# Education Quarterly Reviews

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# The Effect of Middle School Students' Metacognitive Awareness and Logical Thinking Skills on Success in Mathematics Course[*]

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**Abstract**
The aim of this study is to investigate The effect of logical thinking skills on the success of mathematics course at the Metacognitive Awareness of Secondary School Students. The research was conducted in the Siirt city centre of Fevzi Çakmak Secondary School with 120 5th, 6th, 7th and 8th grade students in 2018-2019 education year. The data were collected through both Metacognitive Awareness Inventory Schraw ve Dennison (1994) and the Test of Logical Thinking Skills Tobin and Capie (1981). During the research, the collected data were analyzed using Pearson product-moment correlation coefficient, independent samples t-test, and linear regression on SPSS. According to the results, a positive effect is evident the success of mathematics course metacognitive awareness and logical thinking skills. There is a significant relationship between metacognitive awareness and grade point average mathematics (GPAM) scores. In addition, there is a considerable relationship between logical thinking skills and GPAM scores. The research results suggest that metacognitive awareness and logical thinking skills are positive predictors of mathematics academic achievement. Also, it was examined whether mathematics academic achievement, metacognitive awareness and logical thinking skills differ according to gender. Results show that secondary school students' mathematics academic achievement and metacognitive awareness levels differ significantly in terms of gender. Female students are more successful than male students. Besides, female secondary school students' metacognitive awareness levels are higher than that of male students. Also, the significant relationship was found between logical thinking skills with respect to the gender.

**Keywords:** Metacognitive Awareness, Logical Thinking Skills, Secondary School Students, Success of Mathematics

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[*] This research has been produced from İsmail TOPÇUL's master thesis.

**1. Introduction**

In the century we live in, it requires educated people to generate knowledge and develop practical, permanent and successful solutions to real life problems. In this context, the Ministry of National Education, believing that the behavioral education theory was insufficient as of 2005, preferred the constructivist education theory, which aims to produce new knowledge by making use of individuals' own knowledge. The primary and secondary school programs, which were renewed as of 2005 in our education system, are revised according to the constructivist education approach and aim to raise students who can discover new information by using their existing knowledge, gain awareness of what and how they learn, and understand the cause-effect relationship between information.

A person with sufficient level of metacognition knows about the structure and functioning of his own mental processes. An individual with metacognitive awareness assumes the responsibility of learning by recognizing himself, discovering how he learns, and can successfully realize the learning process by building his own knowledge (Çakıroğlu, 2007a). In this way, the awareness provided by the beyond cognition ensures that education achieves its essential goals. As a matter of fact, Senemoğlu (1998) emphasizes that having awareness about their own learning activities and determining a direction for their self-learning is very effective in achieving students' success, and students need to gain the necessary awareness from primary school. In this context, Piaget named the mental development of children in school age as the abstract operational period in children aged 11-12 and above. During this period, new and stronger mental abilities develop (Yıldız, 2010). Although each child shows individual differences, it is observed that students of this age are generally subject to education at the secondary school level. It requires the development of metacognitive awareness of students in order to increase learning efficiency in educational institutions.

The main purpose of our education system is to gain skills in researching and discovering information rather than transferring existing information (Kaptan, 1999). Achieving this goal is possible with the effective use of high-level cognitive thinking skills. In other words, rather than memorizing information, it requires learning by comprehension, solving problems related to real life situations, and using skills related to scientific method process (Kaptan & Korkmaz, 2001). People with high level cognitive abilities become aware of their own learning processes.

On the other hand, it is aimed to raise students who are aware of how their own learning takes place instead of people who memorize information in today's educational institutions (Doğan, 2013). For this reason, children are asked to research, question and assimilate information and have basic skills to construct this knowledge (Balcı, 2007). Beyond cognition is putting problem-solving steps to work in the right place at the right time (Brown, 1987). According to these definitions, it can be said that situations such as the correct interpretation of a problem, the use of appropriate strategies after determining the methods that will ensure the correct solution of the problem, abandoning inappropriate strategies and analyzing the results after the strategies are applied draw attention to metacognition.

When the last half-century of studies on education are examined; It is seen that it is centered on providing students with high-level mental skills such as accessing information, learning information with the method of discovery and determining their own mental processes rather than providing ready-made information (Darling-Hammond, 2000). It is important for the individual to manage his / her own cognitive processes and to be aware of the method of learning information. In the cognitive process, the person conducts the flow of information on his own and the most important thing is that the information is applied. Studying mental processes, raising generations who are aware of their own cognitive processes based on the questions of how people learn information has brought about the concept of metacognition. The concept of metacognition, which was introduced to research in the field of education as a metacognition concept and first mentioned by Flavell in 1976, has been introduced into our language with different names (Çakıroğlu, 2007). Akin et al. (2007) have mentioned it as metacognitive. In this study, on the basis of Özsoy's (2007) application to the Turkish Language Institution, the word metacognition was used in return for the word metacognition. Metacognition; awareness of the learning process, planning and implementing, correcting mistakes, monitoring the learning process, using

strategies, controlling the efficiency of preferred strategies, changing the learning method and strategies when needed (Özsoy & Ataman, 2009; Özsoy et al., 2009).

While the learning and application of knowledge are conveyed through the mental process in students, even the learner's awareness of the cognitive development (which way he / she uses, what method he / she uses) and the process (what he / she does and what order he / she gains) in this process involves an awareness. Here, the concept of executive cognition, known as metacognition in subject studies, has taken place in the language. It can be said that metacognitive awareness includes the learner's ability to be aware of what and how to construct mentally, to form a thinking system, and ultimately to learn to learn (Çakıroğlu, 2007).

Logical thinking requires consistent thinking in order to obtain and evaluate a result. In essence, this thinking model has thinking stages that trigger each other. This task means obtaining all comments, facts, and results about the problem and arranging them in a way to relate them (Bozdoğan, 2007).

Logical thinking skill, which has an important function for people to develop successful solutions when they encounter daily life problems, is among the most important issues within the framework of studies on education (Barr, 1994). One of the mental skills is Piaget's logical thinking skills that develop in the pre-operational and abstract operations phase. Children in the concrete operations stage develop their own solutions to concrete problems by using the logical thinking skills they have acquired in the mental development process. These features differ individually among children. In the abstract operations phase, the mental progress process reaches the maturity level in terms of logical thinking skills. This skill is the development of various mental activities for children to find a solution to a problem or to discover new information by trial and error using the invention method (Yaman, 2005).

*1.1.Problem Condition*

The problem statement of this research is expressed as the effect of middle school students' metacognitive awareness and logical thinking skills on academic achievement in mathematics lesson.

In the content of the study, answers were sought for the following sub-problems.
1) Is there a significant relationship between metacognitive awareness inventory (PPI) scores and logical thinking skills test (MDYT) scores of students at all grade levels (5th, 6th, 7th, 8th grades) in secondary school?
2) Is there a significant relationship between middle school students' metacognitive awareness inventory (PPI) scores and academic achievement (MDAB) scores in mathematics classes?
3) Is there a significant relationship between the logical thinking skills test (MDYT) scores of middle school students and their academic achievement (MDAB) scores in the mathematics course?

*1.2. The Purpose and Importance of the Research*

The aim of this study is to examine the metacognitive awareness of middle school students at every grade level according to the problem solving steps (understanding the problem, writing and planning, implementing the plan, and checking the solution) the problems they encounter in mathematics lesson by using their skills of measuring, comparing and logical thinking. to provide a solution.

## 2. Materials and Methods

*2.1. Research Model*

This research is a survey model research in which middle school students' metacognitive awareness and logical thinking skills are measured. This study is also a correlational study, as the relationship between the sample's scores from three data collection tools will also be examined.

*2.2. Universe and Sample*

The universe of this research is 5th, 6th, 7th and 8th grade students who continue their education in Fevzi Çakmak Secondary School located in the city center of Siirt. The sample is 5/E, 6/A, 7/E, 8/C students who continue their education in a randomly selected branch at each grade level.

*2.3.Data Collection Tools*

Prepared by Scraw & Dennison (1994) and Akın et al. "Metacognitive Awareness Inventory (BFE)" translated by (2007) into Turkish was used. In addition, "Logical Thinking Ability Test (MDYT)" was applied to determine the logical thinking skill levels of middle school students. The "Logical Thinking Ability Test (MDYT)" was prepared by Tobin & Capie (1981) and contains 10 questions in order to determine the thinking abilities of the students in the research sample; A test was applied that measures the skills of defining and controlling variables, establishing proportionality, developing relationships, calculating probability and combining. The Logical Thinking Ability Test (MDYT), Geban et al. (1992) translated to Turkish. The reliability coefficient of MDYT was calculated as .77. At the stage of determining the academic success of the students in the mathematics course, the grades of the students' first term mathematics exams were taken as a basis.

The tests were applied under the supervision of the teacher of the lesson in the mathematics lessons in which the students participated. In order to collect the data completely and to answer the inventory in order to serve the purpose of the research, informative studies were carried out by the researcher. The data obtained were analyzed using the SPSS 22.0 program in computer environment.

*2.4. Data Analysis*

The data obtained in line with the objectives of the study were transferred to the computer environment and analyzed using the SPSS 22.0 (Statistical Package for The Social Sciences) program in computer environment using statistical techniques according to the characteristics of the data. In the beginning, Kolmogorov-Smirnov test and Shapiro-Wilk test were applied separately for each scale in order to understand whether the data showed normal distribution or not. The value found as a result of this test ($p < .05$) was found to be that the data showed normal distribution during the study phase and in this context, it was deemed appropriate to analyze it with parametric analysis methods.

Correlation analysis technique was used to determine whether there was a relationship between variables in the study. Pearson product-moment correlation studies are a technique used to describe the relationships between variables (Kaptan, 1998). If the Pearson moments correlation coefficient is close to 1.00 or 1.00, this positively correlates; Being close to -1.00 or -1.00 indicates a negative relationship; A value of 0.00 reveals that there is no relationship. Although there are no standard intervals for interpreting the Pearson product-moment correlation coefficient in terms of magnitude, the following limits are mostly used to interpret the correlation: Pearson's product-moment correlation coefficient is in the range of 0.70– 1.00 as an absolute value; It should be in the range of 0.70-0.30; The fact that it is in the range of 0.30-0.00 can be explained as a low level relationship (Büyüköztürk, 2002).

In addition, multivariate regression analysis technique was used to determine to what extent metacognitive awareness and logical thinking skills predicted academic achievement in mathematics course. Regression analysis refers to the process of explaining the correlation between two or more variables with a mathematical equation, one being the dependent variable and the others being the independent variable (Büyüköztürk et al., 2010).

**3. Findings**

In this section, problem statements, null hypotheses and alternative hypotheses are restated. Null hypotheses have been tested according to appropriate analysis techniques, and the findings and interpretations obtained by testing the hypotheses are included.

*3.1. Normality Test Analysis Results of Data*

Here, before proceeding with the hypothesis tests, it was investigated whether the data per group show normal distribution or not. Hypothesis tests all have various assumptions. The common assumption of all of the parametric tests (t-test, ANOVA, ANCOVA) is that the data distribution per group should be normal. In addition to this assumption, each hypothesis test has its own assumptions. Middle school students' Metacognitive Awareness Inventory (PPI) scores, Logical Thinking Ability Test (MDYT) scores and Academic Achievement (MDAB) scores in Mathematics Course were tested with normality test Kolmogorov-Smirnov test and Shapiro-Wilk test. If the group size was over 50, Kolmogorov-Smirnov test was used, while Shapiro-Wilk test was used if it was below 50 and 50. Normality test results are given in table 1.

Table 1: Kolmogorov-Smirnov and Shapiro-Wilk normality test results for PPI, MDYT, and MDAB data of secondary school students

|  | Kolmogorov-Smirnov | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
|  | KS | df | P | SW | df | P |
| PPI | .065 | 120 | .200 | .964 | 120 | .003 |
| MDYT | .097 | 120 | .008 | .960 | 120 | .001 |
| MDAB | .123 | 120 | .000 | .947 | 120 | .000 |

As seen in Table 1, the results of the Kolmogorov-Smirnov test show a normal distribution of PPI [BH (120) = 0.065, p = .200> .05] of the sample. However, it was observed that MDYT [KS (120) = 0.097, p = .008 <.05] and MDAB [KS (120) = 0.123, p = .000 <.05] did not show normal distribution. However, if the sample size is 30 and above, normality assumption can be neglected. In this study, the sample size is 120, which is considerably larger than 30. As a result, although the results of the Kolmogorov-Smirnov test showed that there was no normal distribution for MDYT and MDAB data, since the sample size was over 30 (N = 120), it was accepted that the data were normally distributed and it was decided to analyze the data with parametric tests. The results of Anova and t-test normality tests for PPI, MDYT and MDAB data of middle school students on the basis of classes and gender are also given in table 2 and table 3. Comments for table 1 can also be made for table 2 and table 3.

Table 2: Anova test analysis results for PPI, MDYT, and MDAB data of middle school students on the basis of classes

|  | Class | N | Average | Std. Deviation | f | p | Difference |
|---|---|---|---|---|---|---|---|
|  | 5 | 30 | 112.93 | 15.77 |  |  |  |
|  | 6 | 30 | 115.67 | 14.62 |  |  |  |
| PPI | 7 | 30 | 121.27 | 12.55 | 3.45 | 0.019 | 7-8 |
|  | 8 | 30 | 109.17 | 16.81 |  |  |  |
|  | Total | 120 | 114.76 | 15.48 |  |  |  |
|  | 5 | 30 | 3.10 | 2.20 |  |  |  |
|  | 6 | 30 | 6.33 | 2.02 |  |  |  |
| MDYT | 7 | 30 | 5.67 | 2.12 | 21.27 |  |  |
|  | 8 | 30 | 7.60 | 2.61 |  | 0.00 | 5-6,7,8; |
|  | Total | 120 | 5.68 | 2.77 |  |  | 7-8 |
|  | 5 | 30 | 70.33 | 19.31 |  |  |  |
|  | 6 | 30 | 77.07 | 19.08 |  |  |  |
| MDAB | 7 | 30 | 74.50 | 12.84 | 1.60 |  |  |
|  | 8 | 30 | 79.87 | 18.13 |  | 1.93 |  |
|  | Total | 120 | 75.44 | 17.67 |  |  |  |

Table 3: T-test analysis results for PPI, MDYT and MDAB data of secondary school students on the basis of gender

|  | Gender | N | Average | Std. Deviation | Std. Error | t | p |
|---|---|---|---|---|---|---|---|
| PPI | Female | 50 | 116.76 | 2.66 | .38 | 1.20 | .23 |
|  | Male | 70 | 113.33 | 2.77 | .33 | 1.15 | .25 |
| MDYT | Female | 50 | 6.30 | 17.66 | 2.50 | 2.12 | .04 |
|  | Male | 70 | 5.23 | 13.66 | 1.63 | 2.14 | .04 |
| MDAB | Female | 50 | 77.10 | 17.95 | 2.54 | .87 | .39 |
|  | Male | 70 | 74.26 | 17.50 | 2.09 | .86 | .39 |

As a result, it was decided to test the PPI, MDYT and MDAB data of all groups with parametric tests.

*3.2 Findings Regarding the First Sub-Problem*

First Sub-Problem: Is there a significant relationship between metacognitive awareness inventory scores and logical thinking skills test scores of students at all grades (5, 6, 7 and 8 grades) in secondary school?
To solve this sub-problem, the correlation between middle school students' metacognitive awareness scores (PPI) and logical thinking skills test (MDBT) scores was investigated. For this, the null hypothesis was tested with the Pearson Correlation analysis technique.

3.2.1. Testing the First Sub-Problem
Null Hypothesis 1: H01: There is no significant relationship between Middle School students' Metacognitive Awareness Scores (PPI) and Logical Thinking Skills Test (MDBT) Scores.
H01: $p = 0$

Null hypothesis 1 was tested with the Pearson correlation analysis technique. Pearson correlation analysis results showed that there was a significant relationship between middle school students' PPI scores and MDBT scores at the 0.01 significance level, and according to this result, the null hypothesis 1 was rejected, r (N = 120) = 0.176, p = .000 <.01. This relationship is a positive and moderate relationship. According to this result, it can be said that there is a significant relationship between metacognitive awareness scores and logical thinking skills scores of middle school students.

Table 4: Pearson correlation analysis results of middle school students' MDAB, MDYT and PPI

|  |  | MDAB | MDYT | PPI |
|---|---|---|---|---|
| MDAB | Pearson Correlation | 1 | .644[**] | .229[*] |
|  | Sig. (2-tailed) |  | .000 | .012 |
|  | N | 120 | 120 | 120 |
| MDYT | Pearson Correlation | .644[**] | 1 | .176 |
|  | Sig. (2-tailed) | .000 |  | .054 |
|  | N | 120 | 120 | 120 |
| PPI | Pearson Correlation | .229[*] | .176 | 1 |
|  | Sig. (2-tailed) | .012 | .054 |  |
|  | N | 120 | 120 | 120 |

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

*3.3 Findings Regarding the Second Sub-Problem*

Second Sub-Problem: Is there a significant relationship between Middle School Students' Metacognitive Awareness scores and their academic achievement scores in mathematics lesson?

In order to answer this sub-problem, the correlation between the Metacognitive Awareness Scores of middle school students and their academic achievement in the Mathematics course was investigated. For this, the null hypothesis was tested with the Pearson Correlation analysis technique.

3.3.1 Testing the Second Sub-Problem
Null Hypothesis 2: H02: There is no significant relationship between Middle School Students' PPI scores and MDAB scores.
H02: p = 0

Null hypothesis 2 was tested with the Pearson correlation analysis technique. Pearson correlation analysis results showed that there was a significant relationship between the PPI scores of middle school students and MDAB scores at the 0.01 significance level, and according to this result, the null hypothesis 2 was rejected, r (N = 120) = 0.229, p = .000 <.01. This relationship is a positive and moderate relationship. According to this result, it can be said that there is a significant relationship between metacognitive awareness scores and academic achievement scores of middle school students.

*3.4. Findings Regarding the Third Sub-Problem*

Third Sub-Problem: Is there a significant relationship between the logical thinking ability scores of middle school students and their academic achievement scores?

In order to find an answer to this question, the correlation between the Logical Thinking Skills Test (MDBT) scores of pre-service science teachers and their Academic Achievement in Mathematics Course (MDAB) scores was investigated. For this, the null hypothesis was tested with the Pearson correlation analysis technique.

3.4.1. Testing the Third Sub-Problem
Null Hypothesis 3: H03: There is no significant correlation between MDYT scores and MDAB scores of middle school students.
H03: p = 0

Null hypothesis 3 was tested with the Pearson correlation analysis technique. Pearson correlation analysis results showed that there was a significant relationship between MDYT scores and MDAB scores of middle school students at the significance level of 0.01, and according to this result, the null hypothesis 3 was rejected, r (N = 120) = 0.644, p = .000 <.01. This relationship is a positive and high level relationship. According to this result, it can be said that there is a significant relationship between the logical thinking skills scores of middle school students and their academic achievement scores in the mathematics course.

## 4. Discussion, Conclusion, and Suggestions

*4.1. Discussion*

According to the results obtained from studies on metacognition, a significant relationship was found between metacognition and problem solving success. In addition, providing students with metacognitive and logical thinking skills increased the problem solving success in mathematics lesson. When qualitative studies on metacognition and problem solving were examined, it was determined that in most of these studies, metacognitive skills exhibited only in the problem solving process for mathematics were dealt with a limited number of samples. In qualitative research, unlike quantitative research, the sample is not large enough to represent the universe, so the results of such studies do not allow to reflect the general situation and make

analytical generalization. When quantitative studies on metacognition and problem solving are examined, it is seen that the relationship between these two concepts is determined using only correlation analysis. Such an analysis does not allow for deeper interpretations beyond revealing the strength of the relationship between variables. In this context, there is a need to use stronger statistics that allow the relationships between variables to be examined. In addition, when the studies in the literature are examined, it is seen that the number of studies dealing with the concept of metacognitive awareness in any course is quite limited. As a matter of fact, these studies try to examine the metacognitive awareness levels of students in general without any lesson-based. Unlike the studies in the literature, the relationship between metacognitive awareness and problem solving skill perception was evaluated within the scope of the mathematics course. In this study conducted at secondary school level, students' mathematical metacognitive awareness and perceptions of general problem solving skills were determined. The current study differs from the relevant studies in the literature in all aspects and also in terms of data analysis method. Based on this, the aim of this study was to determine the effect of middle school students' metacognitive awareness and logical thinking skills on academic achievement in mathematics lesson.

*4.2 Conclusion*

The problem solved in the study is as follows: "Do middle school students' metacognitive awareness and logical thinking skills have an effect on academic achievement in mathematics lesson?" in the form. The first of the sub-problems that need to be answered while seeking answers to this problem is, "Is there a significant relationship between the metacognitive awareness inventory (PPI) scores and the logical thinking skills test (MDYT) scores of students at all grade levels (5th, 6th, 7th and 8th grades) in secondary school)?" As a result of the analysis performed to find an answer to this sub-problem, it was revealed that there was a positive significant relationship between middle school students' metacognitive awareness and logical thinking ability.

The second sub-problem of the study, "Is there a significant relationship between middle school students' metacognitive awareness inventory (PPI) scores and their academic achievement (MDAB) scores in mathematics class?" It was noted as. As a result of the analysis, it was determined that there is a moderately significant positive correlation between the metacognitive awareness scores and academic achievement scores of middle school students. When the studies on the subject are examined, studies supporting this result are encountered. Bağçeci et al. (2011) found a positive significant relationship between students 'metacognitive awareness and their success in the SBS central exam, and it was found that there was a positive significant relationship between students' metacognitive awareness and year-end grade averages. According to the results obtained in the study, it can be said that metacognitive awareness is a positive predictor of course success. Gürşimşek et al. (2009) stated that students with high metacognitive awareness have a more comprehensive problem-solving understanding than students with low metacognitive awareness. As it is known, problem solving ability is one of the high level mental skills and is very important for learning. Considering that students with a high level of metacognitive awareness have a more positive understanding of problem solving, it can be stated that they may be more advanced in terms of course success. Young & Fry (2008) examined the relationship between the metacognitive awareness of university students and their academic success in their study and found similar findings. According to Young & Fry (2008), it has determined that there is a positive significant relationship between academic achievement and metacognitive awareness of university students. In addition, Coutinho (2007) conducted correlation and regression analysis in his research with 179 undergraduate students at Midwestern University and found that metacognitive awareness was related to academic achievement.

The third sub-problem of the study, "Is there a significant relationship between the logical thinking skills test (MDYT) scores of middle school students and their academic achievement (MDAB) scores in the mathematics course? expressed in the form. According to the findings, there was a significantly and positively high level of relationship between the logical thinking ability scores of middle school students and their academic achievement scores. Kıncal and Yazgan (2010) obtained similar results in their study on primary and secondary school students and found a significant relationship between logical thinking and course success.

*4.3. Suggestions*

Within the framework of the teacher training and program, we can work in cooperation with the Ministry of National Education and our universities to determine and develop individuals' metacognitive awareness and logical thinking skills in order to ensure that the future generations of teacher candidates studying in Education Faculties at our universities have metacognitive skills. In addition, seminars and trainings can be given by experts in this field in public education centers and meeting halls within the scope of non-formal education of our teachers who are currently working as teachers. Metacognitive awareness and logical thinking skills, which have an effect on the academic success of teacher candidates studying at education faculties at universities, can be developed and exams that measure the development level of these skills can be applied by taking these skills into the acquisition.

New acquisitions can be prepared for students who are found to have low metacognitive awareness and logical thinking ability levels of our current teachers who have passed or have passed the trainings provided within the framework of the new principles, and new exams can be applied to students to experience success by examining these skills in terms of gender factor and supporting the group with a low level.

Courses including cognition, metacognition and logical thinking skills can be taught in educational programs of universities. Considering the practical studies, the effect of metacognitive awareness and logical thinking skills on learning can be investigated.

By organizing plans, programs and activities aimed at improving metacognitive awareness, their effect on the learning and teaching process can be investigated. However, lesson tools and materials that support the development of metacognitive skills and metacognitive awareness can be included in the curriculum.

Considering the effects of logical thinking skills and metacognitive awareness in achieving academic success, these skills can be included in learning environments.

In the light of the researches, teaching strategies that are thought to be effective in differentiating the level of metacognitive awareness and logical thinking ability according to the class level variable can be developed and integrated by examining in-class teaching methods and techniques.

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