THE EFFECTIVENESS OF USING A VIDEO-RECORDING TO REPRODUCE RANDOMLY GENERATED SEQUENCES IN PROBABILITY RESEARCH

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A composite class of grades 5 and 6 students observed a sequence of balls, drawn at random, from a box containing coloured balls. Students, unaware of the contents of the box, were required to predict the next colour drawn after a set sequence of draws. A video-recording was then made of a researcher drawing balls from a box which reproduced the identical colour pattern. This video was then shown to a group of students in a parallel class who were given the same prediction tasks. Qualitative and quantitative data indicated that no significant differences were found between groups in their predictions. Both groups gave a range of responses consistent with a variety of strategies, including clear examples of probabilistic reasoning. It was therefore concluded that the use of a video has the potential to be a useful tool into probability research.

A common tool of probability research is the random selection of balls from a bag or box; for example: Ayres, 1996; Fischbein, 1975; Hoemann and Ross, 1971; Shaughnessy, 1981; Truran, 1992; Way, 1996). By making a number of consecutive selections of coloured balls (of differing proportions) a random sequence of events can be generated which can be utilised to investigate various aspects of students' understanding of likelihood, including how particular sequences of outcomes effect their reasoning. Research into this aspect of probability is often in relation to misconceptions in adults, who tend to use inappropriate reasoning strategies such as *representativeness* and *availability* (Shaughnessy, 1981; Tversky and Kahnemann, 1982). However, random generators produce sequences which vary from trial to trial. Consequently the ability to test large groups of students with controlled variables is restricted. Although it is possible to reproduce such sequences using computers, it is anticipated that a video featuring people would represent a more realistic medium for children. This study investigated the effectiveness of a video-recording as a research tool.

SUBJECTS

Two parallel grade 5/6 composite classes from a comprehensive primary school in the state of New South Wales, Australia, participated in this experiment. The study was quasi-experimental in design as students were not randomly assigned to a group. One class consisting of 30 students (15 girls and 15 boys; with a mean age of 10.9 years) completed the study *live* and participated in the random selections. In contrast, the second group consisting of 23 students (9 girls and 14 boys; with a mean age of 11.4 years) were shown a *video-recording* of the selections. All students had been assigned to the two classes at the beginning of the school year and had different teachers. As no students had been formally taught chance or probability the potential effects of having different teachers may be small.

METHOD AND PROCEDURE

Phase 1 (Students observe a live sequence of random selections)

The first phase of the study was completed by the class with 30 students. Ten coloured table-tennis balls (6 orange, 3 white and 1 yellow) were placed in an opaque brightly-coloured box (18cm x 18cm x 14cm) with no lid. As an introductory instruction phase, a student was asked to select a ball from the box, show it to the rest of the class, before returning it to the box. The class were then asked to predict what colour would occur the next time a coloured ball was selected in this fashion. This procedure was repeated a couple of times, so that students became familiar with the idea of making predictions following a random selection. Following this instructional phase, the researcher walked around the class and invited different students to select a ball from the box. The box was positioned so that it was not possible to choose a particular colour. After each selection, the ball was returned to the box and its colour recorded on the whiteboard. The box was also shaken to ensure random outcomes. After the first four selections, students were asked to make a prediction. The experimenter used the following statement: "*What do you think the next colour will most likely be?"* The wording "most likely" was used to encourage students to make decisions based on their concepts of chance; however, it should be noted that children may interpret words, like "likely", differently to what is expected (Konold, 1991). Students were then given sufficient time to record their prediction on an answer sheet. This prediction procedure was then repeated for five cycles of five random selections. The whole sequence of thirty selections was recorded on the whiteboard as it unfolded (see Table 1).

Finally the students were shown the contents of the box and then asked to make a prediction prior to a final selection. This last task was designed to investigate how students would respond to knowing the colour proportions.

Table 1: Colour Outcomes (O = Orange, W = White, Y= Yellow)

O	Y	W	Y	<u>O</u>	W	O	W	O	<u>O</u>
W	O	W	O	<u>W</u>	O	O	O	O	<u>O</u>
Y	O	O	O	<u>O</u>	W	O	O	O	<u>O</u>

Note: The underlined colours indicate where predictions were made.

Phase 2 (Making a video-recording of the previous selection pattern)

In this phase a video recording was made of the colour sequence which occurred in phase 1. To duplicate this sequence the box used previously was fitted internally with three cardboard compartments which were only visible from above. Within each compartment was placed a ball so that the three colours were represented once only. In addition, the box was fitted with a false bottom in which seven balls were placed. Hence when the box was shaken, the noise was consistent with a box containing ten balls. Furthermore, the compartment design made it possible for a researcher to select a particular coloured ball at will, but give the appearance that the ball was selected at random. In this fashion, a researcher was able to make thirty selections from the box and reproduce the colour sequence of Table 1 exactly. To make a video, a researcher (positioned in front of a white board) was filmed making 30 selections from the box with replacement. As each selection was made, a second researcher recorded the colour on the whiteboard in a 6 x 5 array format. At all times the researcher making the selections and the box was visible, as was the record of the colours previously selected. In order to make the video as authentic-looking as possible, a clock was positioned close to the whiteboard to indicate a continuous time passage and avoid possible suspicions of video-splicing.

Before continuing the study with the second class of primary students the effectiveness of the video was trialed on pre-service teachers enrolled in primary and secondary mathematics method subjects. These students responded to the video as though the selections were random, and were genuinely surprised when told after the trial that the colour pattern had been artificially constructed.

Phase 3 (Students observe a video sequence of selections)

The final phase of the study was completed by the class with 23 students. Initially, the students were given a short instructional period identical to that outlined in phase 1. However, for the main part of the experiment the students were shown the video of the coloured ball selections rather than live participation in making the selections. A large TV monitor was positioned at the front of the classroom. After each selection a record of the colours was also recorded on the classroom chalkboard. When it was time for a prediction to be made, the video was stopped. The language used by the researcher was identical for both groups, as was the tasks that the students were required to complete. Following the prediction phase the class was interviewed as a group to assertion their reactions to the video.

RESULTS AND DISCUSSION

Qualitative data supporting video effectiveness

General observations by the researchers suggested that the students were quite comfortable with the use of the video and responded to the whole activity in the same relaxed and co-operative manner as the previous class. The class discussion lead by one of the researchers at the end of the session revealed that although the students were able to think of potential differences between live and video presentation of the experiment, they were thoroughly convinced of the video's authenticity. As can be seen from the extract of dialogue below, the students quite willingly provided some critical evaluation of the activity and some even considered the mathematical implications of videoing random events.

Experimental data supporting video effectiveness

For the final prediction, made after the content of the box was known, the live Group all predicted Orange balls; whereas the video group predicted all Oranges except for 3 whites and 1 yellow, indicating that most students have an understanding of likelihood when given the proportions in the same sample space. Analysis of individual student's responses in both group indicate a wide variety of strategies were adopted by both classes. Students from both groups make predictions consistent with probabilistic reasoning by selecting 3 or 4 oranges in the last four trials. In contrast, other student responses fluctuated considerably or employed strategies involving all yellows or a predominance of yellows and whites.

Extract of dialogue from end of session group interview
(Q. signifies a question posed by the researcher, A. signifies a response from a student)
Q. We did this activity with Mrs B's class, but didn't use the video, we just took the balls out of the box in front of the class. Is there any difference between these ways do you think?
A. Yes (A few students)
A. Live - you see each go really happening. The video - it's already been done, it's written up on the chart, and you can show it again. But live it could be different - you know - it's chance. (Trent)
Q. Which way do you think is better?
A. Live maybe.
Q. Why?
A. It'd be more fun, a little. (Jazz)
A. Doesn't matter. (Several students)
A. You could rig the video. (Angus)
Q. You mean make the colours come out the way you wanted?
A. Yes.
Q. How could you do that?
A. Umm....When you put your hand in and got a colour, if you wanted that colour again, you could hide it in your hand and pretend to get it again. (Angus)
A. You cut and paste, you know, change the way it happens. (Lachlan)
A. Or stop the recording and fix it how you want it. Maybe put all the same colour in the box so it would have to be that colour. (Cameron)
Q. Did you notice the clock in the video?
A. You could turn the clock back. (Catlin)
Q. You've thought of lots of ways that we could have rigged the tape to make the results come out a certain way, but do you think we did that? Is there anything about the video that makes you think we might have been trying to trick you?
A. No. (Most of class)
A. You wouldn't do that.
Q. Why not?
A. There's no need. Why would you want to?
A. You're too nice.
A. You wouldn't because it's supposed to be just chance. It's supposed to happen differently each time - so it wouldn't be a good maths activity if you controlled it. (Chantele)

To compare the two groups, a focus was made on the effects of the experimental outcomes. Students who had developed aspects of probabilistic reasoning might be expected to select a high percentage of Oranges. The mean number of Oranges selected were 2.9 and 2.5 for the Live and Video groups respectively. Overall both groups exhibited less than 50% predictions for Orange. However, it should be noted that after the first four colour selections the experimental probability of yellow occurring was 0.5, which is clearly not representative, but implies that Orange was not necessarily an informed choice at this stage. In contrast, by the 20th selection the experimental colour proportions were more representative of the actual proportions (O:W:Y = 58:32:11). To allow for the unfolding of more representative data, the mean number of Oranges chosen were calculated for the first and last three predictions made. For the Live Group, the means were 1.1 and 1.8 for the first and second halves respectively, compared with 0.9 and 1.6 for the Video group. One-tailed Wilcoxon signed-rank tests for matched pairs indicated a significant increase in choice of Orange during the second half for both the live Group ($T(21) = 36$, $p < 0.01$) and the Video Group ($T(19) = 37.5$, $p < 0.01$). Clearly, both groups have made substantial changes to their prediction patterns and have begun to favour the colour with the greatest likelihood of occurring. Further analysis of the last three predictions supports this argument, as 63% of the Live Group and 57% of the Video Group chose two or more Oranges.

In summary, the interviews and observations made indicate that the Video Group responded to the video in much the same way as the Live Group responded to the actual random selections. There were many similarities between the two groups in their predictions. Pattern analysis of individual students revealed that both groups contained students who indicated a variety of strategies. Some were influenced by experimental probability, some guessed in an apparent random fashion, while others chose the same colour repetitively. It is therefore concluded that the use of a video in the described fashion has the potential to be a useful tool into probability research.

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