International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Teaching Through Reasoning with Sudoku Puzzles: Effects on Pupils' Mathematical Achievement and Reasoning Performance

Dr. Stephen Raymund T. Jinon

West Visayas State University
DOI: https://doi.org/10.55248/gengpi.2022.3.8.18

ABSTRACT

This quasi-experimental study was conducted to find out the reasoning performance and mathematical achievement of pupils taught through two teaching strategies- traditional and teaching through Reasoning with Sudoku puzzles. The participants in the study were the 62 Grade 5 pupils of the a selected Laboratory School in Iloilo. The pupils were randomly chosen and match-paired on the basis of their pretest scores in the researcher-made mathematical achievement test. Thirty-one pupils from each section were given the interventions after the match pairing. The data-gathering instruments were the validated and reliability-tested researcher-made mathematical achievement test and adapted reasoning performance test. The 60-item mathematical achievement test comprised 50 multiple choice items and 10 items on problem solving were based on topics about fractions, decimals, percents, ratio, and proportion. On the other hand, the reasoning performance test measured the pupils' performance in verbal, numerical and abstract reasoning. The mean was used to determine the pupils' level of mathematical achievement and reasoning performance, coupled with the use of standard deviation in determining the pupils' homogeneity or heterogeneity in their scores. The inferential statistics utilized were the paired sample t-test to test the difference in the pretest and posttest scores of the pupils in both tests and the t-test for the independent samples to test the difference between the mean gain of the two groups in their mathematical achievement as well as reasoning performance scores. Statistical computation and processing were done through the Statistical Package for the Social Sciences (SPSS) software version 17. The 0.05 level of significance for two-tailed test was used for the inferential test. Results revealed that before the intervention the two groups were on equal level in their mathematical achievement and reasoning performance and showed homogeneity in their scores. Also, before the intervention, the pupils were hesitant in the use of Sudoku puzzles and in participating in the classroom because it was their first time to encounter the strategy. After the 7-week intervention the result showed that teaching through reasoning with Sudoku puzzles enhanced the pupils' mathematics achievement and reasoning performance, making higher marks than those taught with the traditional strategy, where reasoning was not the main focus of the teaching process. The mean gain scores of the Sudoku group were higher than the mean gain scores of the non-Sudoku group; this implies that the strategy as well as Sudoku helped the pupils in the process of learning If pupils were given the chance to practice their reasoning skills, they could have high achievement and could improve their reasoning performance.

Keywords: Reasoning; Mathematical Achievement; quasi-experimental , sudoku puzzles

INTRODUCTION

Mathematics covers many things in life at any age and in many circumstances. Its values are not only limited inside the classroom, but most importantly it gives meaning to people's lives. As a subject, it should be learned comprehensively and with much depth. One of the primary goals of the K to 12 curriculum is to maximize learning to improve the potential of each student. In the mathematics curriculum, students should be molded to boost their potential as critical thinkers and good problem solvers which are the twin goals of mathematics in the basic education levels K-10. To achieve these goals, teachers should help students improve their reasoning as well as give them chances to find ways around difficulties or obstacles and to find solutions to problems. Increasing students' reasoning by any means makes them critical thinkers. Critical thinking can help them cultivate better attitude towards mathematics and make them achieve higher. Most students are taught traditional algorithms in elementary school without a solid foundation of conceptual understanding, and by the time they reached middle school, many of them have rules all mixed up and no sense of the reasonableness of their answers. In schools, pupils learn procedures by imitating and practicing them, and it is hard to go back and understand a procedure after they have practiced it many times. The procedures they have been taught become obstacles, rather than supports to their understanding. Ball (2005) opined that early instrumental instruction – learning rules without reasons– can interfere with subsequent attempts at relational learning - learning what to do and why. Thus from procedures, there are some attempts to teach through understanding, that is, " convince yourself, convince a friend, and convince an enemy/skeptic" , adapted from thinking mathematically. Hiebert and some colleagues, (1997) said that authority for reasonability and correctness lies in the logic and structure of the subject.

A wide body of research has shown that students do not learn simply by being told, but they need to actively connect new knowledge with their previous conceptions and beliefs (Brandsford, Brown, & Cocking, 2000). In essence, people do not learn what other people say; they learn from what they say (Schwartz 1999). Learners need to construct understanding by making connections because the primary aim of education is not to enable students to do well in school but to help them do well in the lives they lead outside the school. Eisner(2004) highlights the act of reasoning and judgment, making it as among the most important abilities that schools can cultivate in students. Educated citizens of qualitative society need to be able to contend, critique, analyze, and deduce; in essence, they need to reason with numbers in mathematical society. The practice of reasoning is a means through which students learn to connect the different places that they visit in the mathematical environment. As students learn to reason, they will also learn what a reasonable answer is; that is, if students learn to reason mathematically, they are more likely to consider and appreciate the fascinating and important network of routes and connections that link mathematical ideas and methods.

How can mathematics be worth doing for the 21st century learners? Learners at this age like simulations and games. They are learning by the things that attract and challenge them. With these, putting games and puzzles in every mathematics class could catch the attention of the students and might improve their achievements and reasoning in the subject. One of these puzzles that might lead to better achievement and reasoning is the Sudoku puzzle.

In mathematics, learners traffic in logical certainty or we prove things. Sudoku puzzle is a game of logic and critical thinking and making quick decisions based upon an available evidence. It is an intellectual game that improves logic, concentration and reasoning. Teaching through reasoning in mathematics and using Sudoku might improve the achievement and the reasoning ability of pupils, the very reason why the researcher conducted this study. This study is part of a search for more effective approaches to facilitate teaching and learning in mathematics. It was also conducted to ascertain the perception of Grade 5 pupils on the use of Sudoku puzzles in their mathematics class.

METHODS

This study was an experimental type of research. According to Leedy, P.D. (1997), an experimental research is an attempt by the researcher to maintain control over all factors that may affect the result of an experiment. In order to attain these objectives, the researcher utilized a quasi-experimental method, specifically the two-group pretest-posttest design to gather the data available from the population included in the study. This was the most appropriate design, since intact classes were utilized as experimental and control groups (Walliman, 2001).

The control and experimental groups were both pretested, after which the control group was exposed to teaching through traditional/conventional approach without Sudoku while the experimental group was exposed to the teaching through reasoning approach with Sudoku puzzles.

The two intact classes of Grade 5 pupils of the elementary school were the subjects of the study. The subjects were sixty two (62) pupils, specifically, thirty-one (31) pupils from each section, fourteen (14) males and seventeen (17) females. The two classes were randomly assigned as experimental and control groups through tossing of a coin. The classes were heterogeneously grouped and, to identify the pairs of comparison, their scores in the pre-test of the achievement test were utilized and their sex was considered. Two intact classes were chosen as subjects of this study and their classes were all scheduled in the morning. Moreover, for logistic reasons, these two classes were chosen since their classrooms were located on opposite sides of the of the school building.

Table 1 shows the distribution of the respondents.

Group	*N*	*M*	*Mean Difference*	*t*	*df*	*Sig.*
A. Entire group						
Sudoku	31	25.97	3.48	1.36	60	0.541
Non- Sudoku	31	29.45				
B. When sex was considered						
boys						
Sudoku	14	26.64	2.86	0.74	26	0.467
Non- Sudoku	14	29.50				
girls						
Sudoku	17	27.53	1.88	0.52	32	0.607
Non-Sudoku	17	29.41				

Table 1. Comparison of the Two Treatment Groups with Respect to the Number of Boys and Girls and to the Mathematical Achievement Pre-test Results

The two groups were comparable as revealed by their mathematical achievement pretest result [$t(60) = 1.36$, $p=0.541$]. As far as sex was concerned, the boys were comparable [$t(26) = 0.74$, $p=0.467$] as well as the girls [$t(32) = 0.52$, $p=0.607$] .

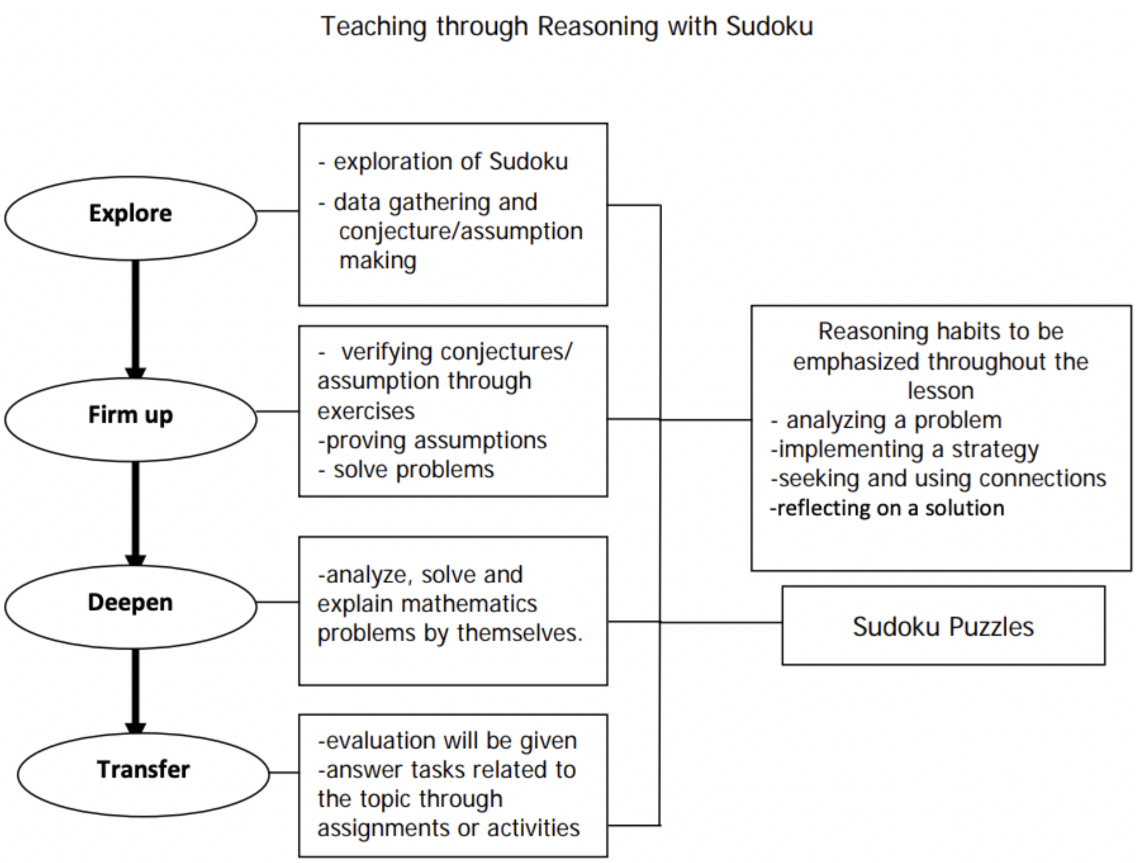
To insulate the study from threats of internal and external validity, the researcher instructed the pupils not to write their names, instead, a colleague was requested by the researcher to randomly assign them their respective examinee numberrs during the pretest and posttest. Hence, their identities relative to their scores were not revealed during the entire research process. On the other hand, respondents who were not included in the study were given equal opportunities and treatment and were unknown to the researcher throughout the intervention. There was also permission from the parents and to the respondents prior to the conduct of the study as among the ethical considerations for conducting a research.

The researcher used an adapted test in determining the participants' reasoning performance and a researcher-made test in determining their mathematical achievement. These tests were pilot tested . A prepared lesson plan and Sudoku puzzles for 7 weeks were utilized during the conduct of the study. These instruments were validated by experts.

To change the traditional classroom environment, the researcher employed the use of Sudoku puzzles in teaching through reasoning in the entire duration of mathematics classes. The subjects were taught five hours per week, equivalent to a thirty-five hour period for the entire duration of the experiment. To prevent intrusion of any extraneous variable, all the selected groups had their classes in the morning. Also, classrooms were far from one another to ensure exclusivity, prevent leakage, steer clear of contamination, and to warn off forms of novelty effects. The following flow of lessons, classroom observations, and procedures were observed

The topic plans were made and were validated by experts before the conduct of the study. The plans had two parts, the left part was the lesson plan for Reasoning with Sudoku strategy while the right side was for Traditional without Sudoku strategy. Reasoning with Sudoku is like a UBD (Understanding By Design Plan) which uses this flow: (1st) Explore (give the overview of the lesson) - The pupils answered a Sudoku puzzle in 5 minutes, after which they were asked to observe the puzzle. Situations and review games were given by the teacher and he asked some probing questions leading to the topic or to have a conjecture for the day, this stage could take a longer time depending on the topic, there were less teacher interventions'. Most work were done by the pupils; (2nd) Firm up (introduce varied learning experiences) – The pupils in this part answered activities to verify their conclusion or conjecture by answering the activities prepared by the teacher or in the book, if possible, pupils in this stage were encouraged to prove their conjecture using diagrams or essay; this was still a guided activity; (3rd) Deepen (let learners engage in understanding knowledge and process) - The teacher summarized the lesson by a demonstration to clarify misconceptions done during the Exploration and Firming up. Then, the pupils applied their firm ideas by answering the activities by themselves and with a group; some of the questions required reasoning, their scores were recorded as their seatwork; and (4th) Transfer (encourage learners to organize learning experiences) – An evaluation was given after each topic, the pupils were given tasks or take-home tasks or assignment that required them to apply what they had learned. On the other hand, Traditional Strategy followed these steps; (1) Motivation – Review game and some problems related to the topic , (2) Discussion – Teacher/students were engaged in the demonstration and question and answer, (3) Activity/exercises – Pupils were required to answer the exercises on the board or book with the guidance of the teacher; (4) Seatwork - This was a graded activity, (5) Evaluation – To evaluate if the students learned and mastered the topic, an evaluation test was given in a form of a short or long quiz, (6) Assignment – A follow up takehome activity was given before the period ended. Different strategies were employed in the two plans, like cooperative learning, pair share, etc.. These plans are summarized in the following flow charts:

Figure 1. Flow of Lesson in a Teaching with Sudoku Puzzle Plan



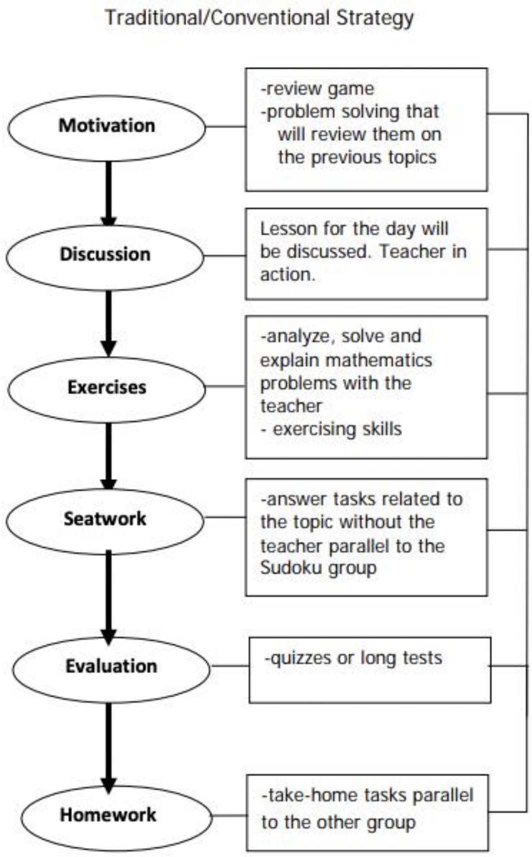


Figure 2. Flow of Lesson in a Traditional Class

RESULTS

From the data gathered, it appeared that the Sudoku group (M= 25.97, SD=9.95) and the non-Sudoku group (M= 29.45, SD=10.24) fell in the category "Developing" mathematical achievement. The results showed a slight difference in the mean scores before the intervention was conducted. This means that prior to the intervention, the pupils in the two groups did not have sufficient conceptual understanding or might not have encountered concepts on fractions, decimals, percent, ratio and proportion. Thus, the two groups were comparable at the onset of the study. It is interesting to note that the standard deviations of the two groups were almost close to each other. Thus, the respondents were homogeneously grouped. As a whole, the two classes were "Developing" (M= 27.71, SD=10. 17) in their mathematical achievement prior to the intervention.

Table 2. Pretest and Post Test Scores of the two groups in Mathematical Achievement

Group	Pretest				Posttest			
	N	*SD*	*M*	*Description*	*N*	*SD*	*M*	*Description*
Sudoku	31	9.95	25.97	Developing	31	13.43	56.71	Proficient
Non-Sudoku	31	10.24	29.45	Developing	31	11.85	48.87	Approaching Proficiency
As a Whole Group	62	10.17	27.71	Developing	62	13.17	52.79	Approaching Proficiency

Scores	*Description*
72.01 – 90.00	Excellent (E)
54.01 – 72.00	Proficient (P)
36.01 – 54.00	Approaching Proficiency (AP)
18.01 – 36.00	Developing (D)
0.00 – 18.00	Beginning (B)

On the other hand, the posttest mean scores in mathematics achievement of pupils in the Sudoku group (M=56.71, SD=13.43) and non-Sudoku group (M=48. 87, SD=11.84) were "Proficient" and "Approaching Proficiency", respectively. As a whole group, the Grade 5 classes were "Approaching Proficiency" on the topic about fractions, decimals, percent, ratio, and proportion, (M= 52.79, SD=13.17). Table 2 shows the difference in the pretest and posttest scores of the two groups. Meanwhile, the mean gain score in mathematics achievement of the pupils in the Sudoku group (M=30.74, SD=11.65) showed that the group performed better compared to the non-Sudoku group (M=19.42, SD=11.53).

With regard to their reasoning performance, from the data gathered, the Sudoku group (M= 16.87, SD= 6.34) and the nonSudoku group (M= 17.94, SD= 5.32) were "Average" in terms of their reasoning performance as revealed in their pretest mean scores.

Table 3. Pretest and Postest scores on Reasoning Performance of the Pupils

Group	Pretest				Posttest			
	N	*SD*	*M*	*Description*	*N*	*SD*	*M*	*Description*
Sudoku	31	6.34	16.87	Average	31	6.64	33.74	High
Non-Sudoku	31	5.32	17.94	Average	31	7.38	28.52	Average
As a Whole Group	62	5.83	17.40	Average	62	7.44	31.13	High

Score	Description
30.00 - 45.00	High (H)
15.00 - 29 .99	Average (A)
0.00 – 14.99	Low (L)

This means that prior to the intervention; the pupils in each group did not have a high level of reasoning and critical thinking based on the researcher's adapted questionnaire. On the other hand, the posttest mean scores in the reasoning performance in teaching through reasoning with Sudoku puzzles (M=33.74, SD=6.64), and traditional teaching strategy without Sudoku puzzles (M=28.52, SD= 7.38) were "High" and "Average", respectively. This shows an increase in both groups, with Sudoku group having a numerically higher mean than the non-Sudoku group. As a whole group, the Grade 5 classes had a "High" reasoning performance after the intervention (M=31.13, SD=7.44). Both group performed better after the two strategies were employed.

Moreover, the mean gain score in the reasoning performance of the pupils in the Sudoku group was 16.87, which shows that the posttest mean score is double the pretest mean score. Likewise, the pupils in the non-sudoku group got a mean gain of 10.58. With these results, Sudoku group performed better in the Reasoning Test given by the researcher.

To determine if significant differences would exist in mathematics achievement of the students exposed to the two teaching strategies, the researcher used the paired sample t-test. Table 4 shows that significant differences existed in the pretest and posttest scores in mathematics achievement test of both Sudoku group [t (30) = 14.69, p = 0.000] and non-Sudoku group [t (30) = 9.37, p=0.000]. This means that the students performed better in the posttest.

Table 4. Significant Difference between Pretest and Post Test Scores in mathematics Achievement

Group	*N*	*M*	*Mean Gain*	*df*	*t*	*Sig.*
Sudoku						
Pretest	31	25.97	30.74	30	14.69*	0.000
Posttest	31	56.71				
Non-Sudoku						
Pretest	31	29.45	9.42	30	9.37*	0.000
Posttest	31	48.87				

Note: * p < .001

This result can be attributed to the inherent capacity of the pupils and to the novelty of the strategy used that motivated the pupils to pay attention, learn, and study more. It was also evident in the active participation of the pupils during the discussion and board work. Moreover, the pupils were highly motivated to perform well in the posttest since it had a grade equivalent in their quarter grade. This claim was backed up by some studies where grades are very sound sources of motivation.

To determine if significant differences would exist in the reasoning performance of the subjects exposed to the two teaching strategies, the researcher used the paired sample t-test. Table 5 reveals that significant differences existed in the pretest and posttest scores in reasoning performance of the Sudoku group [t (30) = 9.75, p = 0.000] and the non-Sudoku group [t (30) =7.92, p =0.000]. This means that the pupils performed differently in the pretest and in posttest.

Table 5. Significant Difference between Pretest and Post Test Scores in Reasoning Performance

Group	*N*	*M*	*Mean Gain*	*df*	*t*	*Sig.*
Sudoku						
Pretest	31	16.87	16.87	30	9. 75*	0.000
Posttest	31	33.74				
Non-Sudoku						
Pretest	31	17.94	10.58	30	7. 92*	0.000
Posttest	31	28.52				

Note: *p< .001

This result can be attributed to the kind of pupils and the expertise of the teacher-researcher during the intervention. Regardless of the teaching strategy, the pupils increased their reasoning performance significantly. Moreover, the teacherresearcher motivated the pupils to pay attention during the reasoning part of the lesson since the pupils were still in their intermediate level and they were informed about the importance of reasoning in mathematics. It was also observed by the observers that the pupils in the study were involved in the learning process and they showed interest in learning the lesson. With this interest, they improved their reasoning performance with the use of the strategies and Sudoku puzzles as well.

To determine if significant differences would exist in the mean gain scores of the mathematical achievement as well as reasoning performance of the two groups exposed to the two teaching strategies, the researcher used the t-test for independent samples. Table 6 reveals a significant difference on the mean gain scores of the two groups [t (60) =0.92, p=0.000] in their mathematical achievement. This means that the Sudoku group improved its mathematical achievement higher than the non-Sudoku group. On the other hand, significant difference existed when the mean gain scores in their reasoning performance of the two groups [t (60) = 2.88, p=0.006] were compared. This means that Sudoku significantly improved the pupil's reasoning performance.

Table 6. Differences in the Mean gain score of Sudoku and Non Sudoku Groups

Group	*N*	*Mean Gain*	*df*	*t*	*Sig.*
Mathematical Achievement					
Sudoku	31	30.74	60	0.92**	.000
Non-Sudoku	31	19.42			
Reasoning Performance					
Sudoku	31	16.87	60	2.88*	.006
Non- Sudoku	31	10.58			

Note: *p< .05 **p< .001

DISCUSSION

Teaching through Reasoning with Sudoku would enhance the reasoning performance of the pupils especially when modeled properly. Reasoning can be enhanced through the use of a right strategy that can stimulate the mind of youngsters, enabling them to think and giving them time to justify their ideas.

Teaching through Reasoning with Sudoku puzzles, when planned properly, can promote learning and increase the mathematical achievement of pupils. This new method is one of the best strategies in teaching that can significantly raise the mathematical achievement and reasoning performance of pupils. Achievement and reasoning can be enhanced using the strategy, teaching through reasoning with Sudoku puzzles. Making the pupils think and put meaning to their answers will raise the bar of reasoning and achievement in mathematics.

Using sudoku puzzles affects the reasoning performance and mathematical achievement mean gain of the pupils. This brings positive changes in the reasoning performance of individual pupils as well as improves their achievement in mathematics. The activities involved in teaching through reasoning with Sudoku puzzles can develop the pupils' potential in reasoning as well as get them ready in thinking since the activities in a mathematics class involve much thinking. 5. Mathematical achievement and mathematical reasoning performance go together. The degree of numerical reasoning is positively related to the degree of how the pupils achieve in their mathematics class, or vice versa. Improving pupils' numerical reasoning performance can help pupils enhance their thinking abilities which in turn will enhance their achievement. An environment of thinking with enjoyment will improve the pupil in his mathematics background.

Sudoku puzzles help pupils in the preparation of thinking in a mathematics class. If planned properly, Sudoku can bring excitement and eagerness to learn to pupils, making them enjoy themselves and improve the different aspects of their performance. It can motivate pupils to try harder, to find ways through difficult situations, to plan to get the right answer and, to reason well to justify their ideas. It stimulates their mind to learn hard concepts in mathematics and once the mind works, they can expect positive feedbacks in their mathematics class as well as in their other subjects.

References

Ball D.L. (2005). Connecting mathematical ideas : Middle school video cases to support teaching and learning. Printed in US.

Brandsford, J., Brown A., & Cocking, R. (1999). How people learn: Brain, mind, experience, and school. Washington, DC: National Academy Press

Hiebert, J., Carpenter, T., Fennema, E., Fuson, K., Wearne, D., Murray, H. (1997). Making sense: Teaching and learning mathematics with understanding. Portsmouth, NH: Heinemann.

Schwartz, D. (1999). "The Productive Agency That Drives Collaborative Learning. "In Collaborative Learning: Cognitive and Computational Approaches, ed. P. Dillendbourg. New York: Pergamon.

Eisner, E.W. (2004). "Preparing for Today and Tomorrow." Educational Leadership (January).