EARLY CHILDHOOD EXPERIENCES IN INFORMAL INFERENTIAL STATISTICS USING AN INQUIRY APPROACH

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Young children's capabilities to engage with informal statistical inference are often underestimated in classrooms. Yet prior research suggests that an inquiry approach to learning statistics can foster thinking above age level expectations. This paper reports on a study of an early childhood class where a teacher introduced the statistical inquiry, "Do most children in prep have blue eyes?" The children (aged 4-5) had no previous experience with statistics or inquiry as an approach to learning. The lessons reported followed an age-appropriate protocol for inquiry learning in which children engaged with an inquiry question, interacting with each other and the teacher. Observations of children's statistical thinking, and examples of their inscriptions, illustrated how an inquiry approach created substantive exposure to statistical thinking beyond age level expectations.

BACKGROUND

Children's capacity to engage with and discuss powerful statistical ideas are often underestimated; with support, children are capable of inventing complex and diverse methods of problem-solving using data in appropriate contexts (English & Mulligan, 2013; Greer, Verschaffel, & Mukhopadhyay, 2007). Tentative explorations enrich data concepts in a way that number calculation and formula do not. Prior research in statistics emphasises the challenges that students have with concepts related to calculations when they have not yet built substantive experiences first (e.g., Bakker & Derry, 2011; Konold & Pollatsek, 2002; Shaughnessy, 2007).

An inquiry approach encourages connections between statistical ideas and meaningful contexts and assists to develop sound, if informal, statistical principles (Makar, 2016; in press). When children explore ideas and reasoning in a supportive environment, age-appropriate statistical foundations can be built before statistical concepts are studied formally in later years. For example, supporting children to invent their own representations whilst nudging them towards more formal recording can build relationships between students' thinking and visual artefacts:

> Inscriptions are built on a common history of experience … and much of the classroom conversation focuses on identifying the attributes that are worth capturing. Therefore, from the start, inscriptions communicate shared understandings. Over time, inscriptions evolve as students agree on the need for increased clarity and precision: Inventions evolve into classroom conventions. … Inscription pushes inquiry forward, so that conceptual and inscriptional development bootstrap each other. (Lehrer & Schauble, 2002, p. 195)

This paper briefly illustrates an example of statistical ideas that emerged through children's inscriptions as they sought to resolve a question based on a claim posed by a student in the class: *Do most students in prep have blue eyes?* The statistical inquiry that followed was based on an ill-structured question with the possibility of multiple solutions, supported by evidence from the data, collected and represented by methods invented by the children.

METHODOLOGY

The participants in this study come from a Prep class (first year of formal schooling) of 23 children (4-5 years old). The school was located in a suburb of a major city in Australia consisting primarily of middle class families. The classroom teacher was experienced in inquiry pedagogy but this was the first time teaching this age group; she designed the lessons, which were video-recorded by the second author (a university researcher). The teacher and researcher discussed the children's progress between lessons, but the teacher made the decisions about how the lessons progressed.

Two 40-minute lessons were taught on consecutive days at the end of the second month of the school year. The video data were analysed using a modified version of Powell et al's (2003)

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process of viewing and describing the video, identifying and transcribing key events, annotating the events, constructing a storyline to determine the focus and composing narrative using the data to illustrate the focus. In this case, the focus was to look at the children's inscriptions and underlying informal statistical concepts that emerged as these inscriptions were refined in the inquiry.

The two inquiry lessons followed from an activity exploring characteristics of self, including eye colour. During the activity, one of the children proffered the claim: "I think most children in Prep have blue eyes". The teacher asked the children to respond to the claim by conducting an investigation that would answer the inquiry question, "Do most children in Prep have blue eyes?", thus allowing a context initiated by the child, to be established.

Initially, a short exploration of the broad question occurred, which was unguided. The teacher preferred to initially observe the children's struggle, uncertainty, and hesitation rather than impose a set of guidelines from the start. The teacher's experience and judgement determined when to narrow the focus through questions, sharing ideas with the group and discussion. Her subsequent questions as they worked, then focused on developing methods of evidence and invented recording to allow for findings to be recalled, shared and discussed with the class. This pattern of independent thinking, interspersed with sharing and teacher questioning, is a common protocol in inquiry and several iterations occurred during each lesson. The next section illustrates two of these iterations.

RESULTS AND DISCUSSION

Students began by unsystematically counting their peers and sharing their counts with the teacher as they worked. One child counted three peers with blue eyes and claimed that this was all of the students with blue eyes. Rather than correcting her, the teacher focused her on defending her finding with evidence by contrasting her claim with another student's finding.

Mrs Louarn:	Well Tracey is telling me that 12 people have blue eyes, if Tracey is saying 12 people have blue eyes and you are saying 3 people have blue eyes how can we find out which one is right?
Jessica:	(Shrugs) I don't know.
Mrs Louarn:	Do you think you could count them? (27:24, 25 March, Classroom video)

The teacher used the findings of Tracey, another student, to encourage Jessica to resolve the conflict between the two answers. A third student, Oscar, standing nearby, offered his opinion about the number of students in the class with blue eyes, which reinforced the point that their claims needed to be based on evidence.

Oscar:	Because I think there are 100 people in our class has blue eyes.
Mrs Louarn:	So Oscar's saying that 100 people in our class has blue eyes. Do you think that could be right? 100 people in our class have blue eyes? (28:17)

Another challenge with teaching young students about using data as evidence, is to help them separate opinion from evidence. Mrs Louarn was able to build on Oscar's point to emphasise that both consistency and reasonableness needed to be considered. Caitlin countered Oscar's claim.

Caitlin:	Nooo
Mrs Louarn	Why don't you think so?
Caitlin:	Because that's not how many kids are in the class.
Mrs Louarn:	Ah and how many people are in the class, Caitlin?
Caitlin:	23. (29:26, 25 March, Classroom Video)

Caitlin's contribution justified why Oscar's claim was unreasonable. The teacher guided the conversation through questioning to expose a need for evidence. In contrast, she could have chosen to tell the students they needed evidence, but this would likely have been less effective. In the next lesson, the teacher asked students to share their interim findings with the class. She recapped observations of students whose invented recordings demonstrated effective and less effective examples for the class to discuss. Jasper was the second student who shared.

Figure 1: Section of Jasper's data recording of how many children in the class have blue eyes.

Mrs Louarn:	Yesterday we were talking about eye colour, some people were really clever and they drew a picture of their eyes. … Jasper can you come out and show us what you've been up to with this? Just to remind everybody and give us some ideas. So Jasper tell us your, I can see lots of blue eyes that you have drawn there.
Jasper:	This is how many blue eyes I counted. ...
Mrs Louarn:	Yes, and how many people do have blue eyes? (Jasper looks to the class and starts counting.) Well, which do you think is going to help you most? Counting the children here [in the class] or counting here [on your recording]? What will be most useful for you? (Jasper points to his drawing, Figure 1.) Do you think? (Jasper nods) Well, tell us how you are going to do that.
Jasper:	9 (Jasper counts the blue eyes on his page.) (2:43, 26 March)

Jasper's example gave the teacher an opportunity to privilege his representation of the data above unrecorded counting. The representation was a sharable artefact that provided stronger evidence of his claim that there were 9 children with blue eyes. Jasper didn't yet see his representation as evidence for his count, as he defaulted to counting the children directly rather than counting the eyes in his drawing. By encouraging him to count the eyes on the page, the teacher was scaffolding the class to reference to the data (representation) as evidence.

Over the two lessons, the children moved from drawing themselves literally with their own eye colour, towards drawing one or two children with their eye colours and extraneous details (hair colour, etc). Some children drew a pair of eyes rather than a full face and this idea was adopted by peers. In each iteration of discussion, new innovations emerged that were more efficient. The literal representations became less common, with more children's drawings leaving behind irrelevant information. Jasper introduced a new innovation: one eye per person rather than one pair of eyes.

Mrs Louarn:	So you have counted 9 eyes. Is there one eye for one person?
Jasper:	Yes.
Mrs Louarn:	Alright so you-. Look what Jasper's done. This is a great idea, he's drawn a coloured eye for each person. So is that how many blue eyes we have in the class Jasper? Is it 9 or do you think it might be more than that? Oh, Cassia's saying 'no'.
Cassia:	It's more.
Mrs Louarn:	It's more? So how many do you think, Cassia?
Cassia	I don't know but it's actually, you don't have one eye for each [person]. (3:58)

Jasper's representation was more sophisticated than some drawings, which were literal (full face drawn with eyes coloured with appropriate eye colour). Other children began to realise that they could draw a pair of eyes to represent each person, but Jasper's drawing went further—representing a single person with one eye. Cassia challenged Jasper's representation because she was expecting 9 people to be represented by 9 pairs of eyes ("you don't have one eye for each [person]"), which is how she had represented her data. Jasper could respond to Cassia and explain why he drew only one eye for each person. These sharing sessions provided an opportunity for the children to be exposed to increasingly more sophisticated representations designed by their peers.

Simplifying the representations, making them more efficient and representative, demonstrated that the children became more focused on evidence that helped them answer the question. Irrelevant information, extraneous representations, and repetitive symbols were abandoned.

CONCLUSION

Statistical inquiry goes beyond statistical content to incorporate investigation processes, ways of thinking, interrogation and disposition (Wild & Pfannkuch, 1999). Given a relatable context and an appropriate classroom environment, children are able to explore powerful statistical ideas that are usually only introduced formally at an older age (e.g., data collection and representations). For young children, data as evidence involves a number of related ideas. Counting, one-to-one correspondence, recording, representation, veracity and common understanding of a number (count) are all aspects of data sense that are accessible to young children. The strong language-based nature of inquiry, with its inherent interaction among students and teacher, create a positive attitude towards statistics learning. Young children can access powerful statistical ideas and develop norms of statistical inquiry through meaningful problem contexts. The excerpts presented in this paper illustrate how an early years classroom used statistical inquiry to introduce complex statistical ideas informally. Over time, these experiences can provide a strong foundation for when formal statistics are later introduced.

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