Magic by numbers

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Since beginning to use mathematical magic in English lessons over 5 years ago, the presenter has found the fun of magic to be a great motivator. This paper features two magic-based activities that are flexible enough to be used with English students of various ages and skill levels. Both activities get and keep students' attention while maintaining a professional atmosphere, require almost no preparation, and most importantly, are very easy to perform. The lasting impression of magic reinforces the target structures and vocabulary practiced in a memorable way. Step-by-step procedures involved in doing magic illustrate the method of teaching language containing simple requests, commands, and questions about common objects and concepts (specifically counting, adding, writing, pointing, opening, closing, and choosing). The activities explained here involve listening and responding to contextually similar but grammatically different questions. They incorporate all four skills. Group-based magic effects, incorporated into a meaningful language task, can take the lesson beyond the teacher-student / entertainer-audience hierarchy, empowering students to use the English they have practiced. Criteria for discerning the difference between a great magic effect and an unsuccessful English activity are also discussed.

数理マジックを用いた英語の授業に5年以上取り組む中で、マジックを楽しみながら授業に参加することにより、生徒がより高い動機付けを得られることが分かった。ここでは、様々な年齢やレベルの英語学習者に対応できる2つのマジックを用いた活動を紹介する。両活動とも準備もほとんどいらず簡単に行うことができ、またプロフェッショナルな雰囲気を保ちつつ生徒の注意を引きつけることができる。マジックでレッスンの印象が強まることにより、学習目標となる文法や語彙が、より効果的に記憶に残るようになる。また段階を追ってマジックを生徒に披露するなかで、様々な事柄や概念（数の数え方、足し算、ライティング、指摘、開閉、選択等々）に関する簡単な依頼や命令、質問を英語で行っていくが、前後関係から同様と推測されるが異った形を取る文法形式の質問を複数聞き取り、またそれに答えるという活動も含んでおり、4技能を駆使した形での活動となっている。効果的な言語活動を盛り込んだグループベースのマジックを導入するにより、授業は教師と生徒／エンターティナーと聴衆のヒエラルキーを超えたものとなり、生徒は練習した英語を実際に使う力を養成することができる。この論文では、効果的なマジックと失敗に終わってしまう英語活動との違いを見分ける基準について議論していく。

Since I began using magic in my classes over 5 years ago, I have seen classes respond to the challenge of understanding novel and fun activities. Students leave class with a great sense of satisfaction because of a lasting impression that successfully reinforced the target structures and vocabulary practiced. I would like to explain two magic effects that are flexible enough to be used with students of various ages and skill levels, are guaranteed to get and keep students' attention while maintaining a professional atmosphere in the classroom, require almost no preparation, and most importantly, are easy to do.

Is magic pedagogically appropriate?

I first witnessed the use of magic effects in the classroom as an ALT. A couple of the teachers with whom I team-taught occasionally used magic in their classes. Students' attention was peaked by the novelty of the situation, but the procedure often demanded an explanation that inevitably fell back on the L1. Our English lesson became a magic performance with very little language learning. At other times, the target structure was so simple that the time involved in a preparatory explanation did not warrant the activity itself. The target structure had become an excuse to entertain the students; and entertainment is only the result of a teacher-centered lesson formula. Still, I believed that magic effects held some potential to motivate students to learn English through authentic communication. However, not all teachers were enthusiastic about bringing magic effects into our team-teaching lessons. As Wright (2002) points out in one book, although magic has "a serious role in language learning," it is often considered to be "frivolous" (p. 57). Consequently, some teachers may feel "reluctant to take on the role of magician" (p.57). However, there are professional methods for incorporating magic into classes. Target structures can be "exemplified in a concise and memorable way through a magic trick" (p. 57). Furthermore, practice is an intrinsic part of mastering both magic effects and second language usage.

Like so many activities, magic effects can:

- get students'attention and provide motivation
- set up a situation in which students desire to understand what is happening
- provide an opportunity for students to practice speaking commands, requests, aural comprehension, and recent vocabulary
- create a context for authentic communication
- bring students back to class with an interested attitude
- help the teacher move beyond teacher centered lessons

Keep in mind, always, that great magic effects don't necessarily make good English lessons until the instructor makes them so. Conversely, marginally good magic effects can be made into great English lessons.

A thumbnail sketch of a lesson involving magic effects might include the following steps: (1) review vocabulary and phrases, (2) perform the magic effect, (3) distribute a form with cloze or short answer exercises. Students make groups of three or four and present an explanation of how the effects work, or they practice the dialogue and the magic effect in pairs. Later this practice can be channeled into speaking tests.

Below is a list of ten criteria for determining the usefulness of various effects. To the right of each criterion is a scale from 1 to 10. Until teaching has been developed into an exact science, this scale will remain subjective and personal. The instructor's subjective but informed assessment is quantified as *x*. The total possible is 100.

Appropriate for the role of a teacher	+1 to10
Appropriate for you	+1 to10
Appropriate for the students' age and skill levels	+1 to10

Preparation required is minimal	+1 to 10
Class time required is not excessive	+1 to 10
Fully visible from anywhere in the room	+1 to 10
Opportunity for authentic communication with many students	+1 to 10
Suited to the number of students in the class	+1 to 10
Opportunity for independent or small group analysis	+1 to 10
Opportunity for a subsequent activity	+1 to 10
Total	= *x* / 100

Method

Following are two effects that I have found useful in class. Judge for yourself what score they merit, using the criteria above.

The automatic magic square

Level: fifth grade elementary and up. This activity practices: numbers; quantities; phrases regarding time such as "How long" or "How many minutes/hours" (seconds, minutes, hours); the preposition "between"; and mathematical functions "plus" and "equals." Materials needed: chalk and blackboard.

A *magic square* is a block of squares with values written into each space in such a way that the relationships between the numbers yield unexpected and exciting results. I came across the magic square discussed below in a book titled, "Self-Working Number Magic," by Karl Fulves (1983). Fulves writes, "magic squares are among the best-known mathematical diversions" and though of a "venerable age" still "exert a hypnotic fascination" (p. 59). Even young children can appreciate magic squares as evidenced by Frank Murphy's children's book titled "Ben Franklin and the Magic Squares." While the magic square in Murphy's book is interesting for its historical connection, it is also fairly complex and not very eye-catching. The magic square explained here is terribly simple and visually dazzling. When added together, the sums of each row and column are equal. A sixteen-space magic square may be filled in within a minute for any value between 21 and 100. I am borrowing the effect from Fulves (p. 68-70), but the illustrations and classroom language learning adaptations are my own.

Step 1. Begin by introducing the concept of a magic square. Ask a student to choose and speak out any number between twenty-one and one hundred. Suppose the student chooses the number 34. Draw the magic square on the board (such as is shown in Figure 1) and demonstrate that the columns and rows add up to 34.

14	1	12	7
11	8	13	2
5	10	3	16
4	15	6	9

Figure 1. A magic square for a value of 34

The explanation of how to fill in the squares with the correct values is provided below, after Step 7.

Step 2. Erase the numbers of that example, leaving the empty spaces for reuse, and ask the class how long it would take them to fill in the 16 spaces of the magic square so that the rows and columns all add up to a single given value. Some will say that it would take them all day, others three or four hours. One or two students may say they can do it in 5 minutes, but it is unlikely that any student will claim to be able to do it in under a minute. In fact, this magic square can be completed within 45 seconds.

Step 3. Ask a student (Student A) to choose another student (Student B) to come to the blackboard. Ask Student A to think of any number between twenty-one and one hundred and to tell it aloud to Student B who should write it on the board. Then within 45 seconds, fill in the spaces so that the numbers in each row and column adds up to the number Student A chose. Ask the class members to check your work. Ask students to add in English using vocabulary items such as plus and equals. Next, ask the class if they can find any other combinations besides the numbers in the columns and rows that add up to the target value.

The complete set of the thirty possible combinations as shown in Figure 2 are as follows: First, of course are the four rows and four columns. Seven full circles denote groups of four in square blocks. Those include (14, 1, 11, 8); (1, 12, 8, 7); (12, 7, 13, 2); (8, 13, 10, 3); (5, 10, 4, 15);(10, 3, 15, 6); (3, 16, 6, 9). Two long arrows denote numbers adding up to the target-value along the two major diagonals (14, 8, 3, 9); (4, 10, 13, 7). Numbers in the three half-circles on the left and right (14, 11, 7, 2); (11, 5, 2, 16); (5, 4, 16, 9); and three circles on the top and bottom (14, 1, 4, 15); (1, 12, 15, 6); (12, 7, 6, 9) also add up to the target value. Note that if the square were wrapped around a cylinder (either vertically or horizontally), these half-circles would meet up to form full circles. Short arrows denote diagonals on opposite corners of the square (11, 1, 6, 16); (12, 2, 5, 15) that add up to the target-value. The large circle around the square itself signifies the four corners (14, 7, 4, 9) that add up to the target-value. There is a reason for these surprising combinations. The term “magic square” is something of a misnomer. What appears to be a magic square is actually a magic sphere. To illustrate this point make magic sphere using a tennis ball and a felt marker.

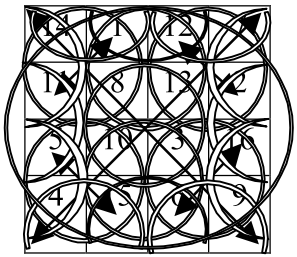

Figure 2. The combinations that produce the target value.

Step 4. Ask each student to call out a combination that adds up to the target value. Draw a large square on the board and use various colors of chalk to create an impressive design like Figure 2. Naturally, your students are not going to see every possible combination, so after they seem to

have run out of ideas, point out the remaining combinations yourself. Lead the class in practicing reading the numbers in each kind of combination.

Step 5. Erase the entire square and tell the class that the effect is too easy to do while looking at the board. Tell the students that you will perform the effect without looking at the board. Ask a student (Student C) to go to the board. Ask the rest of the class to open their notebooks. Ask another student (Student D) to choose a number and say it aloud so that Student C can write it on the blackboard and the class can see the target value. Instruct Student C to write the numbers he or she hears left to right, top to bottom. Now turn your back to the board and write the first number on any student's notebook, telling him or her to dictate the number you wrote so that the Student C can hear it. Student C should write it in the top left square. Move on to another student and repeat this until the Student C has filled all sixteen squares left to right, top to bottom.

Step 6. Next, sit down and give the chalk to another student (Student E) and ask him or her to go to the board. Student E then does all the circling of numbers as the students take turns calling out the combinations. After circling four combinations as read out from the class members, Student E may pass the chalk to any other student. Continue until all thirty combinations are circled. Again, toward the end, you may have to call out remaining combinations yourself or prompt other students to do so.

Step 7. Conclude with a follow-up exercise, for example, a cloze exercise covering parts of the dialogue between performer and participant. Vocabulary items such as choose, add, say, tell, write, listen, show, and so on may be reinforced in a manner appropriate for the students' skill level.

Invite any student who knows how the magic effect is done to explain using as much English as he or she can. You can also explain it yourself. Then one student may take over the role of the mathematical genius using the dialogue on the worksheet to ask other students to work through the procedure as before. You may also ask students to do essentially the same thing in pairs. An example of a worksheet is provided below:

Choose words from the box to complete the conversation below.

circle squares Tell numbers between

A: ____ me a number _____ 21 and 100.

B: Okay, 52.

A: Now, write these _____ in the _____. 31, 1, 12, 7 . . .

(Student B writes the numbers then passes the paper back to Student A)

B: Okay, now you _____ the numbers I read to you. 31, 1, 11, 8 . . .

The main strength of this activity is that it is a fun way for students to practice pronunciation of numbers in a second language. If your aim is to practice intermediate conversation

skills, this activity will obviously fall short. If you simply want your students to practice using numbers in English, then you may find this activity to be very satisfying. I find that as basic as the pronunciation of numbers in English is, many students still have considerable difficulty doing it. Any compulsory course in English should have at least one lesson in the numbers from 1 to 100, and such a lesson should be as interesting as possible.

So, just how is this masterful exercise in advanced mathematics executed? As one might expect, this magic effect is very simple to do. Whatever number Student A chooses, you subtract twenty-one from it. Call Student A's number "*X*." In Figure 3 below, Student A's number minus twenty-one becomes *A*. Add the value of 1 to *A* to find *B*. Add the value of 1 to *B* to find *C*. Add the value of 1 to *C* to find *D*.

X=student's number
A=X-21
B=A+1
C=B+1
D=C+1

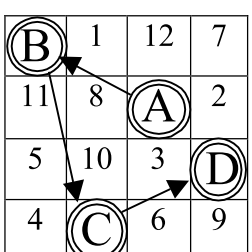

Figure 3. The four variable points in sequential order

As for the 12 other numbers, they never change. Simply memorize their positions. After practicing a few times these numbers will become easy to remember. After becoming a seasoned pro, you can improve the illusion by rotating, inverting, or otherwise flipping the arrangement of numbers in the square so that the pattern is not easy to recognize even when the magic effect is repeated two or three times. Figure 4 shows four examples of how the arrangement shown above can be turned to look quite different although the relative positions remain unchanged.

In a class of around 25 students and a lesson on basic numbers from 1 to 100, I would rate this activity at around 85. My reason for that assessment is as follows. The activity is always a success with the students, who tend to get quite excited about what Fulves (1983) calls "lightning calculation" (p.70), as well as eye-catching combinations and patterns. The effect successfully gets all the students involved but at a fairly remedial level. However, the dialogue between performer and spectator is limited by the simplicity of the procedure. As I pointed out earlier, your assessment of this activity will vary according to what you wish to accomplish. When it comes to numbers, I want my students to know the difference between 12 and 20, 40 and 30, 15 and 50, and I want them to be able to speak and understand those numbers quickly, without hesitation. Still, we should hope that magic effects could be used to a higher purpose, such as basic conversation, using commands, requests, and questions. The following magical effect, Criss-Cross Card Detection, succeeds in motivating students to use simple and useful English with a lot of repetition, is open to possibilities of expanded vocabulary and target structures, and is ideal for students' performing themselves.

4	5	11	**14**
15	10	8	1
6	3	**13**	12
9	**16**	2	7

14	1	12	7
11	8	**13**	2
5	10	3	**16**
4	**15**	6	9

7	12	1	**14**
2	**13**	8	11
16	3	10	5
9	6	**15**	4

9	6	**15**	4
16	3	10	5
2	**13**	8	11
7	12	1	**14**

Figure 4. Four identical magic squares in different positions

Crisscross card detection

Level: fifth grade elementary and up. This activity practices basic classroom English commands and requests such as "Please choose / point / show." It also practices simple questions in the second and third person as well as the simple present and simple past tense. For example: "Is it here?" "Yes, it is. / No it isn't." "Do you see?" "Did you choose?" Materials needed: two decks of playing cards.

Step 1. Select a block of students' desks from the room five by five in rank and row. Shuffle a deck of cards and then, walking up and down the rows, distribute a card to each student so that twenty-five students each have a card lying face-up on their desks. Select one student (Student A) to come to the front of the class and choose one card from among the twenty-five. Demonstrate walking among the desks, selecting a card, showing the card to everyone at the front of the class and then returning the card to the desk. Next ask Student A to select a card, show it to the class, and return it to the desk. While he or she does this, turn your back to the class. Wait a few moments and then ask, "Are you ready?" Turn back around, gesture towards the left-most row and ask "Is it in this row?" Instruct Student A to answer, "Yes, it is," or "No, it isn't." The instructor should work his or her way from the left to the right until Student A answers in the affirmative.

Step 2. At this point tell Student A, "Thank you," and let him or her sit down. Suppose Student A indicated the third row from the left. From the third row, pick up the card from the fifth rank (the position in the third row nearest the back of the room) and then take all the cards from the first (left-most) row. It is very important when picking up the cards to consistently place each card on the bottom of the stack. Next, take the card from the fourth rank of the third row and then pick up all the cards from the second row. Return to the third row and pick up the card in the third rank and then all the cards in the fourth row. Pick up the card in the second rank of the third row and then all the cards in the fifth (right-most) row. The last card picked up will always be the remaining one from the indicated row (in this case third row) in the first rank (the front of the classroom). The deck will now be

stacked so that the first and afterwards every sixth card is one from the indicated row.

Step 3. Announce that you will now find the chosen card by flipping through the deck. Select another student (Student B) to assist you. All the student has to do is to say, "Stop!" Stop flipping through the deck at that point and pull out the card. Ask the class, "Is this the card?" as though absolutely certain that it is. Of course, it most likely is not. Put the card back where it came from. Repeat this two or three times and appear flustered. Tell the class you will "Try again."

Step 4. Turn the deck over and begin redistributing the cards as before from the back to the front rank, left to right. Because every sixth card is from the third row, the chosen card will lay along the diagonal from the left-most fifth rank to the right-most first rank (see Figure 5). Choose another student (Student C) and repeat the questioning process explained earlier. When Student C answers in the affirmative, you will know the chosen card. If the chosen card is in the first row then it will be in the fifth rank. If it is in the second row then it will be the card in the fourth rank. If it is in the third row then it will be the card in the third rank. If it is in the fourth row then it will be the card in the second rank. If it is in the fifth row then it will be the card in the first rank.

Step 5. Suppose the chosen card is a three of spades. When the Student C tells which row the chosen card is in, pretend to be completely baffled as though sure it would be in a different row. Have all the students pass forward the cards as though the magic effect has not worked. Since everyone thinks the activity has come to an abrupt end, no one will be paying any particular attention to what is occurring. Place

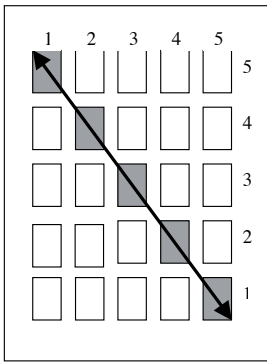

Figure 5. A 5x5 layout of the crisscross with the diagonal delineated

the three of spades face down on the bottom of the stack. (Placing the chosen card second from the bottom will allow you to handle the deck with feigned carelessness.)

Step 6. Stand at the front of the class and apologize for having wasted everyone's time. Then, ask a third student (Student C) to help find the chosen card using his or her "special power." Deal the cards face down, into stacks of five. Ask Student C to point to three of the stacks. If the three of spades is among one of those stacks, discard the two remaining stacks, but if the three of spades is in one of the two remaining stacks, then discard the three stacks to which the student pointed. From the students' point of view, Student C is calling the shots. In fact, you are narrowing down the selection based on your knowledge of the card's location. This is called "forcing a card." When you have only

one stack remaining, spread those five cards out over the blackboard and repeat the narrowing down process until you have one card. Ask the student to look at the card, because the instructor is "too nervous." Appear to be just as surprised as everyone when the last card turns out to be the three of spades and thank the student for saving the lesson.

Step 7. Up until this point, it might well be argued that the communication has been somewhat one-sided, with the teacher asking questions and the students answering. However, Steps 1 through 6 are preparatory stages the class must pass through before students finally take on a more autonomous role. Having seen a magic square completed twice and having participated in the activity communally, students should have the confidence to risk performing the magic effect with their partners. As students succeed in using English in progressively independent stages, their confidence also increases progressively. After the completion of the demonstration in Step 6, students break into groups and complete a worksheet that reviews the language content while confirming that each student understands the magic effect from beginning to end. The worksheet includes a script with cloze exercises with the answers provided (in random order) in a text box at the top of the page.

Students perform the magic effect with a partner using the script as a guide. They are told that during the next class they will work in pairs and perform the effect without the script. In a conversation class, the instructor can ask the students to work in pairs and perform the effect in an oral exam. Below is an excerpt from such a worksheet.

row isn't choose in take do Please
see is pick ready Did take Is

A: _____ choose one card. Point at it but don't _____ it.

B: All right. I'm _____.

A: __ it in this ____?

B: No, it____. / Yes, it__.

A: Do you ____ it ___ this row?

B: No, I don't. / Yes, I do.

A: ____ you _____ a card in this row?

B: No, I didn't. / Yes, I did.

A: Okay. Now, I'll _____ up the cards and ___ it again . . .

Crisscross Card Detection is a good playing card magic effect and a very good English activity as well. However, there is a problem of visibility. A glossy, standard-size playing card can be difficult to see from the back and sides of the classroom. I solved this problem and produced a novel and durable tool by scanning a deck of cards, enlarging the image to A3 size, reproducing them front and back with a color laser-jet printer and laminating them. With cards that are visible to everyone in the room the activity jumps about 5 to 7 points on my personal scale. After walking into class a few times I found that I had underestimated the novelty of the giant cards. They were such a sensation that it became

obvious that it was a waste to simply walk into class carrying them in plain view, and I introduced the following addition to the activity.

Using a deck of very small cards such as are sold in tourist shops. Demonstrate the western way of shuffling, saying "In Japan, people shuffle like this, but in the west people shuffle like this." Then ask if anyone in the class can shuffle in the western way. Usually, someone will volunteer. Ask him or her to come to the front of the room and stand next to you. Say, "Please shuffle these cards," and begin to hand the cards over, but at the last instant pull back and say, "But wait a moment—I think these cards are *too small*." Hold a card up to the class and ask a student at the back "Can you see this card?" Often, the students at the back of the class actually can see it. In that case, show them another card at an impossible angle and shake the card so quickly that they cannot possibly identify it. This is always good for a laugh. Then turn to the student and reiterate, "These cards are *too small*." Look perplexed for a moment and then say, "I have a good idea." Pull the cards out from under the lectern and hand the giant deck to the student and request that the he or she "Please shuffle *these* cards. Oh what's wrong? Are they *too big*?" Now the student knows that he or she is in trouble. As it was the instructor who got the student into this difficulty, the instructor had better help them out with a little teamwork. Take half the deck back and with the student shuffle the deck once on the lectern. Lead the class in applauding the student and send him or her back to his or her desk. Then proceed with the activity as usual. Using this introduction increases the student-teacher interaction, uses familiar English such as "Can you see?" "too small," and "too big." It captures the complete attention of every student and at the same time helps them to relax. Large cards can be set in the blackboard chalk tray so that all the students can see them. Strong magnets can also be used to affix the cards to the board in a more visible position.

This magic effect can be made to score even higher on the scale by making the question-and-answer part of the activity more challenging. For older students at a higher skill level, vary the question from row to row so that they must listen more carefully. Whereas in the first row you ask "Is it in this row?", for the second row ask "Do you see it is this row?" to elicit a "Yes, I do," or "No, I don't." For even more advanced students, add a third variation, such as "Did you choose from this row?" changing verbs and verb tense. In a speaking test situation, students working together in pairs can be challenged to vary their questions and answers between two or three of the possibilities shown above. In a writing class, students can write a process essay and explain how to perform the magic effect.

Conclusion

I have explained only two of several effects that I perform during a school year. You might suppose that I have many tricks up my sleeve, but that is not so. The *trick* to making magic effects work is not having a great variety, but having just a few that you can do very well. Doing very well, in a language-learning environment, means not only performing the mechanical process without detection, but also stepping back from the linear A-to-Z of it all and seeing how the activity can be made more interesting and challenging on a linguistic and educational level. For example, where there

is a lot of repetition, finding different ways to ask the same question can further challenge students to develop their listening and conversational skills. Also, a well-placed digression can increase three-dimensionality of the activity and, as in the case of the A3-sized playing cards, humor can play a positive role. There is any number of ways that the instructor can improve an activity, but the first and most important step is to realize that magic effects are not language learning activities until used as such. The instructor needs the ability to discern which elements of a particular magic effect are suitable to a classroom English learning environment, the imagination to see how each stage of a given effect lends itself to English communication peripheral to the mechanical aspects of the process, and the diligence to follow through in the development of materials that help students take over the performance role.

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