The Educational Value of Tic-Tac-Toe for Four- to Six-Year-Olds

Do your students like to play tic-tac-toe? If so, do you think of games as time fillers or part of your educational program? In our classrooms, we use this game as a serious educational activity. The purpose of this article is to explain why we value this and similar games and how we use them. We base our opinion on research conducted in Japan (Nagahiro, Kato, and Miyakawa 2003) and the United States (DeVries and Fernie 1990; Kamii 2000; Kamii and DeVries 1996), and our observations in many classrooms.

Tic-Tac-Toe for Four- to Six-Year-Olds

In the study described here, the authors played tic-tac-toe with eighty children—four-, five-, six-, and seven-year-olds (twenty from each age group). The game playing was to verify and simplify developmental levels—determined by previous research—for the purpose of teacher use in the classroom. (The developmental levels are described in detail below.) Each game was videotaped and played using a commercially made game board that comes with ten plastic pieces: five Xs for one player and five Os for the other player. Opponents took turns putting a piece on the board, and the winner was the first player to place three pieces in a straight line vertically, horizontally, or diagonally. The teachers were careful not to win too often.

The teachers formulated four questions, based on previous research procedures, to ask themselves as they played with each child. If the answer to a question was yes, they continued to play the game and focused on the next question. The answers to the questions were indicators of the developmental level at which each child was functioning.

Answers As Indicators of Development

Question 1: Does the child try to make a straight line with three pieces? If the answer to this question was no, the teachers categorized the child at level 0 and ended the session. For example, Tom (4 years 5 months) was categorized at level 0 because he kept randomly putting his Xs down until there were no more spaces left on the board (see **fig. 1**). When the teacher asked, "Who won?" Tom examined the board, pointed to his line of X5, X1, and X7, and raised his hand. The teacher pointed to her line of O6, O2, and O4 and asked, "Did you win, or did I win, or did we both win?" Tom responded, "We both won." Four-year-olds often play games without competing, and "winning" to them means "successfully doing what one was supposed to do" (Kamii and DeVries 1996). Tom was categorized at level 0 because he did not even try to win and did not notice anything significant when he and the teacher completed their respective lines with O6 and X7.

If the answer to the first question was yes, the child was tentatively categorized at level I. According

Figure 1

This figure shows the piece placement for "We both won." The numbers indicate the play sequence. For example, Tom started the game with X1; the teacher then played O2. Although Tom's line was completed with X7, the teacher finished her line first with O6.

O: Teacher
X: Tom

X9	O6	X5
X3	O2	X1
O8	O4	X7

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Figure 2

Winning the game with O8 rather than blocking the opponent

X: Teacher
O: Ken

X3	O2	X5
	X1	X7
O6	O8	O4

Figure 3

A seven-year-old's placement of X6 without realizing that losing the game was inevitable

O: Teacher
X: Mike

X6	O1	O5
	X4	
X2		O3

to the authors' classroom observations, some level-I children can make a line vertically or horizontally but not diagonally. These children later become able to think about a diagonal line. If the child thus met the criterion for level I, the teacher continued playing with him or her with the next question in mind.

Question 2: Does the child *try* to block the opponent? If the answer to this question was yes, the child was categorized as having met the criterion for level II. At first, children can block the opponent only vertically or horizontally, but, according to classroom observations, they later become able to think about diagonal lines, too. If a child met the criterion for level II, the teacher continued to play with him or her, asking herself the next question.

Question 3: Can the child win by comparing the relative advantages of (a) blocking the opponent or (b) completing his or her own line? If the answer to this question was yes, the child was categorized as level IIIA. For example, Ken (5 years 9 months) won the game with O8 in **figure 2** when he could have blocked the teacher on the line extending X7 and X1. He explained to her that he could have blocked her but that such a move would have ended the game in a tie. When a child met the criterion for level IIIA, the teacher continued to play with him or her in order to encounter a situation that would define level IIIB.

Question 4: Can the child figure out that losing the game is inevitable when the teacher has two possible ways of winning? Mike (7 years 1 month) had met the criteria for level IIIA but not for level IIIB. When he blocked the teacher with X6 in **figure 3**, she asked him, "Is that the best place for that piece?" Mike took a long time looking at the pieces on the board and ended up grinning with embarrassment when he realized that the teacher had another possibility of winning. He remained categorized at level IIIA because he did not notice on his own that losing the game was inevitable.

Table 1

Relationships between Developmental Levels and Children's Ages

Level	0	I	II	III	Total
Age 4	1 (5%)	14 (70%)	5 (25%)	0 (0%)	20 (100%)
5		6 (30%)	6 (30%)	8 (40%)	20 (100%)
6		2 (10%)	5 (25%)	13 (65%)	20 (100%)
7		0 (0%)	5 (25%)	15 (75%)	20 (100%)
Total	1	22	21	36	80

Level and Age Relationship

The four developmental levels summarized in **table 1** confirmed the following findings from previous research:

- Level 0: The child does not try to win (by being first to make a straight line of three pieces).
- Level I: The child tries to win (by being first to make a straight line with three pieces).
- Level II: The child tries to block the opponent.
- Level III: The child compares the consequences of winning the game now with blocking the opponent (Level IIIA) or foresees that the opponent has two possible ways of winning (Level IIIB).

As **table 1** shows, the four-year-olds were generally at the lowest level, with 75 percent of them at

levels 0 and I. By contrast, the six- and seven-year-olds were at the highest level, 65 percent and 75 percent, respectively, at level III. Thus, a developmental relationship was evident, with the five-year-olds distributed across levels I, II, and III.

Children's Logico-Mathematical Relationships

We value tic-tac-toe as a serious classroom activity because it encourages children to make many kinds of logico-mathematical relationships (a) in an interrelated way and (b) in a hierarchical way. These reasons are elaborated below.

Interrelated relationships

Piaget studied the development of the following five kinds of logico-mathematical relationships:

- Classificatory relationships (Inhelder and Piaget 1964)
- Seriational relationships (Inhelder and Piaget 1964)
- Numerical relationships (Piaget and Szeminska 1952)
- Spatial relationships (Piaget and Inhelder 1956)
- Temporal relationships (Piaget 1969)

An example of *classification* is putting "all the plastic Xs" together and "all the Os" together. For a player to understand that the winner must be first to make a straight line with three of one's pieces involves simultaneously making temporal, spatial, numerical, and classificatory relationships. *Seriation* means ordering things according to relative differences. In tic-tac-toe, children figure out that the most desirable place to start a round is in the middle (see **fig. 4a**) because it offers four possibilities of making a straight line—a horizontal line, a vertical line, and two diagonal lines. The next most desirable place to start a round is in a corner (see **fig. 4b**) because it offers three possibilities for making a straight line. The least desirable place is one that offers only two possibilities (see **fig. 4c**). Note that this seriation is based on numerical, spatial, and temporal relationships. This seriation is an example of the interrelated way in which children develop various aspects of logico-mathematical knowledge while playing tic-tac-toe.

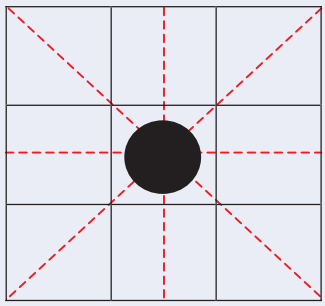
Making many interrelated relationships at the same time is very different from doing isolated exercises in sorting to sort (circles versus squares, for example) or in seriating to seriate (e.g., from the longest to the shortest stick). In an exercise, children have to be pushed and encouraged by a teacher or a computer. In a game like tic-tac-toe, by contrast, they are intrinsically motivated to think intently about how to win and develop many kinds of logico-mathematical relationships simultaneously in an interrelated way.

Piaget (1954) showed that logico-mathematical relationships are mental relationships from which each child constructs meaning within, starting on the first day of life, without any instruction. Anybody who has watched babies has been impressed by the new mental relationships they make from one day to the next. For example, they categorize

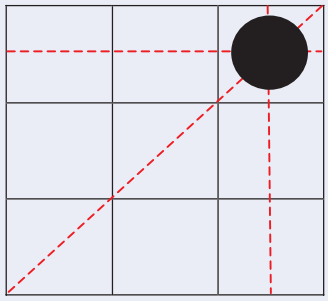
Figure 4

How to start the game

(a) The most advantageous place



(b) The next most advantageous place



(c) The least advantageous place

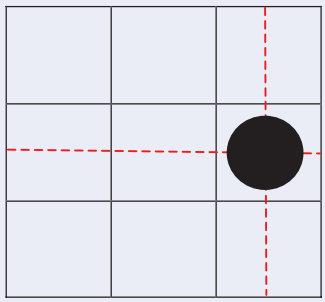


Figure 5

In Quartette, one player takes four checkers or chips and the other player takes four of another color. The players arrange them as shown and take turns moving one of their checkers either vertically or horizontally (but not diagonally) into any unoccupied adjoining square. Whether vacant or not, squares must not be jumped over, and players must always make a move when their turn comes. The winner is the first person to get four checkers in a straight, unbroken line horizontally, vertically, or diagonally.

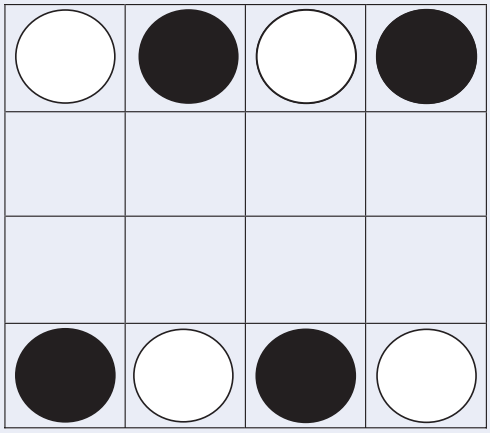
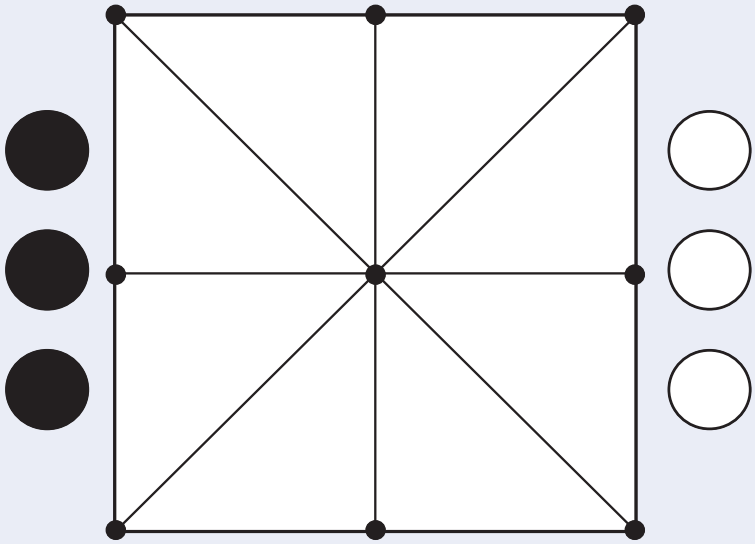


Figure 6

In the game of Tapatan, two players each take three colored counters and try to be the first to make a horizontal, vertical, or diagonal line of three. Players begin by taking turns placing one colored counter at a time on any of the nine points where the lines intersect. When all six counters are placed, the players take turns sliding from one point to the next along a line. They cannot jump over another counter, and two counters cannot be on the same point.



strangers and familiar people without a single lesson in sorting. And the more logico-mathematical relationships they make, the more relationships they will make. To paraphrase Piaget and Garcia (1974, p. 17), children may occasionally be interested in sorting to sort and in seriating to seriate; but, in general, their logic develops most fully, and in an interrelated way, when they try to attain a goal of their own, through their own thinking. We, therefore, recommend tic-tac-toe and similar games, such as Quartette (see **fig. 5**), Tapatan (see **fig. 6**), and those found in Kamii (2000).

Hierarchical relationships

Level II children can do everything level I children can do and more. Likewise, level III children can do everything level II children can do and more. This kind of development is said to be hierarchical. In tic-tac-toe, children who figure out how to win (see the smallest oval in **fig. 7**) soon think about blocking their opponent (see the medium-sized oval in the same figure). When children can think about blocking the opponent, they soon become able to compare the consequences of (a) blocking the opponent and (b) simply completing their own line (see the large oval in **fig. 7**).

Another way of talking about this hierarchical development is to say that level I children can think only about what they can do right now, and it does not occur to them to think about how the opponent is thinking. As they experience being blocked, they begin to think about how the opponent is thinking and what the opponent might try to do next. Blocking the opponent (level II) becomes possible when the child can think not only about what he or she can do but also about what somebody else can do, right now and in the future.

Level II children sometimes lose the game because they single-mindedly concentrate on blocking the opponent. At level IIIA, by contrast, they become able to think about blocking the opponent *and* about what the opponent might do afterward. By thinking about their opponent's thinking, they may decide not to block the other player.

Children's thinking thus develops hierarchically while they play tic-tac-toe because they use the logic they already have to figure out what else they can do to win the game. The educational implication of this hierarchical development is that, in games, it is unnecessary to sequence objectives. In exercises and lessons, however, the teacher must sequence objectives and provide questions or problems that may not correspond to the hierarchi-

cal way in which children naturally develop their logico-mathematical thinking.

Principles of Teaching

The value of tic-tac-toe and similar games can be enhanced or decreased depending on what adults do. We therefore explain three of the most important principles of teaching that we follow:

- Do not show children how to play at a higher level; instead, encourage them to do their own thinking.
- Do not reinforce "correct" behaviors or correct "wrong" ones.
- Play with individual children whenever possible.

Most of us have been taught that the way to teach mathematics is by showing children what to do. We now know, however, that children construct logico-mathematical knowledge by doing their own thinking. Therefore, we must encourage them to figure things out rather than obeying and mimicking their teachers.

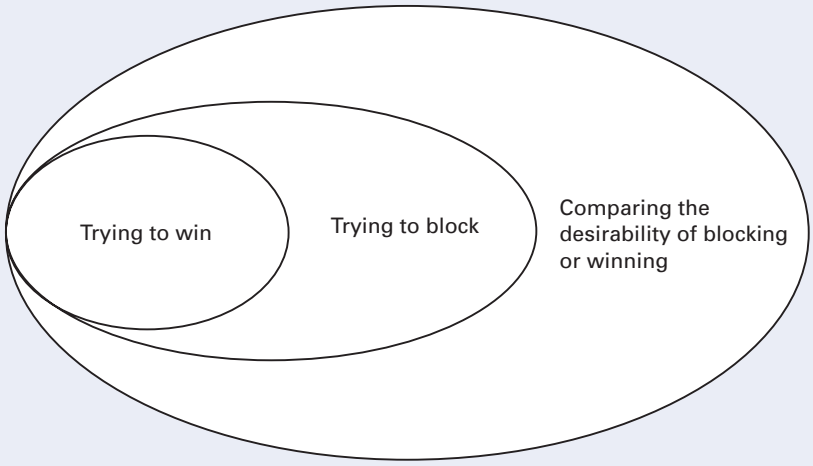
Also, most of us were told that the role of the teacher is to reinforce "right" behaviors and correct "wrong" ones. This is an old belief based on associationism and behaviorism. An adult's occasional expression of pleasure is not harmful, but when the teacher says that an answer is correct, all thinking stops! Children should be encouraged to come to their own conclusions based on debate among themselves. The nature of logico-mathematical knowledge is such that if children argue long enough, they will agree on the correct answer (unless the question is too hard for everybody in the group).

Adults find out much more about children's thinking by playing with individual children or a small group than by merely observing them. Therefore, playing with them whenever possible is desirable.

If children can govern themselves, the teacher is free to play with them. Building a self-governing classroom requires much time and effort at the beginning of the school year. Children naturally come to their teachers for conflict resolution. But teachers who believe that children must become able to govern themselves ask questions such as, "What do you think you can do about this problem?" If a child has no idea, the teacher may make a suggestion: "Can you think of a rule to suggest to your group?" or "Do you think a class meeting might help you get ideas about how to solve this problem?"

Figure 7

The hierarchical development of the three levels



How to build a community that can govern itself is a complex question that is beyond the scope of this article. For more ideas about encouraging children to govern themselves, refer to Kamii (2000), DeVries and Zan (1994), and Nelsen (1987).

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