David Copperfield's Orient Express Card Trick
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On Tuesday, 9 April 1991, a major television network spotlighted an hour-long evening special featuring illusions of the renowned magician David Copperfield. The program, titled "Mystery on the Orient Express," included a card trick in which viewers could participate. The card trick and its potential use in the mathematics classroom are the focus of this article.

Copperfield began his trick by showing the audience a close-up on the television screen of four cards representing four cars on the Orient Express: the shower car, the diner car, the club car, and the mail car. The audience was instructed to choose one of the cards on which to start the trick **(fig. 1).** To these four cards were then added an additional five cards (ostensibly to make Copperfield's feat more difficult) to form a 3 × 3 matrix of cards on the screen **(fig. 2a).** Of course, the magician could see only the backs of the cards and obviously could not see the choices made by the millions of viewers participating in the privacy of their homes.

Fig. 1
The initial four cards

Participants were given the following three general instructions: (1) Moves can be only up, down, right, or left on the matrix, (2) diagonal moves are illegal, and (3) the choice of each move is entirely up to the participant. Copperfield's trick then proceeded according to six sequential steps, with viewers starting on their chosen card.

THE TRICK

Step 1: Make four moves. Copperfield indicated that viewers could not then be on the staff card, so it was removed from the matrix **(fig. 2b).**

Step 2: Make five moves. Copperfield stated that since viewers could not have landed on the club card, it would be removed from the matrix **(fig. 2c).**

Step 3: Make two moves. Since viewers could not be on the mail card, it was removed from the matrix **(fig. 2d).**

Step 4: Make three moves. Since viewers could be on neither the baggage card nor the caboose card, those cards were removed **(fig. 2e).**

Step 5: Make three moves. Copperfield said that since many viewers had previously landed on the shower card, he would remove that card from the matrix **(fig. 2f).**

Step 6: Make one move. Copperfield correctly predicted that all viewers participating in the trick were then on the diner card.

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Readers might want to follow all the steps of the trick to verify that they end up on the diner card no matter what their choice of moves for each of the six steps. This trick served as a perfect transition to the climax of the hour-long special: Copperfield made a diner car from the Orient Express vanish while a group of people encircled the car.

Many of my students watched the program—in some instances, instead of doing their homework—and were intrigued that the trick had worked. Most recognized that it had a mathematical basis but were at a loss to prove why it worked. That evening I worked out the following proof, which I presented to all my classes from basic mathematics through calculus. Almost every student, without regard to mathematical level, understood the proof. Moreover, it whetted their appetites for more mathematical magic and gave them new insight into, and appreciation for, mathematical proof.

THE PROOF

Number the matrix of cards from 1 through 9 as shown in **figure 3.** Notice that a move upward subtracts 3, a move downward adds 3, a move to

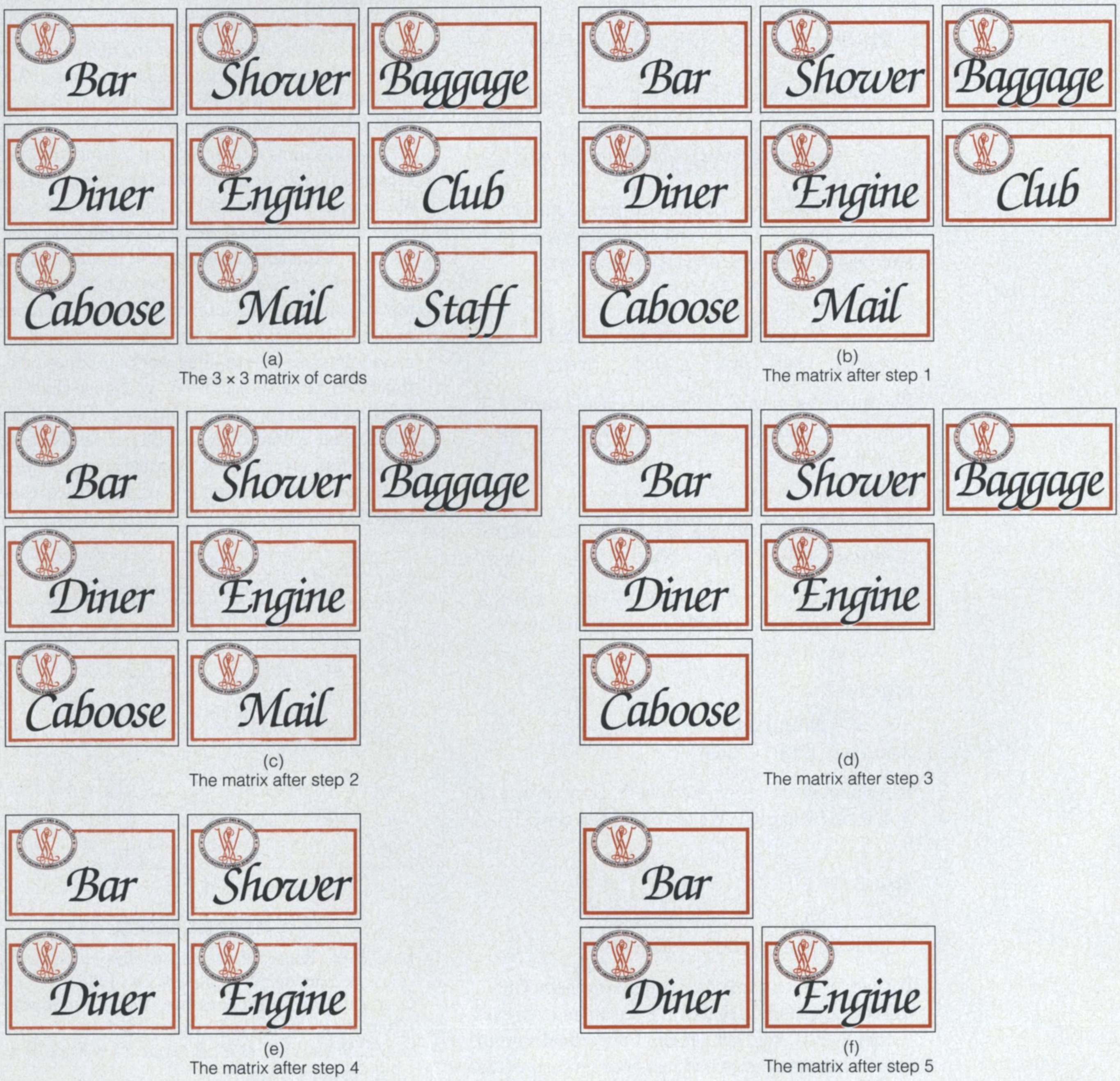

Fig. 2

More cards make the feat appear more difficult

the left subtracts 1, and a move to the right adds 1; therefore, each move adds or subtracts an odd number. Moreover, note that the card on which we start has an even number. Also, keep in mind that—

- an even number plus or minus an odd number results in an odd number and
- an odd number plus or minus an odd number results in an even number.

Therefore, successive moves must alternate between odd and even status.

BAR = 1	SHOWER = 2	BAGGAGE = 3
DINER = 4	ENGINE = 5	CLUB = 6
CABOOSE = 7	MAIL = 8	STAFF = 9

Fig. 3
Numbering the cards from 1 through 9

Proceed as follows: Start on an even number (shower, diner, club, or mail). Remember that each step begins where the previous step ended.

Step 1

	Move 1	Move 2	Move 3	Move 4
Location	Odd	Even	Odd	Even

We cannot be on card 9. Remove it. Only cards 1, 2, 3, 4, 5, 6, 7, and 8 are left. We are on an even card (2, 4, 6, or 8).

Step 2

	Move 1	Move 2	Move 3	Move 4	Move 5
Location	Odd	Even	Odd	Even	Odd

We cannot be on card 6. Remove it. Only cards 1, 2, 3, 4, 5, 7, and 8 are left. We are on an odd card (1, 3, 5, or 7).

Step 3

	Move 1	Move 2
Location	Even	Odd

We cannot be on card 8. Remove it. Only cards 1, 2, 3, 4, 5, and 7 are left. We are on an odd card (1, 3, 5, or 7).

Step 4

	Move 1	Move 2	Move 3
Location	Even	Odd	Even

We cannot be on cards 3 or 7. Remove them. Only cards 1, 2, 4, and 5 are left. We are on an even card (either 2 or 4). For that reason, Copperfield says in step 5 that many of us had just been on card 2 (the shower); theoretically, 50 percent of us are on card 2 at the end of step 4.

Step 5

	Move 1	Move 2	Move 3
Location	Odd	Even	Odd

We cannot be on card 2. Remove it. Only cards 1, 4, and 5 are left. We are an odd card (1 or 5).

Step 6

	Move 1
Location	Even

We cannot be on cards 1 or 5. Remove them. Therefore, we must be on card 4, the diner card, as Copperfield predicted! See **table 1** for a summary of the proof.

Interested readers and their students might want to investigate what happens to the proof when different numbering schemes are used for the 3 × 3 matrix. Also, are any other methods possible for accomplishing the proof?

This reasoning was satisfying to students and required no more than elementary number theory. Mathematical magic tricks such as this one are excellent motivational devices and offer exciting ways of introducing the nature of proof. They can also serve as dramatic introductions to new mathematics concepts. The interested reader could find no better beginning sources on mathematical magic than the outstanding works produced on this fascinating subject by W. W. Rouse Ball (1928), Martin Gardner (1956), Royal Vale Heath (1953), and William Simon (1964). Creative teachers can find myriad ways of integrating into the mathematics curriculum the exciting tricks contained in these books.

TABLE 1
A Summary of the Proof

Step	Moves	Status of Position	Cards Deleted	Cards Remaining
start	0	even	none	1, 2, 3, 4, 5, 6, 7, 8, 9
1	4	even	9	1, 2, 3, 4, 5, 6, 7, 8
2	5	odd	6	1, 2, 3, 4, 5, 7, 8
3	2	odd	8	1, 2, 3, 4, 5, 7
4	3	even	3, 7	1, 2, 4, 5
5	3	odd	2	1, 4, 5
6	1	even	1, 5	4

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