# A Case Study of Math Ability Improvement of Autistic

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## Abstract
The primary intent of this research is to develop the math ability of an individual with Autism, whose name is Fan. During 25 days, we conducted tests every day and collected sufficient amount of data to demonstrate which is a better way to improve Fan's math ability. Alternating intervention was used: One is reading math books, the other one is reading books with reward (reading the same math books and with reward). After a 5-day baseline period without any intervention, two intervention strategies were delivered on alternating days. This article is going to display the test data and illustrate how it works in autistic. From the test result, reward is a more effective intervention to develop kid's math ability.

**Key words:** Reinforcement; Intervention; Autism; Math ability improvement; Empirical

## INTRODUCTION
The world is such a busy one. People in it focus too much on the integrity thus sometimes neglect trivial yet important aspects of life. Special education is one of the essential components that has been ignored for a long time. Normal people like us always want to improve our academic mathematics due to a lot of reasons such as The National College Entrance Examination. It is quite weird that when it comes to special children, people do not even care if they acquire enough academic knowledge; all they care is if those special children can have a normal life. We should change this biased perspective and attempt to improve the academic skills of special children.

The main reason that special children with autism have been focused on in this study, is because of the limitation of their sociability which could have great impacts on their lives. People need to be accepted by the society and others one day, especially for those kids.

Therefore, I decided to do a case study about ways to improve an 11-year-old boy with autism to develop his math ability, whose name is Fan. The reason I chose a case study is that it is designed to bring out the details from the viewpoint of the participants by using multiple sources of data (Tellis, 1997). Moreover, I am also interested in autism, and then I chose to focus on only one kid instead of a lot of special children. I adopted two ways to improve the kid's math ability; hence, my research question focus on which is the more effective way to improve Fan's math ability.

This paper is going to display the research and experiments on mathematic ability improvement of a kid with autism. The next section is focusing on some of the background information about autism, historical research on developing math ability of special children. Then the methodology will be introduced, followed by results and discussions. The last section is a short summary.

## 1. RELATED RESEARCHES

### 1.1 Autism and Autistic Savant
The word "autism" is widely known by people, however, many people define this term as people who do not like talking with others. Smith (2001) said that all children with autism have impairments in communication and in social skills, and restricted and repetitive behavioral

patterns or range of interests. The definition from Collins Dictionary is: "Autism is a mental disorder that affects children, particularly their ability to relate to other people". In addition, the federal government defines autism in this way: "A developmental disability significantly affecting verbal and nonverbal communication and social interaction, generally evident before age 3 that adversely affects a child's performance".

Several well-known causes of autism have come into being since the last century. Some researchers believe that at least some forms of autism are caused by injury to the brain stem (Krieger, 2010). Others suggest that autism is basically a failure of the frontal lobe (Dawson, Meltzoff, Osterling, & Rinaldi, 1998). Regardless, it appears that autism probably has a genetic basis (Pelphrey et al., 2002). Although the cause is unknown, experts believe that autism is a life-long neurologically based disability. No consistently effective medical or behavioral treatments are currently available (Smith, 2001).

People with savant syndrome often score low on intelligence tests already have an island of brilliance (Myers, 2014). The definition from Myers' psychology for AP is: "Savant syndrome a condition in which a person otherwise limited in mental ability has an exceptional specific skill, such as in computation or drawing" (Ibid.). Donnelly and Altman (1994) have suggested that the social and communication deficits characteristic of autistic children may underlie the maladaptive manifestations in their cognitive and/or esthetic capabilities which leads to the idiosyncratic skill areas associated with the savant syndrome.

Some of the autistic savants have special skills, for example, in memory of statistics, dates, telephone numbers or similar types of data. And they can even recall details after a long time. Given a date in the far past or distant future, they are able to tell on which day of the week it falls (Rimland & Fein, 1988). A good example is depicted in the movie "Rain Man" where Raymond did mathematical problems faster than a calculator, but could not make change or understand the value of money (Donnelly & Altman, 1994).

## 1.2 Comparing intervention

Identifying effective interventions often require a comparative strategy as well. When the researcher has identified the target behavior to be examined, more than one potential intervention may come to mind (Morgan & Morgan, 2001). In fact, in some cases there may be sizable literature attesting to the effectiveness of each type of intervention. In such cases, the researcher may find it prudent to utilize both interventions for a particular subject in an effort to discover which intervention is the most effective in this particular case.

Pitting two or more interventions against one another to identify the most effective intervention can be undertaken through the use of an alternating-interventions design (Ibid.). As the name implies, such a design involves systematically alternating the interventions across some reasonable time frame and comparing the relative response of the target behavior to each treatment. The manner in which the competing interventions will be alternated depends on the details of the behavior being targeted and the setting in which the treatments will be employed. In the alternating-interventions design, behavior change that tracks the rapid phase changes (baseline to treatment, or Treatment A to Treatment B) strongly suggests a treatment effect (Ibid.).

The design, first described by Barlow and Hayes in 1979 (Barlow & Hayes, 1979), has become one of the more common single-case designs employed applied workers. The alternating-interventions design was derived from a family of experimental designs developed by laboratory scientists studying operant behavior. These designs, including the multiple schedule design (Hersen & Barlow, 1976), simultaneous treatment design (Kazdin & Hartmann, 1978), and multi-element design (Ulman & Sulzer-Azaroff, 1975), were used for the purpose of identifying functional relationships between behavior and programmed stimulus events in basic learning experiments. In general, these designs shared the feature of rapidly changing experimental conditions, with salient stimuli associated with different conditions. Barlow and Hayes (1979) recommended that alternating treatments are gradually gained from applied treatments. As we will see, the design is capable of considerable adaptation and flexibility, as other single-case designs, particularly when serving the goals of applied researchers.

## 1.3 Reinforcement and Punishment

Table 1 is the description of reinforcement from Myers' psychology for AP (Myers, 2014).

**Table 1**
**Description of Reinforcement**

| Ways to increase behavior | | |
| --- | --- | --- |
| Operant conditioning term | Description | Example |
| Positive reinforcement | Add a desirable stimulus | Getting a hug: Receiving a paycheck |
| Negative reinforcement | Remove an aversive stimulu | Fastening seatbelt to turn off beeping |

Another psychology text book, AP Psychology Crash Course (Krieger, 2010), defines those two concepts. Positive reinforcement: "increasing behaviors by presenting positive stimuli, such as food". A

positive reinforcement is any stimuli, when presented after a response, strengthens the response. Negative reinforcement: "increasing behaviors by stopping or reducing negative stimuli, such as chock". A negative reinforcement is any stimuli, when removed after a response, strengthens the response.

Reinforcement increases a behavior; punishment does the opposite. A punisher is any consequence that decreases the frequency of a preceding behavior (Thorndike & Hagen, 1961).

## 2. METHODOLOGY

### 2.1 Dataset and Data Collection

The experiment was conducted in April 2017. The 25-day experiment Informed Consent Form briefly explained the study. Informed Consent Form with Chinese version could be found in Appendix A while the English version is in the Appendix B. With the Informed Consent Form, I was granted permission to give the test and record the grades. All recorded grades and identities of participants in this study are kept confidential and will not be used for other purposes outside of the scope of this research. All records of the interviews are kept in my personal computer protected with a password and were destroyed promptly after transcription.

Fan was exposed to reading math books intervention for first consecutive 5 days (beginning on Monday), and the math book is attached in Appendix C. Without alternating this intervention with the books with reward intervention, Fan had the books with reward intervention (Fan could be rewarded if he scores 9 or above) in the next 5 days. At the end of day, he had the test contains 10 arithmetic problems before going to bed every night. The final version of the test form is attached in Appendix D.

### 2.2 Analysis Process

Quantitative research is regarded as the dominant approach in educational research because of the "cultural heritage of how science is done" (Maykut, Maykut, & Morehouse, 1994), and especially for gathering data such as test grade. Bogdan & Biklen maintain, quantitative research is sometimes restricted to a systematically stated and testable set of propositions about the empirical world (Bogdan & Biklen, 2007). In this experiment, I will analyze the data in the first 10-day experiment and the next 15-day experiment separately.

The arithmetic mean is simple, which is obtained by adding together each item (or value) and dividing by the total number of items (values). The median allows us to find the middle value. This is particularly useful when there are extremes at both ends or at either end of range that may affect the mean to a significant extent. To find the median, values must be listed in order.

The mode, which is not often used in small studies, relates to the most frequently occurring value. The range is simply the difference between the highest and lowest values measured. Each of these measures of central tendency has different uses. As always it depends on what you need to know.

## 3. RESULTS

### 3.1 10-Day Experiment

The data for Fan's grade during reading math books intervention and books with reward intervention are both presented in Table 1. Comparing the mean, mode and median, the grades during reading math books intervention are lower than the grades during books with reward intervention. Moreover, the standard deviation of reading math book intervention is higher than the books with reward intervention, which means Fan's grade during books with reward intervention is more steady than that of during reading math books intervention. The standard deviation during the reading math books intervention is higher which means the score fluctuated more dramatically.

**Table 2**
**Test Grade**

| Reading math books | Day 1 | Day 2 | Day 3 | Day 4 | Day 5 | Mean | Mode | Median | Standard- deviation |
|---|---|---|---|---|---|---|---|---|---|
| Score | 5 | 7 | 7 | 8 | 9 | 7.2 | 7 | 7 | 1.48 |
| **Books with reward** | **Day 6** | **Day 7** | **Day 8** | **Day 9** | **Day10** | **Mean** | **Mode** | **Median** | **Standard- deviation** |
| Score | 8 | 10 | 8 | 9 | 10 | 9 | 10 | 9 | 1 |

In Figure 1, the orange line represents "books with reward intervention" and blue line represents "reading math books intervention". The orange line is above the blue line overall, which means Fan's test performance is much better during "books with reward intervention". There are still outliers such as day 5 and day 1. I also asked his mother whether something happened. This time, on day 5, he got a letter and watch from his brother in another city. His mom said he was so happy that day. This is called positive reinforcement in psychology, which means adding something pleasure. When Fan had positive emotion, he scored higher. I also concluded this positive emotion as a reward. He did the test on day 1 for the first time, so it was not strange he scores 5.
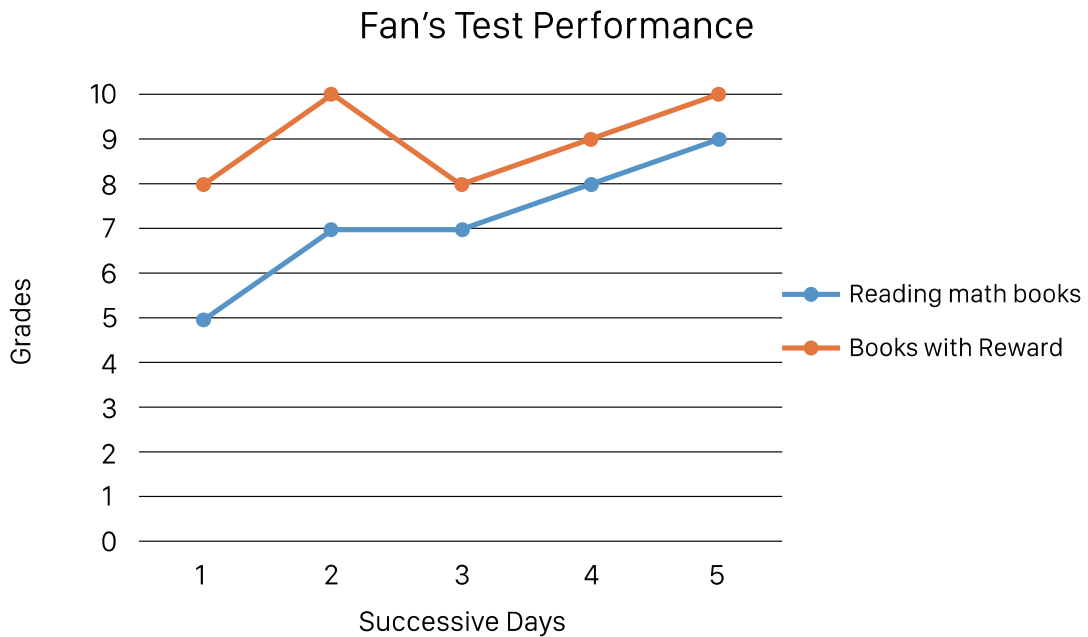
## Fan's Test Performance



**Figure 1**
**Test Performance**

### 3.2 15-Day Experiment

The baseline level of Fan's performance is depicted in Figure 2. During the 5-day period, Fan's reported performance was almost the same as is common of most behaviors observed over time. Moreover, it remained alarmingly low, hovering around six to seven per day. All these grades were based on his own math ability before any intervention.
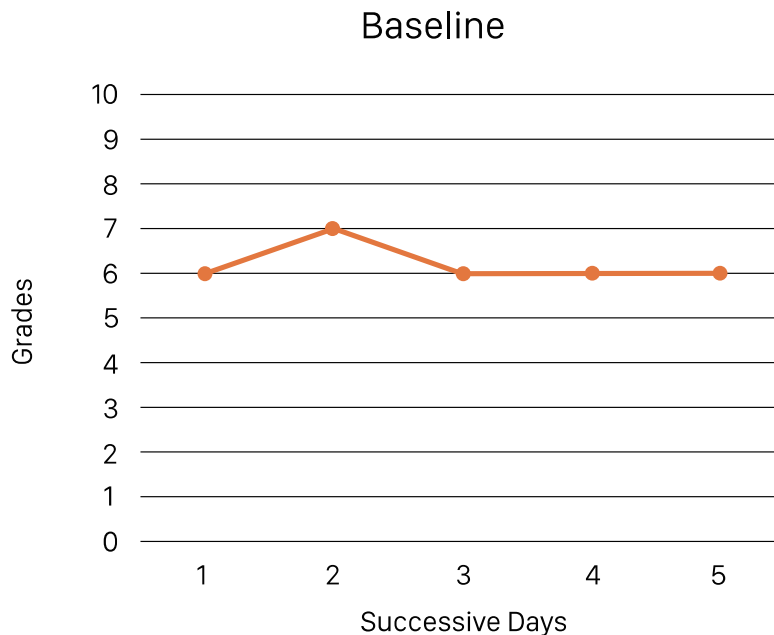
## Baseline



**Figure 2**
**Test Performance Without Intervention**

Figure 3 demonstrates Fan's test performance during the period of alternating interventions (reading math books vs. books with reward). This graph contains two function lines during interventions phase. Each line depicts Fan's test performance (grade he scored per day) under a specific intervention condition. In this particular case, orange line represents grade he scored during the "reading math books intervention", and the blue line represents grade he scored during the "books with reward intervention". It is quite clear that Fan's test performance was considerably greater under the "books with reward intervention" than "reading math books intervention".

Thus, the alternating-intervention design allowed for a quick assessment of two interventions pitted against one another; in particular case, one intervention was decidedly superior.
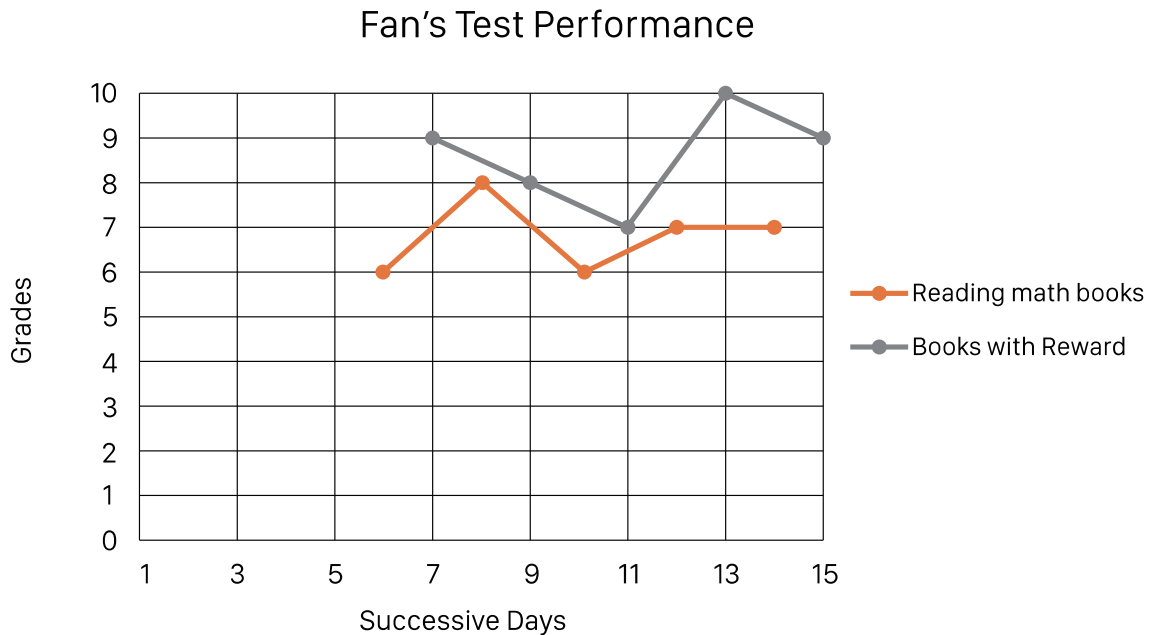
## Fan's Test Performance



**Figure 3**
**Test Performance With Intervention**

But there is a problem, Fan scored 8 on Day 3 but only scored 7 on day 6. It is true that 1 score worth 1 problem, and maybe Fan was just careless when he did that test. But we still needed to figure out why there was an error. Thus, I called his mother asking did anything happened that day, her mother told me that his teacher reproved him since he had an argument with his classmates. Because of the argument and reproach from teacher, Fan had very negative emotion. From psychology perspective, both the argument with classmates and reproach from teacher were negative reinforcement which may cause negative emotion to people, especially people has autism since they are very sensitive. As a result, we can see that emotion was a very significant element when judging Fan's test performance. Fan had bad grades when he had negative emotion. In other words, when he had positive emotion which may be caused by positive reinforcement, he could score higher. Consequently, reward plays a more effective role in improving Fan's test performance. Much more details of this experiment will be presented in following chapter.

The nature of the two interventions makes alternating them on a day-by-day basis quite manageable, so this method was chosen for evaluating the effects of the interventions on Fan's performance. As the result of a simple coin toss, Fan began to read math books on Monday. This intervention required Fan to read one chapter of math books every day at home. Immediately after finishing reading math books, Fan would have a test containing 10 arithmetic problems. This procedure was conducted every night just before going to bed. Thus, in order to complete the test with the requirement, he needed to read each day.

On alternating days, beginning with Tuesday, evolved combinations of reading books and giving reward, Fan was asked to keep reading math books on the day before having test, but he was told that there was a reward if he could score 9 or above 9. Fan was expected, however, to read math books each day as he was expected during a 10-day experiment.

The data for Fan's grade both during the first 5-day period and during the 10-day intervention period are presented in Table 3. Comparing with the mean, mode and median, the grades during reading math books intervention are slightly higher than the grades during nonintervention. On the contrary, the grades during books with reward intervention are significantly higher than both of grades with nonintervention and reading math books. Moreover, the standard deviation of nonintervention grades is the lowest which means the grades for 5-day period are the steadiest. The standard deviation during the books with reward intervention is the highest which means the score fluctuated dramatically.

The data for Fan both during the short (5-day) baseline period and during the 10-day intervention period, in which the two interventions alternated across days, are depicted in Figure 4. Although both the "reading math book intervention" and "books with reward intervention" improved Fan's math ability compared to baseline, over time, the "books with reward intervention" produced greater improvement than the reading math

**Table 3**
**Test Grade with Alternating Intervention**

| Non intervention | Day 1 | Day2 | Day3 | Day4 | Day5 | Mean | Mode | Median | Standard- deviation |
|---|---|---|---|---|---|---|---|---|---|
| Score | 6 | 7 | 6 | 6 | 6 | 6.2 | 6 | 6 | 0.4 |
| **Reading math books** | **Day 6** | **Day8** | **Day10** | **Day12** | **Day14** | **Mean** | **Mode** | **Median** | **Standard- deviation** |
| Score | 6 | 8 | 6 | 7 | 7 | 6.8 | 7.6 | 7 | 0.75 |
| **Books with reward** | **Day7** | **Day9** | **Day11** | **Day13** | **Day15** | **Mean** | **Mode** | **Median** | **Standard- deviation** |
| Score | 9 | 8 | 7 | 10 | 9 | 8.6 | 9 | 9 | 1.01 |

book intervention. During the first 5 days of the test, all the score remained alarmingly low, hovering around six to seven per day. In this particular case, the books with reward strategy seem to have clear advantages, at least for Fan, in bringing about better test performance. Thus, it is obvious that the reward help Fan scores higher.



**Figure 4**
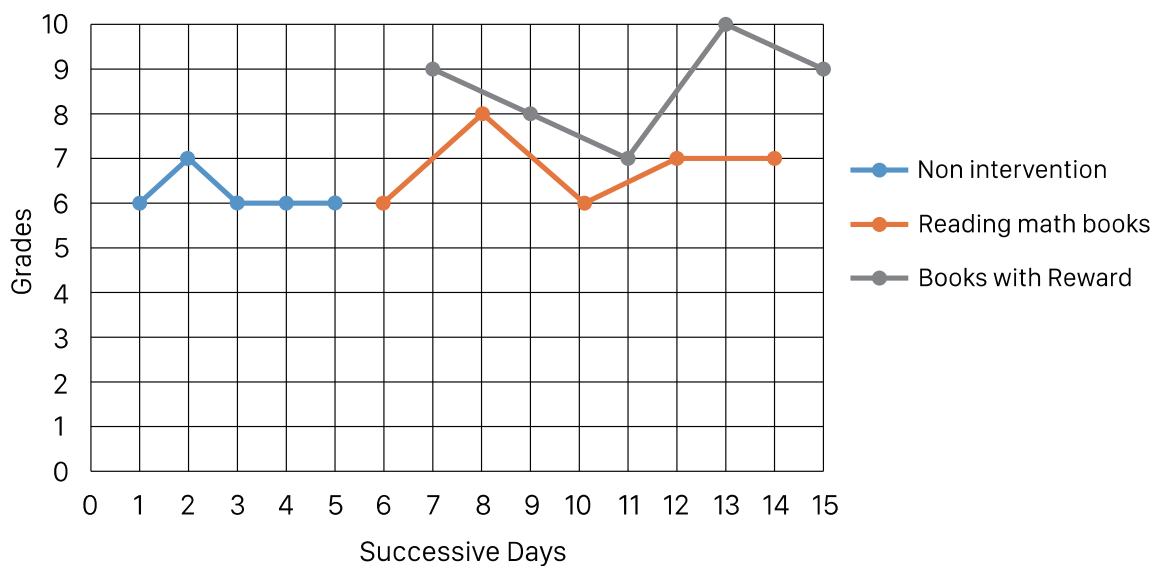**Test Performance With Alternating Intervention**

## DISCUSSION

In 10-day experiment, the books with reward intervention gain the upper hand, at least for Fan, in bringing about better test performance. Thus it's obvious that the reward help Fan scores higher. In 15-day experiment, although both the reading math book intervention and books with reward intervention improved Fan's math ability compared to baseline, over time, the books with reward intervention produced greater improvement than the reading math book intervention. During the first 5 days of the test, all the score remained alarmingly low, hovering around six to seven per day. In this particular case, the books with reward strategy seem to have clear advantages, at least for Fan, in bringing about better test performance. Thus, it's obvious that the reward help Fan scores higher.

Both of two experiments had outliers, and outliers were all caused by his emotion. In the first experiment, on day 5, he got a letter and watch from his brother in another city. His mom said he was so happy that day. This is called positive reinforcement in psychology, which means adding something pleasure. In the second experiment, his teacher reproved him since he had an argument with his classmates. Because of the argument and reproach from teacher, Fan had very negative emotion.

From psychology perspective, both the argument with classmates and reproach from teacher are negative reinforcement which may cause negative emotion to people, especially people has autism since they are very sensitive. The standard deviation in the first experiment shows that Fan's test score fluctuated more dramatically during reading math books intervention. The standard deviation in the second experiment shows that Fan's test score fluctuated more dramatically during books with reward intervention.

Thus, according to the standard deviation, we knew that Fan is influenced by his emotion a lot since Fan is autism. Fan's emotion was influenced by others such as

teacher's reproach or brother's letter. Both influenced Fan could be regard as reward. With respect to standard deviation, we can also conclude that reward help Fan score higher. This point also supports the "reinforcement" theory, when reward plays a role as positive reinforcement.

## CONCLUSION

The main purpose of this research was to find the more effective way to improve Fan's math ability. From the data analysis, we easily found that reward played a better role in improving Fan's math ability. Although emotional influences Fan's test performance sometimes, the emotion is also kind of reward from psychological perspective.

In my experiment, the second 15-day experiment may have influenced by the first 10-day experiment since Fan had already read some math books. In this case, the grades in 15-day experiment are higher may be caused by the books he had already read. Furthermore, I did not take "no intervention" into account in the first 10-day experiment, yet I missed a comparing treatment.

Also, there are some limitations in the reinforcement. People pay so much attention to the method itself that may cause overfitting or even worse results. Another of those limitations with the most frequency is that reinforcement may increase the dependency. The test results will lose the significance when the reinforcement is paused. For instance, Fan's score will decline without reinforcement (Kauffman, 1999).

More future research could be conducted in the areas of special school and career development. Researchers could conduct experiments and then assess the different ability among those special children, like some of them prefer math, while others prefer painting or making handcraft. According to those variable abilities, schools could establish selective or specialized course. Meanwhile, special kids are able to devote themselves to the society and repay their parents like normal kids.

Furthermore, some suggestions for comparing treatment are provided here. Firstly, although an alternating-intervention design can be a powerful tool for quickly assessing the relative effectiveness of two potentially useful interventions (Morgan & Morgan, 2001), for large-scale studies as this method primarily target to one individual. In addition, people can spend more time with special children and find out what they are interested in, so that they can be more likely to achieve good performance.

Our society sometimes gives very little attention to special education. The special kids, however, all have their own expertise like normal people. Unlike the general education proposed by Cuban (1996), the special education needs more patience, more persistence, and more interaction. Even in general education classes with small groups of students, some students with disabilities do not get the individualized attention they need to understand the academic content (Baxter et al., 2002; Bottge et al., 2002; Kauffman, 1999).

As more researches done in this field, people can share their advice on social media; thus, more people will pay attention to special education and special children could improve their expertise.

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## APPENDIX A: INFORMED CONSENT FORM (IN CHINESE)

<div align="center">

### 研究知情同意书

</div>

受访者：_____。

受访者学校：_____。

此次的研究话题是--- "如何提高Fan的数学才能"。 我的研究目的是在适当的帮助之后，Fan的数学才能能够得到提高，并且有更多的人能关注到特殊教育这个领域。

在次次的研究中，我希望您能：

1. 提供范的基本信息

2. 在3月27日至3月31日，让范每天晚上读完书后做十道计算题，做完之后请父母批阅；

3. 在4月1日至4月5日，让范每天晚上读完书后做十道计算题，做完之后请父母批阅；正确率达到9个或9个以上给予奖励

4. 在4月6日至4月11日，让范每天晚上读完书后做十道计算题，做完之后请父母批阅；

5. 在4月12日至4月21日，4月12，14，16，18，20日，让范每天晚上读完书后做十道计算题，做完之后请父母批阅；

6. 4月13，15，17，19，21日，让范每天晚上读完书后做十道计算题，做完之后请父母批阅；正确率达到9个或9个以上给予奖励。

此外，根据 "人类受试者协议书"，（1）您的所有信息将予以保密；（2）您的参与是自愿的，如果您觉得不舒服，可以在任何时候停止参与研究；（3）我不会对您造成任何伤害。

如果您有任何疑问，请致电 15928341167 或联系微信 yyh200036

如果您同意以上内容，请在下面签字：

姓名：___;

日期：___。

感谢您同意参与此次活动。

## APPENDIX B: INFORMED CONSENT FORM (IN ENGLISH)

<div align="center">

### Informed Consent Form

</div>

Interviewee (Title and Name): _____;

Interviewer:_____.

My research project focuses on the improvement of Fan's math talents. My study does aim to develop Fan's math talents in appropriate way. Rather, I want to make more people pay attention to special education.

In this interview, I hope you can:

1. Provide Fan's basic information;

2. During March 27th to March 31th ask Fan to read math books and then do 10 calculation problems at home and then revise them.

3. During April 1th to April 5th, ask Fan to read math books and then do 10 calculation problems at home and then revise them, if he scored 9 or above 9, he could be rewarded.

4. During April 6th to April 11th ask Fan to do 10 calculation problems every two days at home and then revise them;

5. During April 12th to April 21th, ask Fan to read math books in April 12th, 14th, 16th, 18th, 20th and then do 10 calculation problems at home and then revise them;

6. Ask Fan to do 10 calculation problems in April 13th, 15th, 16th, 17th, 19th, 21th at home and then revise them, he could be rewarded.

In addition, you must sign a form devised to meet our human subject requirments. Essentially, this document states that: (1) all information will be held confidential, (2) your participation is voluntary and you may stop at any time if you feel uncomfortble, and (3) I do not intend to inflict any harm.

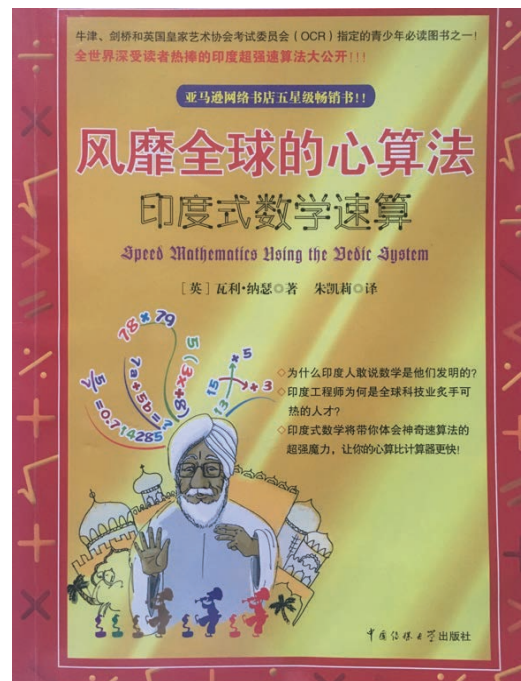If you have any quesitons, please call 15928341167 or contact QQ/ We chat yya200036
If you agree with the the above requirment, please sign below:
Name: _____;
Date:_____.
Thank you for agreeing to participate in this event.

## APPENDIX C: PICTURES OF MATH BOOK



## APPENDIX D: TEST FORM

**Test 1**
57-42-1=
175+53-27=
263+65-22=
292-76-2=
324÷8-2=
35-28+74=
485-60+93=
44×8-23=
519×4-18=
551+52-89=

**Test 2**
676-41+17=
650÷5+62=
772+90÷9=
712÷2+68=

897-75+61=
81÷1+78=
964÷8×19=
963÷9×3=
40÷1÷4=
38-3+8=

**Test 3**
78-74-5=
54-32÷4=
122+1÷1=
84-19×15=
98-78+20=
35+13-37=
78-28-46=
66+16÷2=