

Chapter 11

Statistical Literacy in the Elementary School: Opportunities for Problem Posing

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Abstract This chapter addresses opportunities for problem posing in developing young children’s statistical literacy, with a focus on student-directed investigations. Although the notion of problem posing has broadened in recent years, there nevertheless remains limited research on how problem posing can be integrated within the regular mathematics curriculum, especially in the areas of statistics and probability. The chapter first reviews briefly aspects of problem posing that have featured in the literature over the years. Consideration is next given to the importance of developing children’s statistical literacy in which problem posing is an inherent feature. Some findings from a school playground investigation conducted in four, fourth-grade classes illustrate the different ways in which children posed investigative questions, how they made predictions about their outcomes and compared these with their findings, and the ways in which they chose to represent their findings.

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Introduction

Problem posing has featured in the literature for several decades now, as indicated in Stoyanova and Ellerton's (1996) review of earlier studies on the topic. As far back as 1945, Duncker considered problem posing as the creation of a new problem or a reformulation of an existing problem, a perspective that has been foundational in subsequent studies (e.g., Silver, 1994). Over time, the notion of problem posing has broadened to include its relationship with problem solving, students' strategies in posing problems, how teachers might facilitate a problem-posing classroom, and how problem posing can contribute to students' conceptual development (e.g., Cai et al., 2012; Ellerton, 1986; English, 1997, 1998; English, Fox, & Watters, 2005; Kilpatrick, 1987; Silver & Cai, 1996; Stoyanova & Ellerton, 1996). This chapter begins with a brief overview of some of these perspectives, and then considers how problem posing can play an important role in developing children's statistical literacy.

Perspectives on Problem Posing

In reviewing the literature on problem posing, both Stoyanova and Ellerton (1996) and English (1997) lamented that the potential of problem posing for developing students' understanding of mathematics had been hindered by the lack of suitable frameworks, ones that link problem posing and problem solving within the regular curriculum. In addressing this still timely concern, Stoyanova and Ellerton (1996) developed a framework comprising three forms of problem-posing situations, namely, *free*, *semi-structured*, and *structured*. In the first situation, students generate a problem from a contrived or naturalistic situation presented to them. In the semi-structured form, students explore the structure of an open situation and complete it by applying existing mathematical knowledge, concepts, and relationships. The last category, which appears less broad, involves problem-posing activities based on a specific problem.

The core assumptions of Stoyanova and Ellerton's (1996) framework are still pertinent and warrant further attention in research on problem posing. These include the importance of problem-posing situations corresponding to, and arising naturally out of, students' classroom mathematics activities, and problem posing being a part

of students' problem-solving experiences. The framework of English (1997) adopted a complementary set of features for facilitating problem posing, namely, the importance of children recognizing and utilizing problem structures, the need to consider students' perceptions of and preferences for different problem types, and a focus on developing their diverse mathematical thinking.

Although different, both frameworks highlight the importance of linking problem solving and problem posing within the course of conceptual development. There have been several studies investigating relationships between problem solving and problem posing, with findings suggesting a strong correlation between the two; the focus, however, has mainly been on the nature and complexity of the mathematical problems generated by problem solvers of varying capabilities (e.g., Cai et al., 2012; Cai & Hwang, 2002; Ellerton, 1986; Kilpatrick, 1987; Silver & Cai, 1996). Furthermore, a good deal of the research to date has targeted the posing of problems in response to a specific goal or stimulus (e.g., cultural artefacts; Bonotto, 2012), the posing of real-world scenarios upon solving given problems (e.g., Cai et al., 2012), and the reformulating/extending of existing problems (e.g., Brown & Walter, 2005). As we indicate in this chapter, our approach to problem posing differs from these studies and aligns with Stoyanova and Ellerton's (1996) definition of problem posing, namely, "the process by which, on the basis of mathematical experience, students construct personal interpretations of concrete situations and formulate them as meaningful mathematical problems" (p. 518). They deliberately broadened their definition of problem posing to enable it to fall within the goals of mathematics curricula.

Prior to addressing our approach to problem posing from this perspective, it is worth noting the work of Pittalis, Constantinou, Mousoulides, and Pitta-Pantazi (2004). They produced a structural model for cognitive processes incorporating the major constructs of:

filtering quantitative information, translating quantitative information from one form to another, comprehending and organizing quantitative information by giving it meaning or creating relations between provided information, and editing quantitative information from given stimulus (pp. 51–52).

Pittalis et al. restricted their cognitive processes model to specific types of problem-posing tasks. Editing quantitative information is primarily concerned with tasks that require students to pose a problem without restriction from the provided stimulus. In tasks that require the filtering of quantitative information, students pose problems or questions that are appropriate to given, specified answers. Such answers provide a restriction, which makes filtering more demanding than editing. Posing problems from mathematical equations or computations requires comprehending the structural context of the problem and the relations between the given information. Translating requires students to pose problems or questions from diagrams, graphs, or tables. The findings of their study suggested that, although all four processes contributed to problem-posing competence, the filtering of important and critical information and problem editing play a stronger role than comprehending structural relations in quantitative information and translating this from one mode to another.

The authors thus concluded that students' competence in filtering and editing problems is strongly related to posing problems.

Despite the work that has been undertaken, problem posing remains a complex learning issue requiring a good deal more research (Kontorovich, Koichu, Leikin, & Berman, 2012), especially in underrepresented domains such as statistical literacy. In this chapter we expand the interest in problem posing in yet another direction by considering the opportunities afforded by the needs of statistical literacy in society and a school curriculum that now includes Statistics and Probability (e.g., Australian Curriculum, Assessment and Reporting Authority [ACARA], 2012; Common Core State Standards for Mathematics, 2010; <http://www.corestandards.org/the-standards/mathematics/>).

Statistical Literacy

Young students are very much a part of our data-driven society. They have daily exposure to the mass media where various displays of data and related reports can easily mystify or misinform, rather than inform, their minds. For students to become statistically literate citizens, they need to be introduced early to the powerful mathematical and scientific ideas and processes that underlie this literacy (e.g., Langrall, Mooney, Nisbet, & Jones, 2008; Whitin & Whitin, 2011). Numerous curriculum and policy documents have highlighted the importance of children working mathematically and scientifically in dealing with real-world data in the elementary school years (e.g., Curriculum Corporation, 2006; Franklin et al., 2007; National Council of Teachers of Mathematics, 2006). Limited attention however, is given to the statistical literacy that children need generally for decision-making in the twenty-first century. This is of substantial concern given that students need to make both personal and public decisions based on data when entering society beyond school (Watson, 2009).

Numerous definitions of statistical literacy abound (e.g., Gal, 2002; Watson, 2006). As used in this chapter, statistical literacy is viewed as “the meeting point” of statistics and probability and “the everyday world, where encounters involve unrehearsed contexts and spontaneous decision-making based on the ability to apply statistical tools, general contextual knowledge, and critical literacy skills” (Watson, 2006, p. 11).

Gal (2002) identified core requirements for statistical literacy in the wider society, the rudiments of which we argue need to commence in the younger school grades. These include the ability to “interpret and critically evaluate statistical information... and data-based arguments encountered in diverse contexts,” and the ability to “discuss or communicate their reactions to such statistical information.” Being able to communicate an understanding of what the information means and one's opinions on this, together with concerns about the acceptability of conclusions drawn are important aspects here.

An important, yet underrepresented component of statistical literacy is beginning inference, which includes the foundational components of variation, prediction, hypothesizing, and criticizing (Garfield & Ben-Zvi, 2007; Makar, Bakker, & Ben-Zvi, 2011; Shaughnessy, 2006; Watson, 2006). There has been little research on these components, including children's abilities to make predictions based on data. Children need experiences in drawing inferences from a range of statistical situations and representations including everyday events, raw data sets, graphs, and tables.

Although it is not expected that young students develop a sophisticated understanding of the components of informal inference, it is important that they gain an appreciation of the nature of the statistical process as they answer questions of relevance to them (Watson, 2009). In answering their questions, however, adequate evidence (data) needs to be collected and conclusions drawn with a stated degree of uncertainty that reflects the nature of the investigation and the evidence. If children are not exposed to these various facets of statistical literacy in the elementary school, the introduction of formal statistical tests in the late secondary school can become a meaningless experience because students will not have developed an intuition about the stories conveyed by the data.

Problem Posing and Statistical Investigations

As noted above, a key aspect of these early experiences in statistical literacy is undertaking investigations (Curcio, 2010). Problem posing is an inherent feature of such experiences, especially given that any situation involving problem posing incorporates a certain degree of uncertainty (Kontorovich et al., 2012). Accompanying this uncertainty is the need for critical analysis, a core component of problem posing that requires further attention in the classroom. Indeed, statistically literate citizens faced with making their own judgements on media and other reports need to be critical consumers of information.

The end point of statistical investigations is an inference, or decision, based on the evidence analyzed using available tools. Statistical literacy requires consumers of public reports based on these investigations to judge the inferences claimed within them. Without gaining experience through conducting their own investigations and understanding the uncertainty with which they reach their conclusions (informal as they will be), students will not gain the understanding to judge other claims they meet later. To illustrate further the role of problem posing in statistical investigations, we give consideration to the model presented by Watson (2009).

The model in Figure 11.1 begins with a statistical question. Such questions must be more refined and succinct than the general inquiries students initially pose. That is, their statistical questions must be unambiguous and enable the collection of manageable data to answer their queries of interest. As in all problem posing, there needs to be a context within which a question or problem can be posed. A context might entail, for example, global warming, or road fatalities, or national testing of school students. Whatever the context, skill is needed in posing the question to be

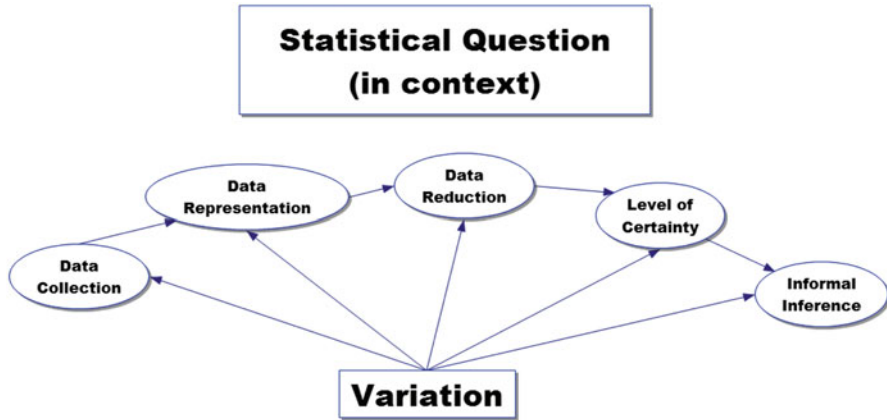


Figure 11.1. Stages of a statistical investigation (adapted from Watson, 2009).

asked through the statistical investigation (English, 2013a; Whitin & Whitin, 2011). Often, however, students are *given* the question to explore in an investigation. In contrast, statistically literate adults must be able to pose their own questions or query those of others. Understanding the relationship of samples and populations, and the uncertainty associated with any conclusion drawn about a population from a limited sample, is essential in posing the question to investigate. Giving school students the opportunity to create their own questions to explore and answer is a stepping stone to statistical literacy.

Following the posing of a statistical question, the stages of a typical investigation, as shown in Figure 11.1, provide other opportunities to pose “problems” in the sense of posing methods from which to choose to collect data, represent data, and reduce data to summary form. The presence of underlying variation in all statistical investigations influences the posing of methods appropriate to the context and to the type of data that are collected. This is likely to be a very open-ended process. The inference that is made at the end of a statistical investigation answering the posed question is constrained to some extent by the choices made during the investigation and is usually stated with a level of confidence in the inference, which may be stated as a chance.

In the present case, we were concerned with elementary school children posing their own questions and response options in undertaking an investigation within a meaningful and appealing context. Although all stages of a statistical investigation shown in Figure 11.1 are essential to students’ development of statistical literacy, we concentrate our discussion here on beginning inference. In particular, we consider students’ responses in predicting the outcomes of the questions they posed and comparing their predictions with their findings. An open-ended process in which the students chose their own forms of representations to display their findings completed the activity.

We focus specifically on prediction given that one of the core goals of statistics education is to assist students in making predictions that have a high probability of

being correct or at least judging what this likelihood might be (Watson, 2007). As Watson emphasizes, many aspects of the mathematics curriculum caution against making predictions without certainty. Beyond the classroom, however, students are often confronted with problematic situations where decisions regarding several alternatives may appear reasonable. Again, critical thinking comes to the fore when students are asked to make a prediction because they must take into account all of the perspectives available in the statistical context.

Investigating the School Playground

The investigative activity addressed here was a replication of one conducted the previous year with third-grade students in the final year of a 3-year, longitudinal project on data modelling (e.g., English, 2013b). The present activity, implemented with fourth-grade students at a different school, served as a benchmark for the impending implementation of a new 3-year longitudinal project on beginning inference.

Although four, fourth-grade classes and one combined fourth/fifth-grade class completed the investigative activity, we report on the responses of the fourth-grade classes only ($n=81$, students with permission for their work to be included).

The activity comprised two components, namely, creating a survey and then implementing it within the classroom. The context of the investigation was exploring playgrounds, with a focus on the school's playing area. The class teachers implemented the first component in one lesson of 1.5 hours duration, with the second component in one, 2 hour lesson. The lessons were conducted on consecutive days, using lesson plan booklets developed to guide the implementation. A highly experienced senior research assistant met with the teachers initially, and subsequently monitored the activity implementation across all classes. The core learnings targeted included: posing and refining of questions; identifying, deciding on, and measuring attributes; developing and conducting a survey; collecting and recording data; organizing, interpreting, analyzing and representing data; and developing data-based explanations, arguments, inferences, and predictions.

The activity was introduced by discussing photographs of varied playgrounds from around the world, including those in underdeveloped countries as well as in Australian cities and outback regions. Students then reflected on their favorite neighborhood playground or park and offered reasons for their enjoyment in these areas. Within this context, the students were invited to find out more about their peers' thoughts on playgrounds, in particular, their own school playing area. The creation of a survey was subsequently discussed, with students offering some possible questions they might ask their peers. These suggestions served as examples only, with the students to pose their own survey questions.

The challenging aspect for students (of all ages) in designing a survey is turning their general inquiries into statistical questions. As noted previously, these questions must be clear to the respondent and enable the collection of manageable data

to answer their queries. For fourth-grade students, the discussion focused on multiple-choice questions with four options for responses. Students worked in groups of about four, each first posing a question with corresponding response options. All students in each group then answered their group's survey, choosing one response option for each question, an example of which appears in Figure 11.2.

Q1 Where is your favorite part of the whole of the senior playground?	Answer the stuck up pole to us people on to climb to the top	Answer the ladder for playing off ground taggy	Answer The part where it's hard to hike a seat	Answer The part of the wobbly bridge
Q2 How long do you play for on second break?	Answer Whole break	Answer half of the second break	Answer A third of the break	Answer A quarter of the break
Q3 What is your favorite thing to play in the playground?	Answer Tag	Answer Ofground Tag	Answer Hide and seek.	Answer ghost Hunter
Q4 Why do you like the playground?	Answer because we can play games	Answer because there is equipment	Answer there is my friend go there	Answer close to the eating area

Figure 11.2. Example of one group's initial survey.

Each group then selected one of their group's questions to be the focus question for the remaining groups in the class to answer and also made a prediction of how this question would be answered. The groups' focus questions were copied, collated as a booklet, and distributed to all groups. Each student in the class then responded to all the focus questions within the class. A whole class discussion on ways in which the students might deal with their data then took place, but no specific direction was provided. The student groups subsequently collated their data, examined their findings, and compared these with their predictions. Finally, each group developed its own representation for displaying its findings; if time permitted, the groups were encouraged to complete more than one representation. A range of recording materials was provided for the representations, including blank chart sheets, lined paper, 2.5 cm squared grid paper, a sheet displaying a circle, and another with unmarked axes. The students were not directed to use any one recording format, however.

All student responses were recorded in their booklets (20 groups), and combined with their representations, served as the basis of our data analysis. We report here some findings from across the four classes, with a focus on (a) the types of question posed, (b) the basis on which students made their predictions for their focus question outcomes, (c) students' comparisons of their predictions with their findings, and (d) the representational forms students chose to convey their findings.

Posing Questions About the School Playground

The initial questions posed by students in each group were analyzed in terms of the type of query and the variation in the number of types suggested by groups. The question types included asking *why*, *what*, *how*, *which*, *where*, *when*, and *if*. Of the 20 groups, 9 posed three or four different types of questions, 10 created two types, and 1 group, just one type. Examples of these question types, with corresponding multiple-choice response options, appear in Table 11.1. It is interesting to note the inclusion of the conditional, *if*, which appeared in eight groups' questions, with three of these groups including two different question types.

Table 11.1
Examples of Survey Questions Posed

Question type	Examples of questions and response options
Why	<i>Why do you like to play in the playground?</i> Fun; Cheerful; Exciting; Amazing
What	<i>What can we add to make the playground a better place to play?</i> Giant Slide; Monkey Bars; Huge Rock Climbing Wall; Small Water Sprays
How	<i>How would you rate the playground?</i> OK; Bad; Good; Excellent
Which	<i>Which playground equipment would you spend the most time on?</i> The Spinner; The Nest; The Twisted Spider Web; The Ladder
When	<i>How do you feel when you go back to class?</i> Exhausted; Sad; Sweaty; Hot
If/what/where	<i>If the P&C had \$1,000 to spend, what would you do to the playground?</i> Improve safety for the playground; make the slide 4.5 meters; get noughts and crosses; Get a longer flying fox <i>If the school built a new playground, where would you put it?</i> Oval; Grassy Patch; G block (year 1 area); Behind B block (bottom of back stairs)

Making Predictions

In analyzing the students' predictions of how their peers might answer their chosen focus question, we first noted that all student groups in one of the classes made a quantitative prediction that encompassed all four multiple-choice options for the question. For example, in predicting their peers' response to the question listed in Table 11.1, "If the P&C had \$1,000, what would you do to the playground?" one group stated, "3 will improve safety, 7 will make the slide 4.5 meters, 3 will get noughts and crosses, 13 will get a longer flying fox." A response of this nature contrasted with the group predictions in the remaining classes, where 12 groups chose only one "most popular" option and three groups selected two possibilities.

Our data collection did not reveal whether the teacher whose students gave quantitative predictions directed the students to do so; such a direction was not provided in the teacher guidelines. This particular teacher, however, strongly encouraged detailed responses in all her students' work, and these did provide greater insights into the students' predictions of the option outcomes.

Analysis of the bases for the students' predictions yielded five categories, namely, those based on: (a) students' personal preferences and assumptions; (b) their observations of what takes place in the playground, such as how long peers spend on items of equipment or the most popular item; (c) students' factual, personal knowledge of the playground equipment/structure; (d) students' assumptions about their peers' preferences/perspectives; and (e) students' informal notion of probability, such as the unlikelihood of an event occurring or of a particular piece of equipment appearing in a school playground. Six groups made predictions that combined two of these categories.

The most common basis for prediction was the students' personal preferences and assumptions, with over half of all the groups displaying this reason (category (a)). For example, one group reasoned that their focus question, "What is your favorite part of the playground?" would be answered as follows: "The flying fox is quick to get around, while the monkey bars need strength, which some children don't have and you can get blisters on your hands which gets annoying. The spider tunnel we think will be the second most popular because it's cool, has a great view, and [you] can quickly escape from someone when playing tiggy."

The next most common prediction base, offered by five groups, was observation of what happens in the playground area (category (b)). One such group based their prediction for their focus question, "Which game would you play in the playground?" on their observation that, "We see that [children] play lots of off-ground tiggy. We do not see anyone play hide and seek; only a few people play hand games, and quite a lot of people play tiggy."

Four groups based their predictions on factual, personal knowledge of the playground (category (c)). One of these groups also included assumptions about their peers' preferences (category (d)). For their focus question, "If the P&C had \$1,000, what would you do to the playground?" (Table 11.1), the group justified their prediction on the basis that, "People like to play on flying foxes. There is a lot of safety in our playground. Our slide is quite short so people want to make it much longer so people can have a longer ride and have more fun."

Only two groups used an informal notion of probability as a basis of their predictions (category (e)). One of these groups, who asked, "If you could add one thing, what would you add?" predicted that "The most popular would be the trampoline," because "We have never heard of a school with trampolines."

Comparing Predictions with Findings

The students' comparisons of their predictions with their findings mostly stated that they matched or otherwise, with the predictions and outcomes cited in their written responses. For example, the group that asked, "What is your favorite part of

the playground?” stated that “The flying fox was quite correct, whereas the monkey bars got exactly 5, and rock wall we got 5, said it was 1–2, and spider tunnel was 6, and we said 6–7.” It was disappointing that only one group offered a substantial justification in their comparisons. The group that posed the focus question, “What would you improve in the playground if you had \$50,000?” predicted that “10 will choose the oval, 7 the spider web, 3 the slide, 3 the flying fox.” In making their comparison, the group explained, “We found that a few of our predictions were off track and unfortunately made our predictions wrong. Here are our results: flying fox 8, slide 2, spider web 6, oval upgrade 10. A couple were off track because our decisions were based on what we see at play time but on the day of the vote, people [students] had not voted according to what we saw, making our predictions incorrect.”

Posing Ways of Representing Findings

As noted, the students were to decide on their own ways of representing their findings and had no specific instructions. Three of the four classes completed the second activity component in the allotted 2 hours, while the teacher of the remaining class chose to allow her class extra time. Consequently, her students created a greater range of representations. One of the other classes who did not have extended time, however, also generated multiple, varied representations. Of the 50 completed representations generated by all groups, vertical bar graphs were the most common, with 50% of the representations being of this nature. There was considerable variation in the nature of these graphs, with some groups using the 2.5 cm grid paper, others creating their own grid paper, and a few drawing their own set of labelled axes.

The popular use of these bar graphs suggests that the students were not given adequate opportunities to pose their own forms of representations in their earlier school years, reflecting standard curriculum recommendations. For example, in the Australian Curriculum: Mathematics, “column” graphs, the equivalent term for vertical bar graphs, are mentioned at all grades from third to sixth (ACARA, 2012, pp. 29, 33, 38, 44). This finding contrasts with that of the previous longitudinal study across grades 1–3, where children displayed a rich repertoire of representational forms following experiences in generating their own means to display their data (e.g., English, 2013a, 2013b). Nevertheless, there were creative representations from the remaining groups, with seven vertical dot plots, three horizontal bar graphs, and three line graphs produced. The vertical dot plots, an example of which appears in Figure 11.3, were interesting variations of the traditional bar graph and foreshadowed, in part, our subsequent implementation of the *TinkerPlots* software program in the new project (Konold & Miller, 2011).

On one hand, the creation of only three horizontal bar graphs and three line graphs again seems to reflect the apparent limited opportunities for posing diverse representations in the early school years. On the other hand, the use of lists and tallies by 24% of the groups did display interesting and diverse approaches to collating

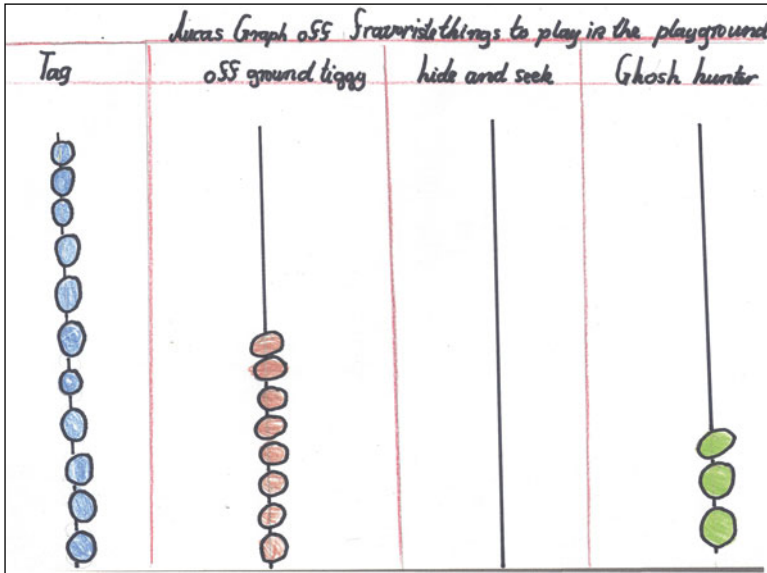


Figure 11.3. A vertical dot [Graph of favourite things to play in the playground: Tag, Off-ground tigg, Hide and seek, Ghost hunter].

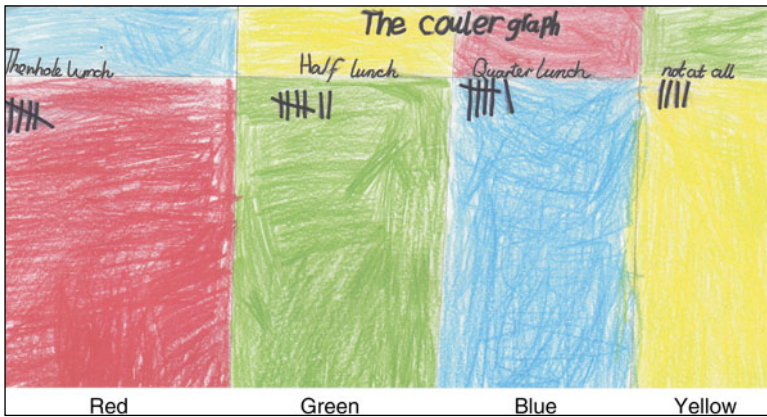


Figure 11.4. Structured tallies representation.

and representing data. An example of one group’s creation appears in Figure 11.4. This group’s representation displayed their findings for their focus question, “How long do you play in the playground?” predicting that “Most will play for a quarter of the lunch break,” because “Most people get a bit bored because there [sic] so use [sic] to the playground,” the group’s representation supported their conclusion,

namely, “We thought that most people would spend a quarter of there [*sic*] time in the play ground... BUT most people spend half of there [*sic*] time.”

Discussion and Concluding Points

In relation to the previous research on problem posing, this study illustrates the rich potential of statistical literacy as a context for the extended development of problem-posing skills. As well, it provides a motivation for those who have been working within more narrow definitions of problem posing, to extend their research into this emerging area of the mathematics curriculum.

With respect to Stoyanova and Ellerton’s (1996) framework with three forms of problem-posing situations, this study fits the semi-structured form in that students explored the structure of an open situation related to their school’s playground and completed it by posing questions and applying their existing knowledge of survey construction, administration, analysis, and representation of outcomes. The examples of semi-structured situations given by Stoyanova and Ellerton were related to incorporating unfinished structures while posing problems or posing sequences of interconnected problems, using content in geometry, arithmetic, and algebra. In this study, the unfinished structures arose from the need to pose questions and alternative response options that would make up a reasonable survey for the class. Going further, the students were required to connect the survey construction with the other aspects of the investigation, including prediction of results, analysis of data collected, and presentation of their results visually.

Turning to the complementary framework of English (1997), all three of her features for facilitating problem posing were present in this study. The importance of children recognizing and utilizing problem structures was clearly seen as students worked creatively and critically with the format of writing a meaningful and understandable question with four multiple-choice options. The need to consider students’ perceptions of and preferences for different problem types was shown in the various types of questions posed for the survey, recognizing the potential difference in responses to “how” and “when” questions and the power of “if” to set a conditional question. Different types of graphs were also considered when suggesting a method of displaying the groups’ results. Finally, the opportunity to develop diverse statistical thinking arose throughout the investigation, but particularly in the reporting of the results and visual justification.

The work of Pittalis et al. (2004) in developing a structural model for cognitive processes contributing to problem-posing competence is also relevant to the outcomes in this study, although their research focused primarily on quantitative examples. Their four major constructs of filtering, translating, comprehending, and editing were all observed during the investigations carried out by students in this study. Although we did not quantify the impact of the four constructs, constant reminders of all were present throughout. Comprehending was required and took

place from the start when students had the context set with pictures of playgrounds from around the world; further at each stage of the investigation it was necessary to comprehend the posing task required. Translating took place, not only from the beginning in interpreting the questions of others in the group, but also in the tasks of representing the results of the analysis in pictorial/graphical form. Filtering was particularly evident when students were choosing the focus questions for each group to contribute to the class survey. Much discussion took place on clarity. Editing was related not only to filtering in the development of the survey items, but also to the production of the final representation of results. As these constructs of Pittalis et al. appear foundational to statistical investigations as well as to problem posing, they support the contention of the potential to make an explicit link between the two important aspects of mathematical learning.

Besides presenting content under the three headings of Number and Algebra, Measurement and Geometry, and Statistics and Probability, *The Australian Curriculum: Mathematics* (ACARA, 2012) requires four proficiencies to be developed alongside the content. These are *Understanding*, *Fluency*, *Problem Solving*, and *Reasoning*. The four constructs of Pittalis et al. (2004) make contributions to each of these proficiencies and problem posing itself is a part of *Problem Solving* (called “problem formulating”). Comprehending links directly to *Understanding*, and translating, filtering, and editing are necessary for success with all proficiencies. Referring to Figure 11.1, any complete statistical investigation also utilizes the four proficiencies, as illustrated by the work of the students in this study. Again the strength of the association between problem posing and carrying out a statistical investigation is shown through the proficiencies in the Australian curriculum and should encourage both researchers and teachers to explore further the power to move students to creative and critical thinking. This is the type of experience that will give students the confidence to pose questions of statistical literacy when they meet suspicious data-driven claims when they leave school (or even before).

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