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Comparison of Performance-Based Techniques to Increase Addition Fluency: A Brief Experimental Analysis Study

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Abstract

A Brief Experimental Analysis (BEA) is an evaluation process based on the determination of the student's response to treatment conditions in order to select the most effective treatment for the student. In literature, by the help of the BEA, the treatment items that are effective in displaying the academic skills in a correct and fluid manner has been determined in recent years. Although effective treatments have been selected in reading and writing areas by using the BEA, there is very little study in the field of mathematics in which the BEA is applied.

This study aims to determine the effective performance-based treatment techniques which increase the students' mathematical processing speed with the help of the BEA. Two students with a low mathematical processing speed at the first grade level participated in the research. In the BEA process of the study, a brief multielement design was used. From performance-based techniques; contingent reinforcement, graphical feedback, timing, verbal encouragement and making a choice techniques were applied. Results varied among students. While the effective treatment techniques were found to be making a choice and verbal encouragement for the first student, it was the timing for the second student.

Keywords

Brief Experimental Analysis

Operational fluency

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Introduction

Basic academic skills such as reading, writing, and operating are skills that are prerequisite for learning. The difficulties that pupils exhibit in these skills affect their learning. Determining what a student can actually do and what he/she is expected to do forms the basis for understanding and explaining the inadequacies of academic skills (Özmen, 2014). Instructional problems that affect skill acquisition, such as inadequate motivation, inadequate practice, inadequate modelling, and inadequate feedback, can affect students' performance negatively in teaching academic skills (Daly, Witt, Martens, & Dool, 1997). When the achievement level of students with difficulty in academic skills was examined the literature, it was seen that reason of existing problem was grouped as skill and performance based. Different teaching factors can lead to problems grouped as skill and performance-based in literature. Skill problems can be noticed as a result of the low accuracy rate of the exhibited performance and this situation shows that the students do not get the necessary skills (Daly et al., 1997). In this case, error

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correction techniques are used in order to increase accuracy. Performance problems, whichare often attributed to the lack of motivation, are used for situations where the student is inadequately fluent in exhibiting this skill, although there is an acceptable level of skill presence without a problem at the acquisition level and students do not want to do the relevant skill (Daly et al., 1997; Özmen, 2014). Strategies used for students with performance problems include using time well, providing feedback on performance and setting goals (Daly et al., 1997; Poncy, Skinner, & Jaspers, 2007). Performance-based techniques are preferred to increase skill fluency.

In recent years, effective treatment has been selected for the teaching of academic skills through the BEA surveys. The BEA is an evaluation process based on the assumption that instructional variables have impact on academic achievement (Daly et al., 1997; Lewis-Lancaster & Reisener, 2013; Wilber & Cushman, 2006). In the BEA process, treatment techniques that increase fluency and accuracy, and that are predetermined according to student performance are applied to the student so as to decide the most effective treatment technique for the student (Kennedy, 2005). In this process, firstly, the student's beginning level is determined. Then, treatment techniques, which are determined by alternating treatment design or by brief multielement design (Orçan & Özmen, 2012), are applied alternately or sequentially, and the most effective treatment is decided by comparing the responses of the student to the treatment conditions (Wilber & Cushman, 2006).

The BEA surveys focus more on fluent reading and correct reading. However, also in mathematical procedures, effective treatment can be selected by using the BEA. Especially, the effectiveness of many treatment techniques has been tested in studies aimed at increasing the operational fluency in mathematics. These techniques are performance feedback, goal setting, reward, timing and making a choice. Research in the field of mathematics emphasizes the importance of fluency in mastering a skill (Grafman & Cates, 2010; Hoda, 2006; Mong & Mong, 2010, 2012). Codding et al. (2009) examined the effectiveness of performance-based techniques on mathematical fluency. In the study, the performance level of the performance feedback, the goal setting, and the reward were determined to be on four students. As a result, it has been found that performance-based techniques are effective in increasing students' mathematical processing fluency and that they are different in each student. Carson and Eckert (2003) tested the effectiveness of timing, making a choice, reward, confirmatory feedback and goal setting in basic mathematical operations on three students who showed performance problems in mathematical processing fluency. The results of the research showed that the performance based techniques selected for the three students were effective in increasing the mathematical processing fluency.

Research has emphasized that motivation problems play a role in the fluency of the skills (Wilber & Cushman, 2006; Lewis-Lancaster & Reisener, 2013). In order to avoid these problems, it is necessary to include the following components in order to complete the task correctly: positive reinforcement (Holt, 1971; Taffel & O'Leary, 1976), feedback (Daly et al., 1997; Skinner, Turco, Beatty, & Rasavage, 1989; Skinner, Shapiro, Turco, Cole, & Brown, 1992; Van Houten, Hill, & Parsons, 1975), goal setting (Eckert, Ardoin, Daisey, & Scarola, 2000; Fuchs, Bahr, & Rieth, 1989; Van Houten et al., 1975), timing (Rathvon, 1999; Rhymer, Skinner, & Hennington, 1998; Van Houten & Thompson, 1976), and making a choice (Carson & Eckert, 2003). When the literature was examined, studies conducted withdifferent group and class levels on mathematical processing fluency were found to be limited in Turkey. In the study conducted by Alptekin, Vural, and Aksoy (2016) with a single subject experimental design, the effect of a skill-based intervention technique on the flow of mathematical addition fluency was tested. It was found that there was an increase in the number of addition that the student solved. Another study by Küçüközyiğit and Özdemir (2017) examined the effect of self-monitoring technique in increasing the multiplication fluency of students with visual impairment. As a result of the research, an increase was observed to be in students' multiplication fluency and accuracy. Various methods and techniques were used to increase the mathematical fluency in the aforementioned studies but these studies did not include the BEA process.

Research conducted in the field of mathematics in recent years has shown that performance-based techniques are effective for students with fluency problems and shows that these techniques differ in each student. However, the number of studies in which each student is compared within the cause of performance retardation remains limited. It is considered that determining the motivational components that affect the fluency of students who have performance problems in the field of mathematics, and that putting these techniques in the curriculum, will increase the student success and will prepare the effective and efficient teaching environment to the teacher. With the BEA process, the effective technique is initially decided for the student, then it is organized to include the teaching technique. Thus, teaching is made effective and productive with the technique or techniques that are determined to be effective, by arranging teaching process according to the students without subjecting the student to a long intervention process. It also differs from other BEA studies in terms of the choice of the set of activities the student will take and the combination of techniques that support both internal and external motivation. That's why, based on the motivation problems, this study aims to determine which of the performance-based techniques is more effective technique in increasing the number of operations performed independently by the two students who have problems in the addition fluency via the BEA. The mentioned performance-based techniques are Target-Based Reward (TBA), Graphical Feedback (GF), Timing (T), Making a Choice and Verbal Encouragement (MCVE).

Method

Participants and Settings

Two students with a low rate of addition without carry during the first year of primary school participated in this study. The primary school where the participants are located includes classes from the kindergarten to the fourth grade level. Education and training activities based on curriculum of the Ministry of National Education (MONE) are being carried out in the school. The first-year curriculum includes five-hour math skills instruction in a week.

Firstly, the teacher of the first grade was interviewed in order to determine students with a low rate of addition without carry. He reported that there were two students in his class. Secondly, these students were directly observed in the mathematics class for an hour in two consecutive days. During this observation, it was noticed that the students independently fulfilled the academic duties required by the teacher, but failed to fulfil them on time. It was also observed that they were interested in other tools on the table instead of continuing to solve the process and could not pay attention to the operations. Thirdly, to determine the correct number of operations per minute for all students in class, except for the reported students, the worksheets containing addition without carry were distributed and the class average was determined. Students in the class have solved an average of 10 additions without carry with accuracy of 95% and above, with a maximum of 16 and a minimum of 4 per minute. Based on the minimum number of operations in the class, the two students reported by the teacher among the students who had less operations than 4 additions without carry were involved in the research. It was determined that these students solved two operations per minute and that the operation accuracy was 100%. The performance of the students showed that they could solve the problem correctly but had a problem in the processing fluency. For this reason, it was decided to select the performance-based techniques.

The first student is a seven-year old girl. The second student is a seven-year old boy. It was observed that the literacy skills of these students were below the class average. The classroom teacher reported that these students had problems in some issues such as participating the lesson, performing the assigned task independently, and completing the given task.

Table 1. Participants Features

Participant	Gender	Age	Problem Areas
First student	Female	7	Attendance to lesson Task completion Homework completion Reading fluency
Second student	Male	7	Attendance to lesson Task completion Homework completion Reading fluency

The experimental phase of the study was conducted in a class used for individual studies at school. There was a table and two chairs in the class and a video camera to record sessions during the experiment. In order to determine application reliability and interobserver reliability, the experiment process was recorded with a camera.

Selection of Research Design and Treatment Techniques

BEA process was used to test the reasons for the low rate of addition without carry of students participating in the study (Daly et al., 1997) and to determine effective treatment for the student (Parker, Dickey, Burns, & McMaster, 2012). BEA processwas carried out by using a brief multielement design. In the brief multielement design, a session initiation level data is first collected, then the effects of the treatment techniques are tested by applying them for one sessions. After the most effective treatment technique is identified for the student, the effectiveness of the treatment technique, which is determined to be effective by retaking initiation level data, is retested (Parker et al., 2012). When the most effective treatment is determined, the brief experimental analysis process is terminated. In this study, firstly, students'starting level was determined and then treatment techniques were appliedfor once. As a result of the application,the effectiveness of each intervention technique is calculated by counting the correct actions.Since there are more than one effective techniques and the numbers are close,the student's starting level data was taken again. Then effective techniques were applied to the student again in order to test the most effective techniques.A total of eight session tests were conducted for each student, two sessions per day, with a 45- minute break between sessions. Five working days per week were worked on each subject individually. The experiment process was completed in two weeks.

The evidence-based performance-based techniques that were selected for this study are target-based reward (Holt, 1971; Taffel & O'Leary, 1976; Eckert et al., 2000; Fuchs et al., 1989; Van Houten et al., 1975), performance feedback (Daly et al., 1997; Skinner et al., 1989; Skinner et al., 1992; Van Houten et al., 1975), timing (Rathvon, 1999; Rhymer et al., 1998; Van Houten & Thompson, 1976), verbal encouragement (Wilber & Cushman, 2006), and making a choice (Carson & Eckert, 2003; Cosden, Gannon, & Haring, 1995; Dunlap, Kern-Dunlap, Clarke, & Robbins, 1991; Dunlap et al., 1994; Dyer, Dunlap, & Winterling, 1990). Target-based reward and graphical feedback were chosen because of the hypothesis that the low rate of student performance might be due to inadequate motivation (Daly et al., 1997), while timing, making a choice, and verbal encouragement were chosen because they were thought to be the result of the student's inability to concentrate their attention on the skill. The order of application of the techniques was determined from the easiest to the most difficult one (Carson & Eckert, 2003; Daly et al., 1997).

Instruments

Worksheets: Worksheets consist of additions without carry. Work sheets were arranged in the order of seven operations per row, and a working paper consisting of 35 operations was prepared. When preparing operation papers, the operations were prepared with each treatment situation in mind and the operations are differentiated in each row so that the student does not encounter the operations that s/he solved in a treatment condition. Besides this, the level of difficulty of operations on each line is equalized. Therefore, attention has been paid to the distribution of operations (e.g., 11+0, 13+1, 23+2, 5+4) on each line the operation. Also, while selecting operations, the operation papers and operation orders are presented in different order for each condition so that the applied techniques do not interfere with each other.

Rocket Graphics: Rocket graphics are used to show the correct operation numbers of students in graphical feedback condition.

Reward list: For each student, a list of rewards determined by asking the teacher and his / her parents was used. As a result of interviews with the family and the teacher, the rewards that the students like were determined and the rewards list for each student was created. The rewards include school supplies, food, beverages, jewellery, and an event promoter (watching cartoons). In the reward lists, 5 to 6 rewards were found for each student.

Experiment Process: Permission has been obtained from the school administration, student parents and classroom teachers before starting the application. The experiment was carried out by the researchers in the following stages.

Baseline: Prepared worksheets were given to the student and s/he was instructed as "Do additions!" The student had one minute, when the time finished, s/he was told that the work had finished by taking the operation sheet. The evaluations were made by counting the correct operations the student made.

Contingent Reinforcement: The student has selected three rewards from the reward list. In this condition, 25% and 15% increase criterion was set for the correct number of operations per minute according to the student' beginning level. If the student makes an operation representing a 25% increase, s/he was given the first reward, while the second reward was given to him/her if a 15% increase occurs. For evaluation, the number of operations that the student solved per minute was calculated, s/he was given the reward according to the criterion reached, and the study was terminated. The target-based reward session lasted between 10 and 15 minutes.

Graphical Feedback: The student was shown a rocket chart with 10 lines (class average). The student was told: "Look! There is a rocket here. Now you will solve the operations on paper that I give you, you can paint this rocket chart as many times as you do correctly." The rocket graphic was painted using operation papers other than the target operations so that students could understand the practice. The student was instructed as "Solve!". The instruction of "Stop!" was given one minute later, and the student was informed about the number of correct operation s/he had solved. Accordingly, the student was informed that s/he could paint the number of rocket graphic line as many times as s/he had correct answers. The Graphical Feedback session lasted between 10 and 15 minutes.

Timing: Given work sheet, the student was told: "Now we will focus on the timing of this work with you. When I say 'Star', you will start; when I say 'Stop', you will stop. and you will circle the last operation." The "Solve!" instruction was provided. This process was repeated 2 times, with the student stopping at 30-second intervals. The evaluation was made by counting the correct operations completed by the student.

Making a choice and verbal encouragement: By showing worksheet and instructing as "you can solve this paper starting with the procedure you want", it was made possible for student to make a choice. Then, s/he was instructed as "Let's start, if you are ready". The student was provided with verbal encouragements such as "well done, you are doing well, you are wonderful" throughout the course. After the time finished, the students were evaluated by counting the number of solved operations.

Data Collection and Scoring

After intervention, the operations that the learners have solved correctly for a minute are calculated and evaluated through the transaction papers given to the students.

Data Analysis

When the BEA results the results were visually analyzed and the level of the data points in the intervention sessions were compared. It has been determined that if the level of data obtained in a treatment session is higher than the data obtained in other treatment sessions, the treatment technique applied is more effective than other treatment techniques.

Inter-observer Reliability and Application Reliability

Generally, reliability data is collected at least from 20% of sessions in studies (Alberto & Troutman, 2009). Inter-observer reliability was calculated for 33% of the study to include all experimental phases. Inter-observer reliability is calculated by a person with a post-doctoral study in special education. In order to calculate the inter-observer reliability, the observer was given video and worksheet, and asked to determine the correct number of operations the student did for a minute. Inter-observer reliability is calculated by dividing the total view union among the observers by observers by the sum of the view unity and the view distinction and multiplying by 100 (Reliability = consensus/consensus+ dissensus x100) (House, House, & Campbell, 1981).It is thought that observers and practitioners are in agreement when inter-observer reliability is 80% and above. For the first and second students, the inter-observer reliability was found to be 95%.

In order to calculate the application reliability, application steps of each treatment condition were transformed into check list and application reliability form was created. The entire experimental process was video-recorded. Application steps checklist and videos were given to the observer participated in the interobserver reliability study. Observer was asked to mark the implementation phases by watching the videos. Application reliability is calculated by dividing the observed applicator behaviour divided by the planned applicator behaviour. Application credibility is calculated for all sessions. It was found 100% for the beginning level, 90% to 100% for the contingent reinforcement condition on average 95%, 100% for graphical feedback, 100% for timing condition, and 100% for making a choice and verbal encouragement.

Results

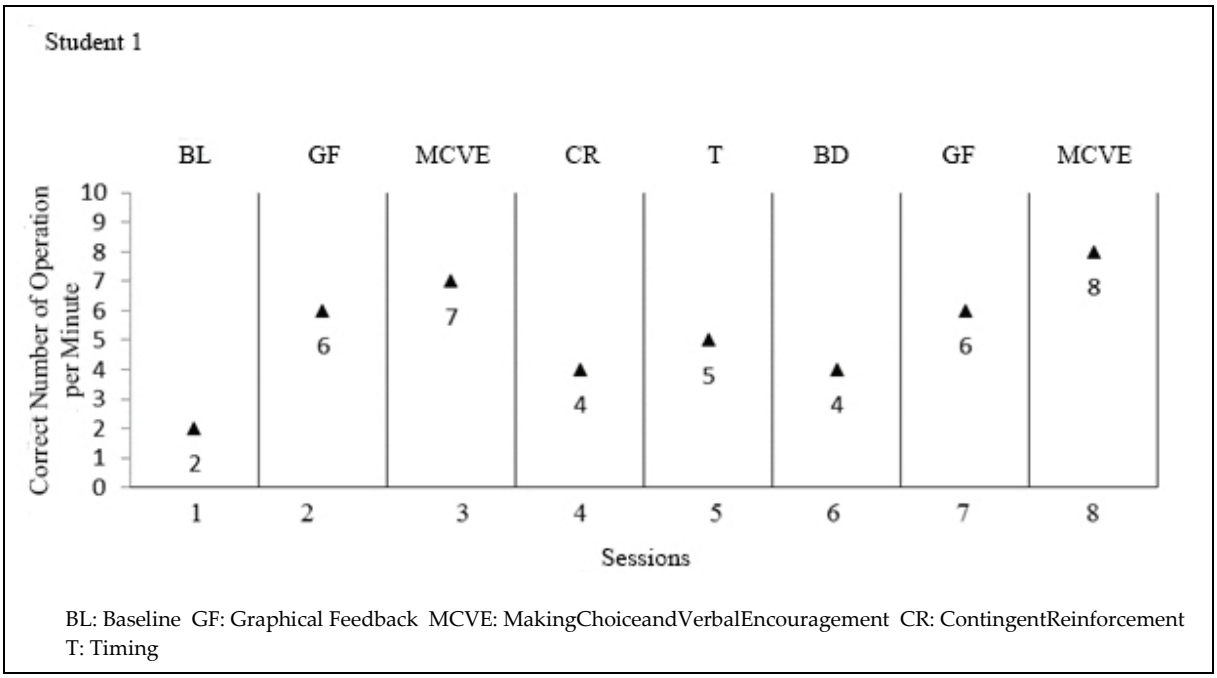

Figure 1. The First Student's Beginning Level with Short Experimental Analysis and the Number of Operations Done Correctly in One Minute in the Treatment Conditions

It is seen that the first student made two operations in the BL condition, six operations in the GF condition, seven operations in the MCVE condition, four operations in the CR condition and five operations in the T condition. When the level of data points in Graph.1 is compared, the highest level data point is MCVE and GF. Since the number of correct operations performed per minute in MCVE and GF conditions was very close to each other, the BL condition was applied to determine the most effective treatment condition. In the BL condition, the student made four correct operations per minute. When the GF was reapplied, the student performed the six operations correctly, while s/he made eight times per minute when the MCVE was reapplied. According to this result, the most effective technique for increasing the processing speed for the first student was MCVE. This result suggests that in order to increase the number of correct operations, making a choice and verbal encouragement techniques should be emphasized in order to improve the student's motivation in teaching practice (Carson & Eckert, 2003).

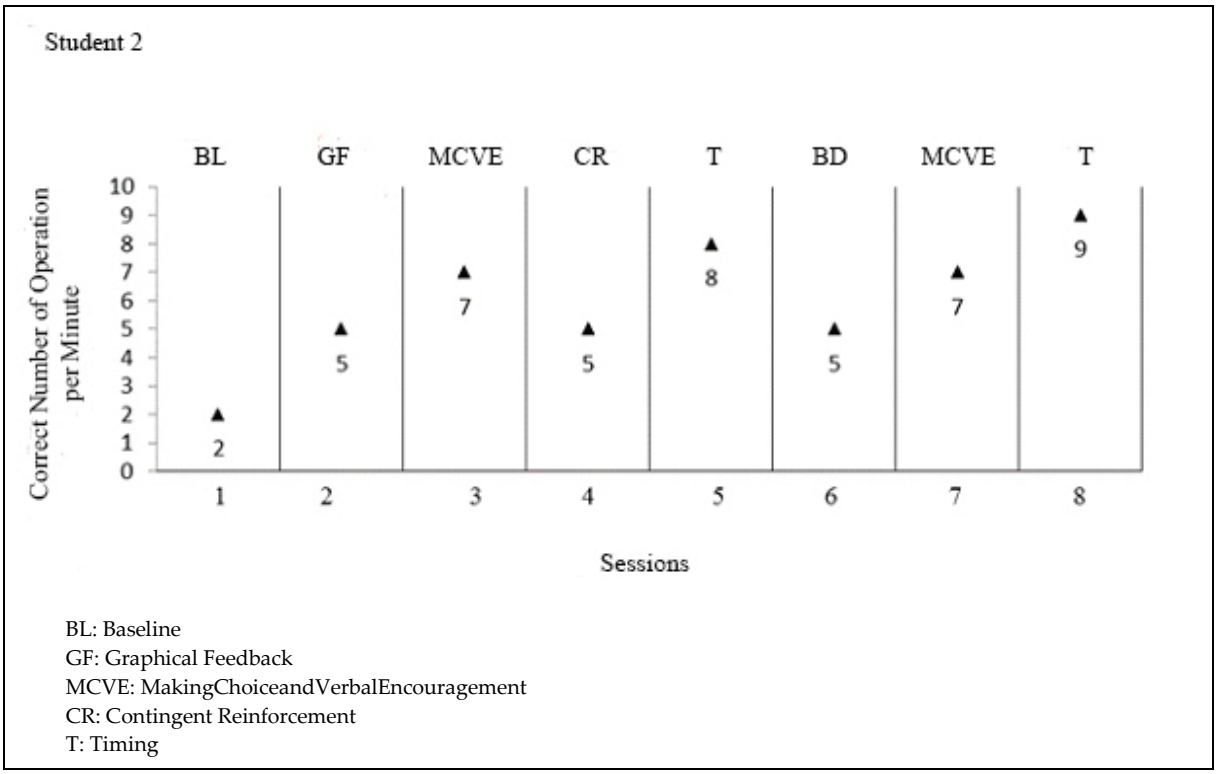

Figure 2. The Second Student's Beginning Level with the Brief Experimental Analysis and the Number of Operations Done Correctly in One Minute in the Treatment Conditions

The second student appears to have performed two minutes of operation in BL condition, five operations in GF condition, seven operations in MCVE condition, five operations in CR condition and eight operations in T condition. When the level of the data points is compared in Graph.2, it is seen that the data point is at the highest level in MCVE and T conditions. However, since the number of correct operations performed per minute in MCVE and GF conditions was very close to each other, the BL condition was applied to determine the most effective treatment condition. In the BL condition, the student did five correct operations per minute. When the MCVE was reapplied, the student performed seven operations correctly, and when T was reapplied, the student did nine operations per minute. According to this result, T is the most effective technique for increasing the speed of the second student. This result shows that in order to increase the number of correct operations, the student needs to be motivated in instructional practices and to have a timing technique in order to increase attention on the skill.

Discussion

In this study, it was aimed to determine the effective treatment in improving addition fluency by applying the BEA to the students who have difficulties in the addition fluency. In the previous researches, it was concluded that the effective technique for the student could be determined in reading fluency, mathematics and writing skills via the BEA and that the effective technique for students differentiated (Burns, Ganuza, & London, 2009; Chafouleas, Martens, Dobson, Weinstein, & Gardner, 2004; Daly, Martens, Dool, & Hintze, 1998; Daly, Martens, Hamler, Dool, & Eckert, 1999; Daly, Murdoch, Lillenstein, Webber, & Lentz, 2002; Eckert et al., 2000; Eckert, Ardoin, Daly, & Martens, 2002; Güzel Özmen, 2011; Güzel Özmen & Çevik, 2005; Güzel Özmen, Karakoç, Çakmak, & Özdemir, 2009; Parker et al. 2012; Özmen & Atbaşı, 2016). The results of this research support the previous research results. The response of the students to the treatment conditions in the research differentiated. This research shows that effective treatment in mathematical procedures can be determined by brief experimental analysis. This result supports other results of the brief experimental analysis study. For this reason, it is necessary to determine the effective method via the short experimental analysis before introducing the student into a long treatment process.

According to the results of the brief experimental analysis, it is found that the MCVE is effective for the first student whereas the T condition is effective for the second student. Both pupils have approached the class average in these conditions. These results show that the operation fluency of the first student is low because of inadequate motivation, whereas the operation fluency of the second student is low because he could not keep his attention on the skill during the study and he had motivation problem. Providing students with the opportunity to make choices has a positive effect on behaviour (Cosden et al., 1995; Dunlap et al., 1991; Dunlap et al., 1994; Dyer et al., 1990). In particular, providing opportunities for students to choose their duties and rewards increases the duration of completing their tasks and focusing on accuracy and work (Kern et al., 1998). In addition, some studies show that giving only choice to students can provide the desired change in behaviour (Cosden et al., 1995; Dunlap et al., 1994; Dyer et al., 1990). These results show that the ability to make choices is an important factor affecting pre-work motivation. The addition of the making a choice component within the treatments offers different options and opportunities regarding the task the student will do. Providing the student with opportunities and options related to the task may enhance the student's motivation while doing the task. Since verbal encouragement will increase the student's attention on the skill (Wilber & Cushman, 2006), making a choice and verbal encouragement techniques were presented together in the current study. The results of the current study indicate that, after a brief experimental analysis, the combination of making a choice and verbal encouragement is effective in a student.

The timing technique concentrates the attention of the student on the skill, and at the same time acts as a motivation tool (Rathvon, 1999; Rhymer et al., 1998; Van Houten & Thompson, 1976). As a result of this research, the timing technique was found as effective technique in a student. This result supports the research indicating the importance of the timing technique (Carson & Eckert, 2003).

These results show that the use of the BEA method for addition fluency will contribute to the field. However, this research has some limitations. One of the limitations is the fact that the effect of the selected technique on the student's addition fluency was not tested with the extended analysis(examining the long-term effectiveness of the techniques compared to the least effective techniques). Another limitation of the research is the fact that this study was carried out with only two students.

Based on the motivation problem, performance based techniques were determined in the study. In the future research, the effects of the BEA can be examined in order to increase the mathematical processing fluency in different groups of students by providing different skills and performance based treatment techniques and packages.

As a result, the current study has identified the performance-based techniques that are effective in increasing mathematical processing fluency of the students. It is thought that such evaluation will guide the determination of the treatment/treatments that enhance(s) the performance of students effectively in a short period of time. For this reason, it is suggested that teachers and researchers should include the BEA process in increasing mathematical processing fluency of the students.

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