a dot plot representation, acknowledging and reducing variability in data, using distribution patterns to analyse data). Throughout these units, frameworks for classroom talk and working collaboratively were regularly reiterated; as students progressed towards the inquiry conclusions, evidence became a focal point for data conversations (*Think of a question you could ask to challenge the evidence presented. Think of a comment you could make on the clarity of the evidence*). Prompts were designed to encourage groups to reflect on their progress (*Is the evidence you've gathered so far sufficient to allow the group to reach a conclusion*?) and to consider what they still needed to do as they worked towards a justified inquiry conclusion (*Have you recorded your evidence in a way that is clear and easy for others to follow?*). Prior to pairing groups to share and respond constructively to others' justified solutions in Unit 4 (*What is the typical time it takes a Year 4 student to read a book?*) students were encouraged to think of questions the teacher would ask to comment on and critique the solution. As a scaffold for both presenters and responders, prompt questions were also displayed and elaborated on to encourage students to consider their solution pathway and the evidence used to convince others that their solution was valid (Figure 1, right).



- What was the inquiry question?
- What evidence did you collect?
- How did you use it to calculate the (approximate) time to read a book?
- How did you represent your data?
- What is your conclusion to the inquiry question?
- How did your representation help you determine the conclusion?
- What patterns did you find in the data?

Figure 1. Prompts in Units 1 (left) and 4 (right) scaffolding data conversations in sharing solutions

RESULTS AND DISCUSSION

In Unit 1, groups were paired to use provided prompts (Fig 1, left) to comment on another group's justified solution. Oliver and Cathy first presented their answer to John, Grace and Kate.

Oliver: … and then you divide on them in 500 by one-eighth then you get the answer of 12.
Cathy: Thank you for listening.
John: *I totally agree with this.* (Italics suggest use of a prompt)
KM: (Long pause) … Is there a question on that circle that you could ask (referring to the prompts)? … (KM is the second author)
Grace: *Did you consider* scanning it? Did you think about it? (repeats over and over)
KM: I like the way some of you are using the words on the sheet. …
Kate: *Can you prove to us* that your answer is 12? Like prove all of the mathematics?
Grace: *Can you prove that* it is right? (repeats this question over and over)
(Oliver tries to explain his answer, but his voice is very soft)
Kate: Cathy, *can you build on the ideas*?
Cathy: What did you say?
Kate: *Can you build on the idea*?

In their first attempt, students did not just parrot questions completely, but attempted to adapt them to the situation ("*Did you consider* scanning it?", used the term 'scan' previously encountered in problem solving lessons). Yet their attempts did not yet reflect that students were actively listening nor even paying attention to the speakers. They struggled with what Yackel and Cobb (1996) referred to as a "taken-as-shared sense of *when* it is appropriate to contribute … [and] actual *process* by which students contribute" (p. 461). However, these initial awkward attempts were important to (1) legitimise the practice of questioning peers, not typically a norm in classrooms; (2) assist students in getting over the difficulty of breaching the silence following a presentation, lowering the level of risk-taking needed to enter into the discussion; and (3) provide a starting point from which the teacher could diagnose and respond to their progress over time.

In Unit 4, groups were paired to offer independent feedback on each other's draft posters of their solutions, including ways that they could improve their evidence, presentation of the data and justification. The excerpt below is from one such pairing, where William and Shane were giving feedback to another group (Jake, Jonah and Emma). William started by describing some of the strengths of the group's representation (Figure 2), before probing further:

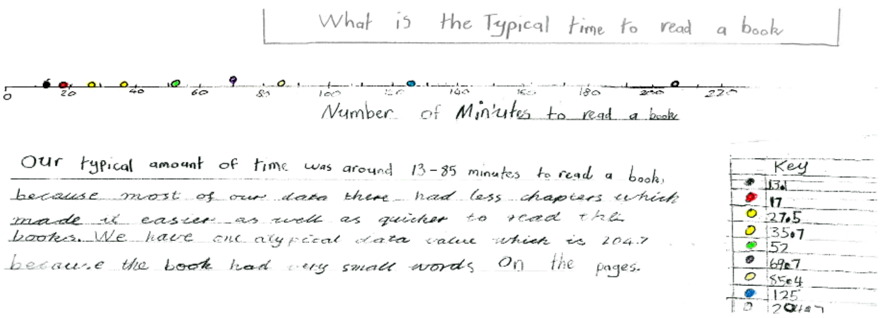


Figure 2: One group's draft presentation poster.

William: On your diagram here I really like how you made your answers [data] into colours and put it on [dot plot representation]. It really is easier [to read] now. You've got a lot of gaps. *What's, like, the pattern in your data*? (Again, italics suggest prompts, Figure 1, right) … (pause, then clarifying patterns for Jonah with examples) Like range, spread?
Jake: Well, that's the range but there's really like no shape because no-
Jonah: a straight line. That's atypical data (pointing to an extreme outlier) and that's kinda atypical (pointing to another point).
Shane: Yeah, it's really nice, but put some borders in between the (points on representation)
Jonah: Barriers
Shane: Put some barriers where most of the data is because I can't see where it is clumping.

The question that William posed was adapted from the teacher's prompts, selected meaningfully to assist the other group to analyse their dot plot. His choice aligned with a statistical intent of the unit to link the evidence (data) to the conclusion. When Jonah struggled to respond, William takes the role that a teacher would usually do to clarify and prompt with an example of what he meant by the "pattern" in the data. This allowed Jake and Jonah to make progress informally describing the distribution, including other patterns observed such as shape and atypical data (outliers). The group had claimed their solution (typical time to read a children's book) as 13-85 minutes, which encompassed nearly the entire distribution. Shane continued with feedback, suggesting that the group go further than observing there was no shape, pointing out a possible location where the data may have been clumping; his suggestion to identify a possible clump with "barriers" was intended to help them to better link the claim to their analysis. The children weren't relying on the prompts as they had done in the first unit. Further, they were engaging with the purpose of the lesson to improve their presentation of evidence, in order to explicitly link question-evidence-conclusion. The prompts that students used were therefore more selective in response to what was needed; this is in contrast to the first unit, where students selected prompts with less of a connection to the goals of the lesson or what their peers were saying.

CONCLUSION

Yackel and Cobb (1996) suggested that inquiry norms require a teacher's ongoing effort to provide scaffolds to assist normalisation of desired practices. Data conversations can support students to engage in statistical sense-making and discussions about statistical ideas with their peers. To normalise these conversations in a statistics classroom, children need repeated opportunities and scaffolds to develop their conversations into norms of statistical inquiry. Prompts are one strategy that can initiate, develop and maintain norms around data conversations. Initially, as these episodes illustrate, students may not use prompts meaningfully. Repeated experiences and scaffolding can progress students in independently adapting prompts to flexibly respond and meaningfully engage in data conversations.

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REFERENCES

Bakker, A. (2018). Discovery learning: zombie, phoenix, or elephant? *Instructional Science, 46*(1), 169-183. doi: 10.1007/s11251-018-9450-8

Cobb, P. (1999). Individual and collective mathematical development: The case of statistical data analysis. *Mathematical Thinking and Learning, 1*(1), 5–43.

Fielding-Wells, J. (2010). *Linking problems, conclusions and evidence*. Paper presented at the 8th International Conference on Teaching Statistics, Ljubljana, Slovenia.

Goos, M. (2004). Learning mathematics in a classroom community of inquiry. *Journal for Research in Mathematics Education, 35*(4), 258–291.

Herrenkohl, L. R., Palincsar, A. S., DeWater, L. S., & Kawasaki, K. (1999). Developing scientific communities in classrooms. *Journal of the Learning Sciences, 8*(3-4), 451-493.

Kazemi, E., & Hintz, A. (2014). *Intentional Talk: How to structure and lead productive mathematical discussions*. Portland: Stenhouse.

Makar, K., Bakker, A., & Ben-Zvi, D. (2015). Scaffolding norms of argumentation-based inquiry in a primary mathematics classroom. *ZDM, 47*(7), 1107-1120.

Powell, A. B., Francisco, J. M., & Maher, C. A. (2003). An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. *The Journal of Mathematical Behavior, 22*(4), 405-435.

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher–student interaction: A decade of research. *Educational Psychology Review, 22*(3), 271–296.

Webb, N. et al. (2014). Engaging with others' mathematical ideas. *International Journal of Educational Research, 63*, 79–93.

Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. *Journal for Research in Mathematics Education, 27*(4), 458–477.