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Single-Subject Research: Mathematical Reasoning Ability of Slow Learners in Straight-Line Equations

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Abstract: Mathematics is one of the difficult subjects to understand, especially for slow learners. Slow learner is a term for children who find it difficult to learn something, be it academics or skills. The present study aims to analyze the mathematical reasoning ability of slow learner students on straight-line equations. -The present study is an experimental research using the single-subject research (SSR) method. The design used is A-B-A. The data were collected through tests and documentation and were analyzed using "inconditions" and "between-conditions" models. The results indicate that students performed slow learning process on straight-line equations using TANDUR framework. TANDUR means instill, experience, name, demonstrate, repeat, and celebrate. The results after the implementation of quantum learning showed no change between the group that was given the treatment and the group that was not given the treatment. From baseline 1, there was an increase in intervention from 4.5 to 8. However, it decreased in baseline 2, from 8 to 4. It can be concluded that the use of quantum learning does not have a positive effect on the mathematical reasoning abilities of slow learners. Thus, it is hoped that teachers should pay more attention to seek and implement the appropriate learning models for such learners.

Keywords**:** Slow Learner, Single-Subject Research, Straight-Line Equation

Introduction

Mathematics is considered to be one of the most difficult subjects to learn. On the other hand, it is also one of the most important sciences in life that it becomes a compulsory subject from the primary education level to higher education level. Learning mathematics ideally requires a variety of knowledge connections, good reasoning, and a good level of intelligence (Gazali and Atsnan 2022). Thus, learning mathematics may become difficult for slow learners.

Slow learner is a term for children who find it difficult to learn something, be it in academics or acquiring skills. Slow learners have IQs ranging from 70 to 90, which means they need more time and intensity of practice to repeat the subject matter to meet the normal demands of education (Z. Mohammad and M. Mahmoud 2014). Slow learners differ from normal students in learning ability but cannot be called disabled learners (Borah 2013). This is because slow learners are normal but have lower interest in learning under the accepted education system (Li 2016; Yap, Neo, and Neo 2016).

According to Borah (2013), slow learners can be identified with five characteristics. First, these learners work very slowly and do not have the ability to do complex or varied problems. Second, they perform poorly in school and exhibit repeated immaturity in their relationships with other learners. Third, they are known to be slow to master academic skills, such as spelling rules or schedules. Fourth, they are said to lack the ability to convey what they learn between assignments and forget time and events. Last, they are reported to have set and tracked long-term goals. Supporting this view, various (Z. Mohammad and M. Mahmoud 2014; Zakarneh, AlRamahi, and Mahmoud 2020) scholars have identified ten characteristics associated with slow learners: difficulty in following multi-step directions; function at abilities significantly lower than grade level; tend to create immature interpersonal relationships; score consistently low on academic and achievement tests; possess a poor self-image; be good at “hands-on” material (manipulative or lab activities); work on assignments at a relatively slower pace than the average student; have no long-term goals and live in the present; and have few internal strategies (e.g., generalization of information, difficulty transferring their learning, and organizational skills).

Furthermore, Ganschow, Sparks, and Javorsky (1998) and Sparks et al. (1998) suggest that students who exhibit learning problems in foreign languages have subtle or marked native-language-learning difficulties and differences that affect their ability to learn foreign languages. In the same vein, Bowers and Wolf (1993), Rashid and Azid (2020), and Rosmin, Rosmin, and Musta’amal (2013) noted that the weakest skills among slow learners are reading and writing. Other similar studies (Botvinick et al. 2019; Hartini, Widyaningtyas, and Mashluhah 2017; Singh 2004) also noted that the factors that cause slow learners to learn include: lack of a safe environment, lack of emotional growth, absence, large class size, untrained teachers, and limited opportunities.

In the context of language learning, Tansley and Gulliford (2018) argue that the factors contributing to a person being a slow learner include the use of inadequate language learning strategies and negative learning experiences in the past that cause a person to lose interest. This is a major challenge for language teachers who are not equipped with the skills and teaching methods needed to deal with mixed-ability classes (Fahradina, Ansari, and Saiman 2014; Saputra et al. 2018). Therefore, instructors in mixed-ability classes need to be given continuous training to address the challenges of diverse learners (Van de Walle, Karp, and Bay-Williams 2010).

Special attention for slow learners is definitely important because they face difficulty understanding abstracts, have quite low motivation, and take quite a long time to understand the material. Thus, this research is carried out to observe the mathematical reasoning ability of slow learners more deeply because it is designed to be more personal (individual). The right learning strategy needed in teaching for slow learners is adjusted to the objectives, time allocation, rewards, assignments, and continuous learning, as a prerequisite for learning for slow learners is to know the students’ abilities and then proceed with treatment with the students involved (Manikmaya and Prahmana 2021). The insufficiently implemented learning models by some mathematics teachers have resulted in students’ low mathematical reasoning abilities (Permana and Sumarmo 2007).

Education is an important part of human life. Every human being has the right to a fair and quality education, including those who are slow learners. Educational institutions need to enforce strict rules with no discrimination against backward children to be able to get the same education as normal children in general. In fact, every child is born with its own, unique potential and possesses different types of intelligences. Therefore, educators must also understand if there are children who have slower pace of learning. Unfortunately, not all teachers can really observe the diversity of their students. Many educators seem to want to take in on only those students who are already perfect physically, psychologically, and academically.

One of the complicated mathematics topics is straight-line equations since it requires knowledge of Cartesian coordinates, linear equations of one variable, and skills to draw straight lines on the Cartesian plane, and there are straight-line equations that students must learn (Kirschner, Sweller, and Clark 2006; Miller and Schraeder 2015). According to Widodo (2017) and Irfan et al. (2018), mathematics learning needs systematic learning, analysis, creativity, and logical thinking. The difficulties experienced by students in learning mathematics arise from the children's lack of ability to imagine, understand, and work on problems related to mathematics and, in other words, learning difficulties such as poor understanding and reasoning (Bernard et al. 2019; Stavy and Babai 2010; Irfan et al. 2020). Mathematical reasoning has a very important role in students' thinking processes. Thus, the better the level of students' reasoning, the better the results of learning mathematics and vice versa.

Quantum learning model is a method that promotes in various ways a comfortable, pleasant atmosphere during learning, such as a comfortable classroom arrangement, use of various media, and provision of positive suggestions (Muchammad, Suharno, and Yuyun 2017; Yunida, Sitompul, and Syukran 2012). Quantum learning model is a strategy used in the learning process to sharpen the learners' understanding and memory with a combination of work and study and providing customized internal and external stimuli for slow learners. Different forms of learning can train students in ways that help develop and sharpen their reasoning abilities and develop their personalities through the TANDUR framework as a learning resource using quantum learning (Yunida, Sitompul, and Syukran 2012). According to DePorter, Reardon, and Singer-Nourie (2010), in carrying out quantum learning steps with six steps reflected in the term TANDUR, namely T—Tumbuhkan (Grow), the objectives included cultivating a pleasant, relaxed classroom atmosphere to promote slow learner students' interest in study. It encourages the learning process to get into the realm of thought of the slow learners. It helps students feel that learning is a necessity and not a demand. A—

Alami (Natural) means natural elements will encourage students to recognize the brain's natural desire to "explore." It creates or provides general experiences that students can understand. In N—Namai (Name), after learning basic competencies, students are invited to write on paper the name of what has been obtained, what the equation is, what the algebraic form is, and what the gradient is and how to find the equation. In D—Demonstrasikan (Demonstrate), students are provided with opportunities to show that they know and understand what they have obtained through the learning experience and know that they have sufficient skills and information. The part U—Ulangi (Repeat) includes repetition to strengthen neural connections and foster a sense of "I know so I do know this." As a result, students will remember what has been said. The part R—Rayakan (Celebrate) refers to students' receiving recognition for participating in and successfully completing learning activities and acquiring new skills and knowledge. To sum up, quantum learning can be an alternative to conventional learning to train slow learners in improving their mathematical reasoning abilities.

Several of the past similar studies focused only on normal students in terms of testing the effectiveness of the learning model. This study specifically examines the mathematical reasoning ability of two slow learners in learning straight-line quotation through quantum learning.

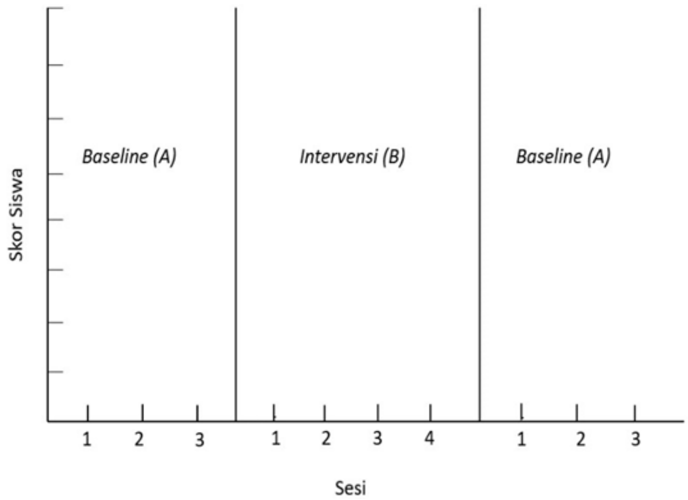
Method

This research is an experimental study analyzing the effectiveness of quantum learning model for the mathematics reasoning abilities of slow learner that they must use to solve straightline equations. The study employed the single-subject research (SSR) design. According to Manikmaya and Prahmana (2021), the SSR is a method that aims to see the effect of a given treatment to the participant repeatedly within a certain time.

Research Design

The design used in this study was a baseline 1–intervention–baseline 2 (A-B-A) design. Sunanto, Takeuchi, and Nakata (2006) offers the view that A-B-A is a design that can show a causal relationship between the dependent variable and the independent variable and can strengthen it compared to the A-B design. In general, the design of this research can be described as shown in the following graph.

Figure 1: Research Design



Research Sample

The present study used a nonprobability sampling technique that does not provide equal opportunities. Participants were enrolled through purposive sampling with specific characteristics that were considered appropriate for the study's goals and objectives (Sugiyono 2016). There were several considerations in enrolling the research participants: (1) grade 8 students of SMP X Yogyakarta, (2) who are slow learners, (3) have difficulties in learning and focusing and lack self-confidence, (4) did not experience physical disturbances, (5) the students' communication skills, and (6) their teacher's considerations. In terms of this consideration, the teacher provides recommendations for the names of participants who meet the criteria determined by the researcher, namely students who are slow learners, have difficulty learning, find it difficult to focus, and lack confidence. Then, the researcher determines the participants based on communication skills and lack of physical disturbances. The said school, SMP X Yogyakarta, was selected because it was an inclusive school. Inclusive schools have an education service system that requires children with disabilities to be served according to their abilities along with their peers (Lipsky and Gartner 2013). The existence of this inclusive school indicates that students with special needs have the right to obtain the same learning as normal students, and teachers, in carrying out the learning process, still pay attention to the characteristics of these students. Differentiated learning conditions optimize the potential possessed by students. We use the term SMP X so that the name of the school is not published. In this school, there are students with slow learning difficulties. The study sample included learners with pronounced weakness in learning mathematics, especially in relation to learning and solving straight-line equations. The students in our study sample scored 70 to 90 in a psychological examination and were categorized as children with learning barriers (slow learners).

Research Variable

The independent variable applied in our study was quantum learning, and the dependent variable used was the mathematical reasoning ability of slow learners in learning and solving straight-line equations. These two variables are interrelated, interdependent, and influence one another.

Data Collection

The data collection techniques used were interviews (conducted before and during the study), a test of mathematical reasoning ability (conducted during baseline 1, intervention, and baseline 2 phases), and documentation (carried out during the study). The research instruments include the test results of mathematical reasoning abilities at the baseline and intervention stages as well as the results of documentation in the form of students' intellectual abilities, photos, and videos.

The first stage used in the A-B-A design includes measuring target behavior in the baseline phase. It was used for three sessions, and each session lasted 30 minutes. In the baseline phase, two questions were given to test the student's ability of mathematical reasoning to understand and solve straight-line equations. The results of this test were used as initial data before conducting further studies to assess the students' skills in relation to the topic of the present study—mathematical reasoning ability.

The next stage was the intervention phase, which was carried out in four sessions with the duration for each session fixed at 50 minutes. The students were studied using the quantum learning model's prescribed teaching and learning activities; subsequently, the mathematical reasoning ability test was administered to the students or their questions post-test were answered. The intervention was stopped when we found the data to be stable, and we returned to baseline 2. At baseline 2, slow learners were given 2 weeks in order to prepare for taking the mathematical reasoning ability test, specifically for assessing the extent to which learning with the quantum learning model improved the students' mathematical reasoning abilities.

This study involved two participants who are slow learner students. The assessment combined scores for each session, and the average value of each session was taken. This is one of the characteristics of the SSR method.

Data Analysis

The data were studied using in-condition and between-conditions analyses. The components of the analysis under conditions include (1) length of condition; (2) directional inclination; (3) level of stability determined by calculating data in the range of 50% above and below the mean; (4) rate of change calculated by finding the difference between the first and the last data; (5) data trail, and (6) range, which is the distance between the first data and the last data and calculated based on the values derived by multiplying the values of the highest score on the condition with the stability criterion (0.15). The components of the analysis between conditions include changes in (1) variables; (2) trend direction and their effects, (3) stability criterion and its effects, and (4) data levels (changes in data determined by finding the difference between the last data in the baseline condition and the first data in the intervention condition), and changes due to (5) overlapping data (overlap), determined by the formula (same data in both conditions/data in baseline condition) □ 100.

Results

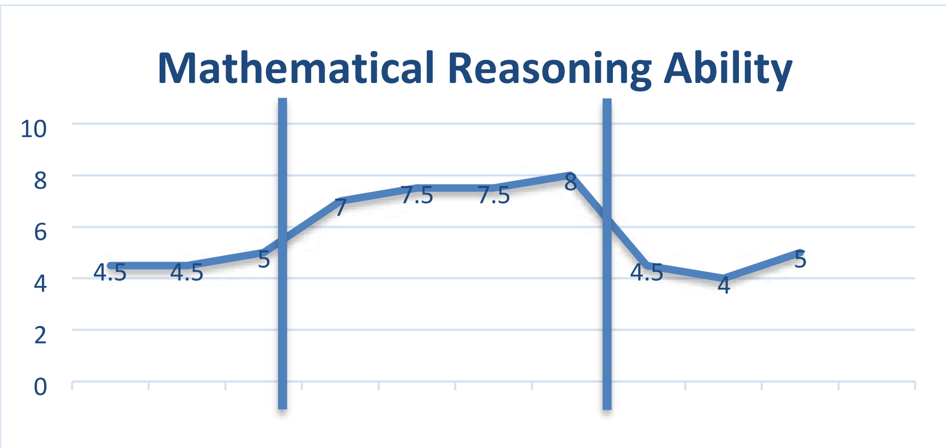
The results for the mathematical reasoning ability test conducted for 10 days in baseline 1, intervention, and baseline 2 phases are presented in Table 1.

Table 1: Accumulated Average Scores of Baseline and Intervention Phase Tests

Phase	Baseline 1			Iintervention				Baseline 2		
Score	1	2	3	4	5	6	7	8	9	10
Participant 1	4	4	6	7	7	7	8	3	4	3
Participant 2	5	5	4	7	8	8	8	6	4	6
Average	4.5	4.5	5	7	7,5	7.5	8	4.5	4	5
Phase average	4.7			7.5				4.5		

Details presented in Table 1 show that the mathematical reasoning abilities of slow learners reached an average value of 4.7 in the baseline 1; an average of 7.5 in intervention, and an average of 4.5 in baseline 2. This shows that the treatment or quantum learning model applied to slow learner students did not show any positive effect on their mathematical reasoning abilities. Figure 2 illustrates the trajectory of how values for each phase were acquired.

Figure 2: Comparison of Mathematical Reasoning Ability Scores in Baseline 1, Intervention, and Baseline 2



sesi 1 sesi 2 sesi 3 sesi 4 sesi 5 sesi 6 sesi 7 sesi 8 sesi 9 sesi 10

As described preciously, two types of data analyses were carried out: in-condition analysis and between-conditions analysis. Components of the in-conditions analysis include the following: length of condition, level of stability, trends and their direction, rate of change, data trail, and range.

Table 2: Summary of the Results of In-Condition Analyses

Condition	Baseline 1	Intervention	Baseline 2
Length of condition	3	4	3
Directional tendency	(+) ↗	(+) ↗	↘ (−)
Tendency of data stability	Stable (100%)	Stable (100%)	Stable (100%)
Track data	(+) ↗	(+) ↗	↘ (−)
Stability level and span	Stable 4.5–5	Stable 7–8	Stable 4–5
Level change	(5– 4.5)	8– 7	5–4

Table 2 shows that the length of condition or the number of sessions carried out in this study: three sessions in baseline 1 (A) phase, four sessions in intervention (B), and three sessions in baseline 2 (A2). The direction of trend in baseline 1 and intervention indicates an increase, and in baseline 2 a decrease. The trend for stability shows that stability was 100% under conditions of baseline 1, intervention, and baseline-2, which means our data are stable. The data trail is the same as seen for the direction of trend—an increase in trend in baseline 1 and intervention phases but a downward trend in baseline 2. Levels, stability, and ranges show that baseline 1 conditions tend to increase (+) in the range of 4.5 to 5 and show stable data. The stability data for the intervention condition in the range of 7 to 8 showed a decline in value, down to 4 to 5, in baseline 2. Especially after the intervention phase, incremental changes in the level of mathematical reasoning ability were observed in one participant student, with a value of +1 assigned to indicate the student's improved mathematical reasoning ability.

After carrying out the in-condition data analysis, an analysis of between-conditions data was carried out to determine the effect or changes in the level of students' mathematical reasoning before and after intervention was administered to them. The between-conditions analysis measured changes in variables, in direction and effects, in stability and its effects, in data levels, and in overlapping data.

Table 3: Summary of the Results of Between-Conditions Analyses

Comparison of conditions	B/A – 1	A – 2/B
Number of variables changed	1	1
Changes in the trend direction and its effects	(+) ↗	(+) ↗
Trend change and stability	Stable to stable	Stable to stable
Level change	7– 5 (+2)	4,5–8 (–3.5)
Percentage of overlap	0	0

Table 3 shows that changes occurred in only one of the variables—namely the ability to reason mathematically in the baseline and intervention conditions. Changes in the trend of direction in mathematical reasoning abilities did not show any positive changes or improvement in the students' mathematical reasoning ability. This is because when the intervention is carried out, a downward trend occurred. Changes in the trend on stability at baseline 1 continued to increase, which was also the case with intervention; both baseline 1 and intervention experienced an increase and thus considered stable, as trends on stability rose to 100% in both cases. The data in baseline 2 are stable as well (see Table 2). Changes in level increased between baseline 1 and intervention but experienced a significant decrease between intervention and baseline 2. There was no overlapping of data (0% overlap) between baseline 1 and intervention, and the same situation was observed between intervention and baseline 2, which again showed a 0% data overlap. After the administration of test to participating students, the target behavior increased significantly during intervention (i.e., when were performing the test) but decreased significantly after the intervention (i.e., after they completed the test). The target behavior in this study is mathematical reasoning ability. For this reason, the success of the intervention carried out by researchers using learning with the TANDUR concept for slow-learning students can be seen from the increase in each phase of their mathematical reasoning abilities.

Discussion

The test was carried out by looking at the effect of the quantum learning method on the learners' mathematical reasoning ability before and after the intervention—that is, the administration of the said test to the participating students. The hypothesis proposed in this study is that the use of quantum learning methods can positively influence and, hence, lead to an increase in the mathematical reasoning abilities of slow learners of Class VIII in SMP X Yogyakarta.

At the initial stage, the observations were carried out both during and after the intervention. Results of these observations served as supporting data for the test results. The observations were conducted to determine the level of student's participation in the quantum learning method through which they were expected to learn and solve straight-line equations. During intervention, it was observed that students showed an increase in their understanding of straight-line equations, which corresponded to an increase in their mathematical reasoning ability. Before the administration of intervention, the students did not demonstrate a sufficient level of understanding about straight-line equations. This is indicated by the low value of students' mathematical reasoning on the straight-line equation material. Uniquely, after the intervention was administered and concluded, the students reverted to their earlier state of low-level understanding of the material on straight-line equations (Manikmaya and Prahmana 2021). In other words, post-intervention observations showed there weren't any lingering or residual effects of the intervention on students' ability to use mathematical reasoning to solve straight-line equations.

The quantum learning model utilized in this study has not led to any improvement in the mathematical reasoning ability of slow learner students who participated in our study (Muchammad, Suharno, and Yuyun 2017; Abdul-Rahman 2020). This became evident through the students' average score of 4.5 to 5 in the straight-line equation learning activity at baseline 1, which increased to 7 to 8 in the intervention phase. However, in baseline 2 (no intervention was given), students showed a decrease in their mathematical reasoning abilities. As shown in the previous stage, their mathematical reasoning ability was still at a lower level compared to the post-intervention phase. However, in the quantum learning model, students demonstrated a decline in their understanding of the questions testing their reasoning competence as given in the baseline 1 phase.

The analysis of results showed there were several types of behaviors exhibited by the participating students. Results showed students had a sense of enthusiasm when participating in mathematics learning. In each intervention session, they were able to understand the instructions provided by the teacher. However, they were unable to use time effectively in each intervention session. They lacked focus and appeared less engaged. However, it was observed that they could indeed demonstrate better problem-solving capabilities when given sufficient time.

In baseline 2, the average value of straight-line equation learning activities with the application of quantum learning method is in the range of 4.5 to 5, which means an increase in the average score from baseline 1 to intervention but a decrease in the average score between the intervention phase and the post-intervention phase (i.e., baseline 2). This shows quantum learning model could not improve the students' mathematical reasoning abilities, especially those who have learning disabilities. The researcher celebrated students' performance by praising the students and applauding the students every time they gave an appropriate response. The results of this study are also in line with research conducted by Putra et al. (2019), which reveals that quantum learning model did not bring any significant improvements to the mathematical reasoning abilities of slow learners in learning straight-line equations.

To sum up based on the findings presented in the foregoing paragraphs, it is concluded that the quantum learning model is not appropriate for use as an alternative learning method in order to stimulate and strengthen the students' mathematical reasoning abilities. It does not have scope for meaningful and fun learning. Overall, the only good effects which were observed from the experiments conducted in the present study include a sense of pleasure and enthusiasm shown by the students in learning via the quantum learning model, which could strengthen students' language development, and, in the case of the present study, the rather minor, but noticeable and temporary, improvement in their mathematical reasoning ability. This shows that the interventions and tests carried through quantum learning method were not effective in bringing the desired level of improvement in the mathematical reasoning ability of the participating students who are slow learners.

Conclusion

The quantum learning model with its TANDUR framework has not yielded any positive effect on slow learners' mathematical reasoning abilities. The limitations of the framework for slow learners include its syntax and the advanced level of language comprehension required, or the way the questions were written, that required the slow learner students to read and learn actively and independently on a level comparable to the normal students who are fast learners. So far, to our knowledge, there have not been any studies that utilized this framework effectively and, specifically, showing that its use can significantly improve the learning and reasoning abilities of students who are slow learners. Many of the past similar studies involved students with average intellectual abilities, and the use of the said learning model had a positive influence simply for the reason that the students in those were average learners whose ability to learn, comprehend, and reason was at a much higher level than the slow learner students who participated in this study. This is supported by the results shown by the absence of improvement in the results of the initial ability test (baseline 1) with students securing only a low-average score of 4.5 to 5. After the implementation of quantum learning model, and during the intervention, the higher-average score of 7 to 8 secured by students indicated a significant increase in their mathematical reasoning ability in each meeting. However, post-intervention, their mathematical reasoning ability dropped down or reverted back to the previous lowaverage score of 4.5 to 5 measured at baseline 1. This goes to show that the quantum learning model does not have a positive impact on or improve the mathematical reasoning abilities of the two slow learner students who participated in our study.

Informed Consent

The authors have obtained informed consent from all participants.

Conflict of Interest

The authors state that the study was conducted without any commercial or financial relationship that could be construed as a potential conflict of interest.

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