‘I GET IT NOW!’ STIMULATING INSIGHTS ABOUT PROBABILITY THROUGH TALK AND TECHNOLOGY

Sibel Kazak, Rupert Wegerif, andTaro Fujita explore the use of a computer simulation tool in an after-school programme of lessons

To play the game, you will select a chip from each bag. If the chips are the same, you will win. If they are different, the teacher will win.

Bag one: 4 red chips.

Bag two: 2 red chips, 2 blue chips

A pair of 11 year-old students were deciding whether the game was fair, or not. Both were initially quite certain that the game was unfair because of the first bag with 100% red chips.

C: *Bag two is fair. Bag one is all red chips. It is impossible to pick out a blue chip from there. It is all made up of red chips.*

J: *If I took out a guess here, I’d probably say, uh [pause], about, probably about 70% we would win, about 40% Taro [Taro was one of the teachers].*

After modeling the game in *TinkerPlots,* and running 1000 repetitions of the game - something that *TinkerPlots* can do instantly, the students completely change their view.

In this article we will describe how this computer simulation tool, and the way in which learners talked together helped them realize that the game was not fair and, at the same time, learn about probability.

Background

Probability is a difficult topic to teach because the answers are often counterintuitive (Murphy, Terrizzi, & Cormas, 2012). With our approach, we consider that students not only overcome their difficulties in understanding probability, but they can also investigate their reasoning about uncertain outcomes.

In the current research we study how the combination of technological tools and peer-to-peer dialogic interactions supports students’ conceptual understanding in data handling and probability. Our aim is to investigate the relationship between students’ talk together, their use of ICT tools, and their development of conceptual understanding of key concepts in statistics and probability.

We conduct our research in an after-school program for Year 7 students in Exeter once a week for an hour in the spring and summer terms. During the after-school program students have engaged in analysing various data sets, including reaction times, backpack weights, and data modeling tasks through using *TinkerPlots 2.0* (Konold & Miller, 2011) software and working in pairs. In the eighth session of our after-school program students began to investigate chance events. The instructional approach involved iterations of making predictions, testing initial theory by collecting simulated data from their model built in *TinkerPlots*, exploring the sample space using a tree diagram to explain and formalize their expectations.

In addition to the use of *TinkerPlots* as an ICT tool to explore data and chance, the participants were taught a dialogic way of talking in group work (Dawes, Mercer, & Wegerif, 2004). More specifically, students were asked:

- to make sure that each person has an opportunity to contribute ideas,
- to ask each other why, to listen to the explanation, and to try to understand,
- to ask others what they think,
- to consider alternative ideas or methods, and
- to try to reach an agreement before they do anything on the computer.

Software

TinkerPlots 2.0 (Konold & Miller, 2011) is a distinct computer program compared to other graphing, or spreadsheet programs as it builds on the intuitive knowledge learners have about data representations and analysis. Students actually construct their own graphs when progressively organizing their data by ordering, stacking, and separating. *TinkerPlots* also includes a variety of tools, such as dividers and reference lines, to intuitively analyze data in making inferences. One of the new features in *version 2* is the probability simulation tool, see Figure 1 (overleaf), that expands its focus from data to incorporate probability. In Figure 1, a single mixer device is set to draw twice with 100 repetitions. The table next to it shows the results of each repetition as they are drawn.

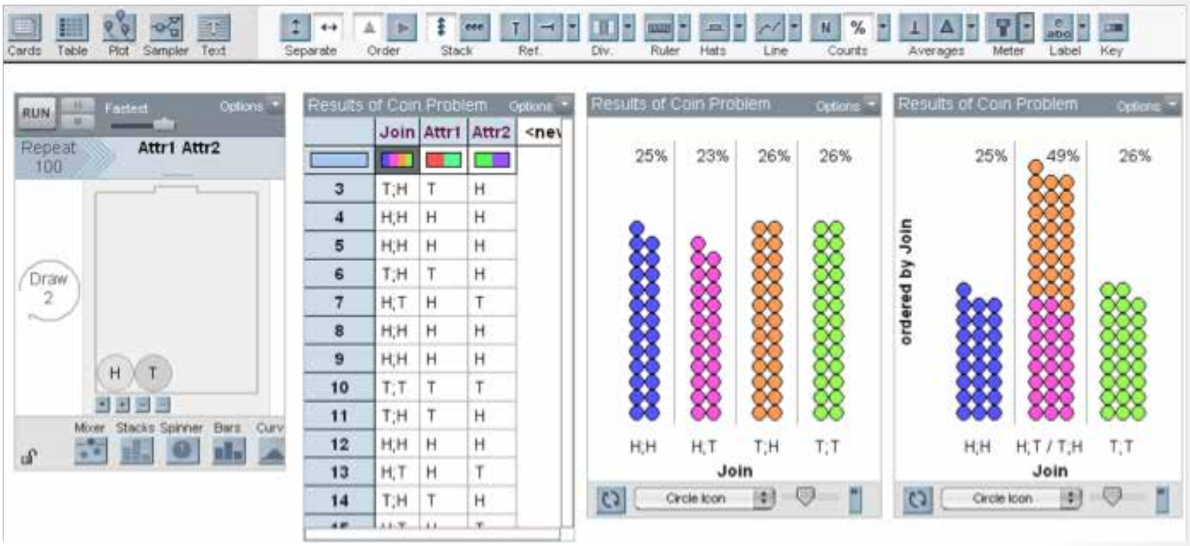

Figure 1. Model of flipping a coin twice in *TinkerPlots* and the outcomes in 100 trials.

The graph on the left-hand side displays the percentage of outcomes for each event. In the graph on the right-hand side, the two outcomes, HT and TH, are combined into a single bin by dragging one into the other.

Testing Conjectures in *TinkerPlots* and Dialogic Talk around Computer

We now focus on the episode introduced at the beginning of the article where two 11-year-old boys investigated their initial predictions about the fairness of a game.

Focusing on the single events in each bag, i.e., bag two is being fair because of the equal number of red and blue chips, while bag one contains only red chips and no blue ones. Chris believed that the game was certainly not fair. Jacob's estimate of chances of winning in the game also supports their idea that the game was in favor of them. Then they moved to building a model of the game in *TinkerPlots* to simulate the game, see Figure 2, with 1000 repetitions.

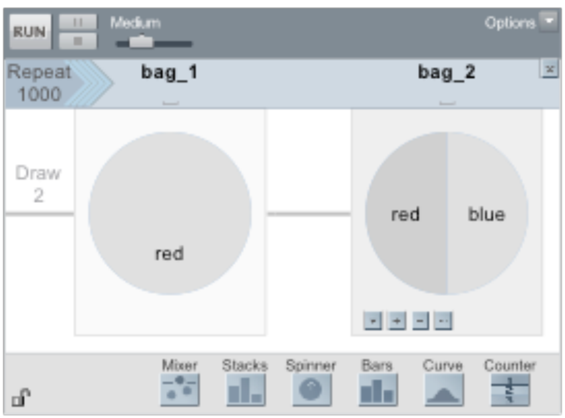

Figure 2.

Figure 2 shows the model of the game in *TinkerPlots*. The spinner on the left represents bag one with 100% red chips and the spinner on the right display the content of bag two, half of which are red chips and the other half blue.

In this task students chose to run their model 1000 times as they observed that the results closely resembled what they expected in the previous games by running successive simulations of playing the game 1000 times. This was a critical step in students' use of the technology tool in such a way as to support/ reject their initial theory based on the simulated data. It is clear in Figure 3 (see page 32) that if students in groups played this game in the classroom 20 times by drawing chips from the bags, they could get quite variable results which would make it difficult to question their initial theory about the fairness of the game.

The following exchange between the teacher [S] and the pupils happened just before they ran their model. Here we see an indication that Jacob is beginning to *see* the situation from another point of view as he expresses his current state of “*debating*” , like introducing new voices and perspectives in his mind.

S: *Okay and you think that you guys will win most of the time, huh?*

C: *I think we will actually win most of the time.*

J: *Actually, I am actually debating now* [while he presses the run button to collect 1000 data]

After they saw that the simulation results contradicted their initial predictions, they thought about it again.

J: *Oh yes, it is 50-50 because oh yeah!*

C: *Jeez, we got an entire army on our side!*

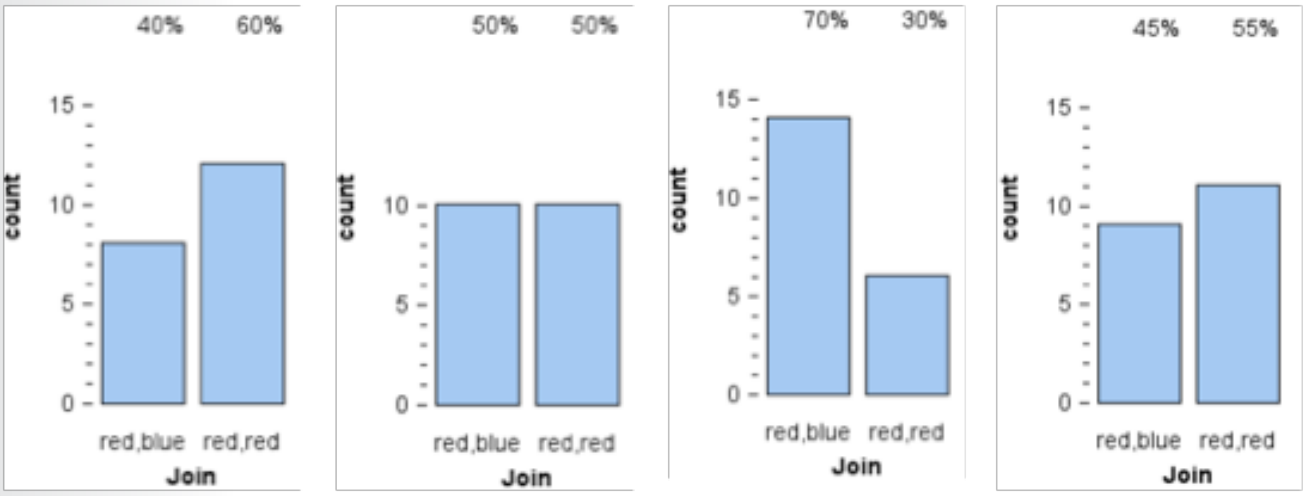

Figure 3. An example of the types of results obtained from running successive simulations of the game with small samples (n = 20).

J: *No no, Chris you don’t get it. The first one you always get 100% red*

C: *Exactly*

J: *Then the next*

C: *Then the next one you could get*

J *It’s a 50-50 chance of getting the same* [he is laughing and almost speechless]

C: *I don’t get it.*

J: *So basically the first time you will get a red, next time you got a 50-50 chance of getting the same or something different* [he is covering his face with his hands and laughing]

C: *I don’t get this at all. Why are you laughing? Jacob, why are you laughing? Just calm down.*

In the above exchange Jacob’s thinking seems to be a result of a dialogue with an absent witness (Wegerif, 2013). It was this reflection about why the results came out even, and looking at the game in a different way that led to a shift in his understanding of the chances in the game. However, the words he was uttering didn’t make sense to Chris. After his “*I don’t get this at all*” remark, Jacob tried to explain his idea by addressing him in this way:

J: [now talking to C] *First one you will definitely get a red, so the next one you would get either a red or a blue. So basically you can either get 50% you will get red*

C: *Red, yeah. So it is*

J: *50% you will get blue.*

C: *So it is 50-50.*

Discussion

We have described the trajectory of two students making conjectures about a chance event, testing and revising their theory based on data. We argue that their insight into the true probability of the situation was supported by their use of technology, and by their use of dialogic talk.

TinkerPlots played a significant role in this task by enabling students to build a model of the chance event, and to gather a large amount of data quickly to test their initial theories using dynamic, visual representations, and revising them. The results from large number of runs of the experiments conducted for them automatically by *TinkerPlots*, challenged their initial model and motivated them to think again. The model they had already built enabled them to break down their analysis into two stages which did not initially occur to them, i.e. theoretical possibility space for combined events, to see the draft Mathematics Programme of study for Key Stage 3 scan the red QR code on page 33.

The dialogic talk also helped these two students in several ways. They feel able to articulate all their thinking including half-baked or uncertain ideas. When Chris says to Jacob *“I don’t get it”* this shows a certain humility and trust. Jacob then manages to explain in a way which, with reference to the model on the screen, enables him to share his insight into the two-part structure of the problem.

Our dialogic approach in this after-school program encouraged students to ask for explanations because they began to feel that it is okay to admit that they don’t understand.

The way in which they helped each other is clear. Less obvious is the mechanism behind Jacob’s initial switch in perspective. We think that this switch is also dialogic, and it implies a hidden dialogue going on between Jacob and a projected ‘witness’ or ‘superaddressee’ looking at the situation as if from the outside and leading him to be able to question his initial view and change his mind (Wegerif, 2013).

Although this example appears specific to the learning of an aspect of probability, we think it has something more general to say about the role that the combination of technology and talk can play in helping students make large shifts forwards in their conceptual understanding.

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