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The Influence of Inclusive Education on the Mathematics Achievement of Students with Intellectual Disabilities

Riski Karunia Ilahi[1], Asrorul Mais[2], Lailil Aflahkul Yaum[3], Endra Priawasana[4]
[1,2,3,4] Universitas PGRI Argopuro Jember, Indonesia
E-mail: [1]akiki0723@gmail.com, [2*]asrorulmais.plb@gmail.com, [3]laililaflah.plb@gmail.com, [4]endracq@gmail.com
*Coresponding Author

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ABSTRACT

This study investigated the differences in mathematics achievement among elementary school students with intellectual disabilities (IDs) enrolled in inclusive classes and those in special schools (SLB). Mathematics achievement was assessed at the beginning and end of the academic year in two groups: students in inclusive classes (n = 44) and in special schools (n = 56). The findings revealed that students with IDs in inclusive settings demonstrated slightly greater improvement in mathematics achievement over nine months compared to their peers in special schools. More students with very low mathematics skills were concentrated in special schools and showed minimal progress, while those with some numeracy abilities were more frequently found in inclusive classes. To account for differences in age, IQ, and prior achievement, a matched sample (n = 44) was used for regression analysis, which confirmed a small positive effect of the inclusive setting on learning gains. These findings suggest that inclusive education can provide a more supportive and stimulating learning environment that promotes academic development for students with IDs. The study holds practical implications for educational policymakers by highlighting the potential of inclusive settings to enhance learning outcomes for children with disabilities, supporting the need for more inclusive practices and tailored support systems within general education classrooms.

Keywords: *Intellectual Disability, Inclusive Education, Mathematics Achievement*

INTRODUCTION

Inclusive teaching is common practice in many countries and an increasing number of pupils with special educational needs (SEN) are attending inclusive classes alongside pupils without special educational needs (Wehmeyer & Shogren, 2017). However, the inclusion of students with intellectual disabilities (ID) is still not as common as the inclusion of students with learning disabilities, language disorders, or behavioral problems. (Göransson et al., 2022; Klang et al., 2020; Wehmeyer et al., 2021). According to the DSM-5 and ICD-11, students with ID demonstrate deficits in intellectual functioning (e.g., reasoning, abstract thinking, and academic learning) as confirmed by clinical evaluation and individual standardized IQ testing. They also demonstrate deficits in adaptive functioning that result in failure to meet developmental and sociocultural standards for personal independence and social responsibility, meaning students with ID may have a wide range of learning behaviors and social and self-care skills. (American Psychiatric Association, 2013; WHO, 2019). The ICD-11 distinguishes between mild, moderate, and severe DI, and students with mild or moderate DI are expected to be able to learn math and reading skills. The ICD-10, which was the guideline in effect at the time of this study, places less emphasis on adaptive functioning.

In many countries, students with DI are taught in special schools or inclusive classes in mainstream schools, alongside students without SEN. (Kauffman et al., 2017). Special educational support is important in both conditions (Florian, 2019; Zigmond & Kloo, 2011), but there is a big difference between the two.

Special schools are attended by a heterogeneous group of students with SEN who may have severe disabilities and very low levels of achievement. In these schools, special education teachers carry out most of the teaching, with occasional assistance from a second teacher or paraprofessional. Typically, therapy (e.g. speech therapy, physiotherapy) is also included in the daily schedule at special schools. This therapy is provided by specialists, usually in a one-to-one setting. The learning provided is usually tailored to the needs of the individual. (Hienonen et al., 2021; Zweers et al., 2020). Often the curriculum prioritizes skills for everyday living to provide students with greater possibilities for independence (Shurr & C. Bouck, 2013). It is generally assumed that these aspects can promote the development of students with SEN. (Hienonen et al., 2021).

Composition of inclusive classrooms, consisting of students with heterogeneous academic achievement. Additional resources, in the form of special education teacher support hours, are allocated based on specific student needs or school population indicators (e.g. schools receiving lump sum funding to pay for resources that reflect the number of students with SEN enrolled). Different district funding models mean that the number of hours per week of special education teacher support for inclusive classrooms can vary widely from district to district (Meijer, 1999). The emphasis in inclusive classrooms is on academic learning, rather than on skills for everyday living. According to Klang et al. (2020), teachers in inclusive classrooms have higher expectations of all of their students, compared to the expectations that teachers have in special schools.

The optimal learning environment for students with DI remains a matter of debate and policy decisions are not necessarily based on empirical evidence (Hienonen et al., 2021; Kauffman et al., 2017). Proponents of special education schools argue that students with DI benefit from protective learning environments, tailored support in small class sizes, individualized feedback, specialized teaching methods, and most importantly, a largely non-competitive classroom climate (Peetsma et al., 2001; Zigmond & Kloo, 2011). Proponents of inclusive education argue that inclusive environments can lead to greater achievement (Barth et al., 2004).

There is little research on how specific educational environments can influence the academic achievement of students with DI (Cole et al., 2021). According to a review conducted by Freeman & Alkin (2000), inclusive education in mainstream schools has had mostly neutral and sometimes positive impacts on the academic achievement of students with DI. Other more recent studies have also found that inclusive teaching has had neutral to slightly positive impacts. Cole et. (2004) compared the achievement of students with learning disabilities and mild DI in an inclusive setting with the progress of students in a pull-out resource program. The researchers found no significant differences between the two groups in achievement, over one year, in reading and mathematics. In a 12-year study, Turner et al. (2008) found that inclusive environments had a small positive effect on achievement in reading, writing, and mathematics for students with Down syndrome. However, differences in academic achievement early in the school career were not considered in the analysis. This is important because only a small proportion of students in this study attended inclusive classrooms and students with different cognitive profiles may have been selected for placement in special schools or inclusive environments; like cannot be compared with unlike.

According to Cole et al. (2021), Students with higher academic ability or fewer behavioral problems were more likely to be enrolled in inclusive education. Three studies addressed this issue by selecting matched pairs. The only study that focused on students with DI found that elementary school students with DI in inclusive classrooms made slightly more progress in literacy than their peers in special schools over two academic years (Dessemontet et al., 2012). However, there was no difference in progress in mathematics. A long-term study by Peetsma et al. (2001) on students with mild DI and students with learning and behavioral difficulties found that school setting had no significant impact on achievement when students were examined after two years of schooling, but positive effects of inclusive education on mathematics and language skills emerged after four years. Cole et al. (2021) found that students from a sample with a variety of SEN types, including 10% of students with mild DI, who spent at least 80% of their school hours per week in inclusive classrooms performed significantly better in reading and mathematics than their peers who spent more time in separate special education classes..

Thus, it can be concluded that inclusive education can have a positive impact on the literacy and language skills of students with DI, but the specific impact of inclusive environments on mathematics achievement is still unclear. The academic impact of placing students with DI in different environments, both inclusive and special, needs to be studied further to find out which factors are most beneficial for student development. Such knowledge can make inclusion more thoughtful, objective, and beneficial. (Kauffman et al., 2017).

This study aims to contribute to a better understanding of the impact of educational settings (inclusive education, special schools) on the mathematics achievement of elementary school students with DI. Therefore, it is important to consider specific knowledge about the mathematics skills and development of students with DI.

Mathematical development of students with intellectual disabilities (ID)

Previous research has shown that students with varying levels of DI are able to acquire mathematical skills (Browder et al., 2008; Lemons et al., 2015; Spooner et al., 2019) and that their development is not fundamentally different from that of normally developing students. (Baroody, 1999; Brankaer et al., 2011). However, most of the research was conducted on students with mild and moderate DI. Students with DI need more time and repetition to learn math concepts. (Faragher & Clarke, 2013), and some students make little progress over several school years. Empirical evidence suggests that progress appears to depend on the acquisition of specific numerical skills. According to a number of researchers (Aunio & Räsänen, 2016; Jordan et al., 2010), Early numerical competencies such as numeracy skills and principles, comparing quantities and numbers, and arranging and decoding numbers, are predictors of later mathematical performance.

A model created by Krajewski & Schneider (2009) describes the early mathematical development of children with and without DI. The model structures development into three levels. At the first level, children can distinguish between discrete quantities and they use number words or Arabic numerals separately from quantities. They recite sequences of numbers as a series (Fuson, 1988). Gradually, they acquire second-level skills, including an important milestone in mathematical development, namely the ability to associate number words and Arabic numerals with precise representations of quantities. This relationship is crucial for understanding number decomposition and learning that relationships between numbers, such as differences, can be named with number words. (Krajewski & Schneider, 2009). This skill is included in the third level of the model. The process of understanding the relationship between numbers and quantities sequentially begins with small numbers and progresses to larger numbers. It may be that, although children relate small numbers to quantities, they may not yet relate larger numbers (level 2).

Researchers have shown that students with DI show different mathematical abilities (Schnepel et al., 2020; Sermier Dessemontet et al., 2020). Some students have difficulty connecting numbers and quantities (level 2), while others can solve addition and subtraction problems (Baroody, 1999; Garrote et al., 2015). Students with DI with different mathematical abilities may be placed in different settings, and it is important to consider these abilities when examining achievement gains for students in different settings. Little is known about the mathematical development of students with DI in inclusive classrooms because students are taught in one-to-one settings in most intervention studies. (Tzanakaki et al., 2014).

Research reviews show that little is known about the influence of the environment (inclusive education, special schools) on the development of students with DI, and in particular, the influence of the environment on their mathematics development is unknown. (Departement für Erziehung und Kultur Thurgau, 2021). This study aims to help close this research gap by using a longitudinal design to investigate the influence of educational background on the mathematics achievement of elementary school students with DI. The research questions are:

1. What are the differences between the mathematics achievement of students with DI in inclusive classes and in special schools?
2. What is the influence of learning settings on improving the mathematics achievement of elementary school students with DI?

It was hypothesized that students with DI in special schools would have lower achievement levels than students with DI in inclusive classes. The second hypothesis, from evidence gathered by previous research, was that inclusive environments have a neutral or slightly positive effect on the mathematics achievement of students with DI. (Dienststelle Volksschulbildung Luzern, 2021).

METHODS

Students with intellectual disabilities in East Java, Indonesia in special schools or in inclusive classes. In some districts, such as Jember, around 40% of the student population with DI are enrolled in inclusive classes, while in other districts, such as Bondowoso, the majority of these students attend special schools, and authorities aim to achieve a 'moderate' increase in the number of students moving to inclusive education. In inclusive settings, resources for special education support are allocated based on an input model (Meijer, 1999); Individual assistance is provided by a special education teacher for 6-10 hours per week, depending on the individual needs of the student. Sometimes the special education teacher also assists students with special needs. In special schools, four to eight students with DI are taught in a classroom by a full-time special education teacher, or sometimes a special education teacher and a teacher's assistant. In both settings, students have individual learning goals. Although no data is indicating which schools students with DI attend, it can be assumed that students with severe and profound DI attend special schools. In addition, the infrastructure for students with severe DI is not yet available in inclusion schools (e.g., no nurse's office)..

Population and Sample

Participants were recruited from students who had participated in two larger longitudinal studies in East Java. Invitations to participate were also sent to principals specifically for students with ID cards in the two districts. Teachers were free to decide whether or not they wanted their schools and students to participate. Parents had to provide written consent for their students to be included in the study. Teachers contacted parents and collected the written consent. The sample was 100 students with ID (total sample).

A school psychologist or child psychiatrist had diagnosed participants as having DI before the study using ICD-10 or DSM-5 guidelines. Some students had a more specific diagnosis or two diagnoses. In addition, some teachers reported that some students had behavioral problems (e.g., DI combined with aggressive behavior, but without a diagnosis) (Table 1). The students were aged between 6 and 11 years (in months: M = 105.35, SD = 12.33). Forty-four students attend inclusive classes (inclusive group) and 56 students are enrolled in special schools (exceptional group)

Table 1. Number of pupils with syndromes and diagnoses in each setting.

	Group^{INCLUSIVE} (*n* = 44)	Group^{SPECIAL} (*n* = 56)
Down syndrome	6	8
Fragile X syndrome	0	3
Other syndromes	2	8
Autism spectrum disorder	5	13
Behavioural issues	15	9
Non-specific aetiology	25	31

Note: Double answers were possible.

Participants enrolled in an inclusive environment

The inclusive group (n = 44) consisted of 18 girls and 26 boys with ID enrolled in 35 inclusive classes in Grades 2 and 3. Thirty students were from Jember Regency and 14 students were from Bondowoso Regency.

Like their peers without DI, students with DI received four to five mathematics lessons per week (M = 4.9, SD = 0.29). Mathematics was taught by a general education teacher, and a special education teacher was present in class for some lessons (M = 3.43, SD = 1.03; min = 1.5, max = 5). Therefore, general education teachers were responsible for some of the mathematics education of students with DI in 24 of the 35 inclusive classes..

Participants enrolled in special education schools

The special education group consisted of 56 students (22 girls, 29 boys) aged 6–10 years enrolled in 15 different classes in special education schools. Eight students attended schools in Jember District and 48 students in Bondowoso District. Most participants had ID of unspecified etiology and 13 students were also diagnosed with autism spectrum disorder (Table 1). Students in this sample were taught in self-contained classes of four to eight students with ID. Thirteen classes were taught by a team consisting of a special education teacher and a teaching assistant. Two classes were taught by two full-time special education teachers (no teaching assistants). There were two to four mathematics lessons per week (M = 2.29; SD = 0.60).

Instrument

Mathematics achievement

Mathematics achievement was tested at the beginning of the school year in September and at the end of the same school year in June. Trained research assistants tested each child individually in a quiet room at school, using selected subtests from a standardized mathematics test that did not require further validation The instrument used to measure mathematics achievement in this study was the TEDI-MATH, a diagnostic test developed specifically for kindergarten and elementary school children to assess basic numerical skills (Grégoire et al., 2015; Kaufmann et al., 2009) The test is approximately 45 minutes long and is conducted with a break in the middle to maintain learner focus. One of the main strengths of TEDI-MATH is its minimal language demands, making it well-suited for use with students with intellectual disabilities (IDs), as demonstrated in a study by Garrote et al. (2015). The subtests used in this study included: procedural and conceptual numeracy, number writing and reading, number recognition and seriation, number conservation, number decomposition, picture-based calculation (addition/subtraction), understanding of the base ten system, and calculation through simple equations.

The internal reliability of the TEDI-MATH is very high, with a Cronbach's Alpha coefficient of 0.98 for the total score (95 items) at two measurement points, indicating excellent internal consistency. In addition, the TEDI-MATH has demonstrated strong construct and discriminant validity, as evidenced by significant correlations between subtest scores and students' actual numerical ability as measured by classroom observations and teacher reports. Initial mathematics achievement scores (t1) ranged from 0 to 93 and were normally distributed, while posttest scores (t2) ranged from 0 to 98 and were approximately normally distributed (kurtosis: –1.33, SE = 0.62; skewness: 0.10, SE = 0.24), indicating improvement in achievement and a data distribution suitable for further parametric analysis.

To control for cognitive variables, students' IQ data were obtained from school records. When not available, assessments were conducted using standardized tools such as the Culture Fair Test (CFT 1-R; Weiß & Osterland, 2013) or the Snijders-Oomen Non-verbal Intelligence Test (SON-R; Tellegen & Laros, 2005), both of which have high reliability and are appropriate for the population of children with special needs. The mean IQ score of the participants was 60.24 (SD = 11.89), confirming that all participants fall into the mild to moderate intellectual disability category.

Analysis

All statistical analyses were performed using SPSS 25. The means of the variables Mathematics t1, Mathematics t2, IQ, age, and number of hours of mathematics lessons in both settings were compared using the t-test for independent samples. Previous research has shown that selecting matched pairs of students in different settings (in this case, inclusive classes and special schools) produces comparable groups of students. (Dessemontet et al., 2012). Propensity score matching procedures are used to create statistically equivalent samples based on observed covariates. Covariate balance is essential to avoid bias in the estimation of treatment effects or background effects (Fan & Nowell, 2011). When each student in one condition is matched with another student who shares the same trait in the other condition, the difference between the groups should be due to the setting. To perform matching, a logistic regression model with setting as the dependent variable and Math t1, IQ, and age as independent variables was run. The propensity of each student to be in one of the two settings, a propensity score, was calculated. Using this score, each student from the inclusive setting was matched with a student from the special school; the difference between their propensity scores had to be below 0.1. Twenty-two matched pairs of 44 students (TOTAL pairs) were found and used for sub-sequence analysis.

Hierarchical regression analysis was used to test the impact of setting on the mathematics achievement of TOTAL sample pairs at t2. In this way, we controlled for other variables and determined whether the newly added variables showed a significant increase in R2. The IQ variable was entered as the first step, followed by Mathematics t1, and then the age variable in the next step. In step 4, the setting variables (inclusion, special school) were entered into the model.

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RESULTS AND DISCUSSION

Results

Group Descriptives

Table 2 shows the descriptives for the INCLUSIVE group and the SPECIAL SCHOOL group and the results of the t-test. The two groups differed significantly in terms of age, IQ, Math scores at t1 and Math scores at t2, and number of math lessons per week. Students in the special school were older, had lower IQs, and lower levels of math achievement at t1 and t2. Students in the inclusive group received more math lessons per week than students in the special school group. Paired t-tests showed that both students in the inclusive group (t(44) = 8.16, p < 0.001) and students in the special group (t(56) = 4.56, p < 0.001) had shown significant improvement in their math skills between t1 and t2. The difference in the number of mathematics lessons between the two groups indicates collinearity as confirmed by the high correlation between the school background variable and mathematics lessons (Eta2 = 0.861, p < 0.001).

Mathematics Achievement

The large range (t1: min. 0, max. 93, t2: min. 0, max. 98) and high standard deviation of the mathematics achievement variables (Table 2) indicate that there are large differences in mathematics ability among students. In the TOTAL sample, a large number of students (n = 40) could read some numbers and count to 10 at t1. These students made little progress in the skills assessed over the course of the school year. Their abilities were mostly at the first level of the model suggested by Krajewski and Schneider (2009). Of these 40 students with low mathematics achievement, 31 attended special schools. The second group, consisting of almost a third of the students (n = 31), could read and write numbers up to 10, count to 20, and relate numbers and quantities. They consolidated their abilities over the nine months of the study period and achieved success in reading numbers up to 100 and understanding number relationships. In this cluster, the number of students in special schools (n = 16) was almost the same as the number of students in inclusion classes (n = 15). The third group of students (n = 29) started with basic knowledge of numbers up to 100 and numeracy skills at t1. This group showed improvement in their ability to decipher numbers and understand the base ten system at t2. Twenty of these students attended inclusion classes and nine attended special schools. Thus, most students in the special group had very low levels of mathematics achievement, with only a few having numeracy knowledge of numbers up to 100 at t1. The hypothesis that students with DI in special schools would have lower levels of achievement than students with DI in inclusion classes was confirmed.

Table 2. Descriptives of sample^{total}, group^{INCLUSIVE} (*n* = 44) and group^{SPECIAL} (*n* = 56) and results of the group comparison (unpaired *t*-test).

	Sample^{TOTAL}	inclusive	special	*t*(98)	*p*
	M (*SD*)	*M* (*SD*)	*M* (*SD*)		
Age	105.96 (12.96)	99.95 (8.86)	110.68 (13.76)	−4.72	<0.001
IQ	60.24 (11.89)	65.34 (11.78)	56.23 (10.42)	4.10	<0.001
Math t1	34.35 (25.69)	45.11 (25.89)	25.89 (22.32)	3.98	<0.001
Math t2	43.71 (29.94)	58.70 (27.85)	31.93 (26.20)	4.92	<0.001
Math lessons	3.42 (1.43)	3.55 (1.15)	2.25 (0.67)	26.76	<0.001
Note: Age in months.					

Table 2 showed significant differences between students with intellectual disabilities (ID) studying in inclusive classes and students studying in special schools (SLB) in various key variables. On average, students in inclusive classes (M = 99.95 months, SD = 8.86) were younger than students in SLB (M = 110.68 months, SD = 13.76), with a statistically significant difference, t(98) = –4.72, p < 0.001. In addition, there was a significant difference in IQ scores, where students in inclusive classes had a higher mean IQ score (M = 65.34, SD = 11.78) than students in SLB (M = 56.23, SD = 10.42), t(98) = 4.10, p < 0.001. Initial (Math t1) and final (Math t2) mathematics achievement also showed a similar pattern, with students in inclusive classes scoring higher on both the pretest (M = 45.11, SD = 25.89) compared to students in special schools (M = 25.89, SD = 22.32), t(98) = 3.98, p < 0.001, and on the posttest (M = 58.70, SD = 27.85) compared to special schools (M = 31.93, SD = 26.20), t(98) = 4.92, p < 0.001. Interestingly, the frequency of mathematics learning per week was significantly higher in inclusive classes (M = 3.55, SD = 1.15) compared to special education classes (M = 2.25, SD = 0.67), t(98) = 26.76, p < 0.001

Regression analysis

A hierarchical regression analysis was conducted to investigate the impact of setting on Math t2 scores while controlling for IQ, Math t1, and age. Math class size was not entered as a variable due to collinearity with the setting variable (Eta2 = 0.801, p < 0.001). Table 4 provides an overview of the results for the TOTAL sample pairs. Entering IQ as the first step in the model yielded R2 = 0.21 (p < 0.01). When Math t1 was entered into the model, the proportion of explained variance increased significantly, R2 = 0.84 (Δ F = 170.92, p < 0.001). R2 did not increase when age was entered into the model. However, R2 increased significantly when the setting was entered into the model (Δ R2 = 0.03, Δ F = 9.26, p < 0.01) with a small effect size (f = 0.03; Cohen 1969). The hypothesis that inclusive environments have a neutral or slightly positive effect on the mathematics achievement of students with ID was proven. The model including all variables explained 87.8% of the variance (R2 = 0.88, F(4, 39) = 78.53, p <0.001).

Table 3. Descriptives of subsamples pairs^{INCLUSIVE} (*n* = 22) and pairs^{SPECIAL} (*n* = 22) and results of the group comparison (unpaired *t*-test).

	INCLUSIVE	SPECIAL	*t*(42)	*p*
	M (*SD*)	*M* (*SD*)		
Age	98.68 (8.27)	101.32 (13.40)	0.78	0.438
IQ	60.00 (11.02)	60.45 (12.58)	0.13	0.899
Math t1	29.23 (20.47)	34.41 (28.95)	0.69	0.497
Math t2	44.59 (27.13)	40.41 (31.73)	−0.47	0.641
Math lessons	4.95 (0.21)	2.50 (0.86)	−13.00	<0.001
Note: Age in months.				

Data analysis on matched subgroups of students with intellectual disabilities (ID) in inclusive and special schools showed that there were no significant differences between the two groups in terms of age (t(42) = 0.78, p = 0.438), IQ (t(42) = 0.13, p = 0.899), and initial (Math t1, t(42) = 0.69, p = 0.497) and final (Math t2, t(42) = –0.47, p = 0.641) mathematics achievement. These results indicate that the two groups had comparable baseline characteristics, which is important for internal validity when assessing the influence of the educational environment on learning outcomes. However, there was a very significant difference in the number of mathematics lessons students received each week, with students in inclusive classes receiving more learning sessions (M = 4.95, SD = 0.21) compared to students in special schools (M = 2.50, SD = 0.86), t(42) = –13.00, p < 0.001..

These findings have important implications for instructional design in the context of inclusive education. Although final mathematics achievement scores did not show significant differences, the higher frequency of learning in inclusive classes may reflect a more intensive and structured approach to mathematics instruction. Considering the equivalence in cognitive and age variables, these differences may indicate that contextual factors such as learning intensity have the potential to influence learning outcomes in the long term.

Therefore, in developing inclusive education policies, attention should be paid to providing adequate learning time allocation and targeted instructional support to optimize learning outcomes for students with special needs.

Table 4. Hierarchical regression analysis with Math t2 as dependent and IQ, Math t1, age, and setting as independent variables.

Step	Predictor variable	R^2	ΔR^2	ΔF	p
1	IQ	0.21	0.23	12.19	0.001
2	Math t1	0.84	0.63	170.92	<0.001
3	Age	0.85	0.01	3.88	0.056
4	Setting	0.88	0.03	9.26	0.004

Note: R^2 = 0.878 (adjusted), (n = 44, p < 0.001), Age in months, setting is coded 0 = special schools, 1 = inclusive education.

Table 4 The results of the hierarchical regression analysis with final mathematics achievement scores (Math t2) as the dependent variable show that each step of adding predictor variables significantly increases the proportion of variance explained in the model. In the first step, IQ accounted for 21% of the variance ($R^2 = 0.21$, $\Delta F = 12.19$, $p = 0.001$), indicating that intellectual ability has a moderate initial contribution to mathematics achievement. However, when initial mathematics achievement scores (Math t1) were entered in the second step, the predictive contribution increased substantially to 84% ($\Delta R^2 = 0.63$, $\Delta F = 170.92$, $p < 0.001$), confirming that initial ability is the strongest indicator of subsequent academic achievement.

The third step, the addition of the age variable, yielded a very small and statistically insignificant increase in R^2 ($\Delta R^2 = 0.01$, $\Delta F = 3.88$, $p = 0.056$), indicating that age differences do not substantially affect learning outcomes in this context. In contrast, in the fourth step, the setting variable (0 = special school, 1 = inclusive education) added a significant 3% of the variance to the model ($\Delta R^2 = 0.03$, $\Delta F = 9.26$, $p = 0.004$), indicating that the educational environment makes a meaningful additional contribution to mathematics achievement, even after controlling for IQ, initial ability, and age.

Overall, the final model explained approximately 88% of the variance in Math t2 scores (adjusted $R^2 = 0.878$), representing a very high level of predictive accuracy. These findings provide empirical evidence that despite initial ability being the dominant predictor, inclusive education independently contributes positively to the improvement of mathematics achievement of students with intellectual disabilities. Therefore, these results support the importance of developing policies that expand DI students' access to quality, intensive, inclusive learning environments.

Discussion

The results of this study confirm previous research, namely the existence of differences between the mathematics abilities of students with DI who are placed in inclusive classes and students who are placed in special schools (Cole et al., 2021). Students in inclusive classes had higher IQ scores and higher levels of mathematics achievement at t1 compared to their peers in special schools. However, all students with DI experienced significant learning gains in both settings. To investigate the effect of setting-inclusive education versus special schools - a matched sample of pairs was selected. Analysis of the matched pairs showed that the inclusive environment had a small and significant positive impact on students' mathematics achievement over the course of one school year..

CONCLUSION

The results of this longitudinal study confirm previous research, namely that there is a difference between the mathematical abilities of students with DI who are placed in inclusive classes and students who are placed in SLB. (Cole et al., 2021). Students in inclusive classrooms had higher IQ scores and higher levels of mathematics achievement at t1 compared to their peers in special schools. However, all students with DI experienced significant learning gains in both settings. To investigate the effect of setting-inclusive versus special schools - a matched sample of pairs was selected. Analysis of matched pairs showed that the inclusive environment had a small but significant positive impact on students' mathematics achievement over the course of one school year.

Differences between mathematics achievement of students with DI in special schools and in inclusive classes

Comparing the two samples shows that more students with very low mathematics achievement are enrolled in special schools, while students with higher mathematics achievement (basic knowledge of numbers up to 100 and calculation skills) attend inclusive classes. More students identified with autism spectrum syndromes and disorders are enrolled in special schools. These diagnoses can affect the acquisition of mathematics and language competencies as well as learning behavior and social skills. Difficulties in these areas can in turn impact the acquisition of mathematics achievement (Jordan et al., 2010). This study found that the effect of setting was relatively small. The different diagnoses, and the possibility that the setting did not have a very large impact in the first two or three years of school, make it possible that the mathematical profile may have existed before this study. This means that students enrolled in special schools have a different academic profile than students enrolled in inclusive education. This mechanism is supported by previous research. (Dessemontet et al., 2012; Peetsma et al., 2001). The assumption is that students with ID who have relatively high cognitive and mathematical abilities and have fewer behavioral problems will be placed in inclusive classes. (Cole et al., 2021; Gilmour & Allison, 2018; Zigmond & Kloo, 2011).

In this study, more teachers in inclusive classrooms mentioned that their students with DI had behavioral problems. However, their assessments of students' behavior may have been harsher than those of their colleagues working in special schools where students often exhibit challenging behavior. (Savoie & Gascon, 2008). General education teachers may also tend to unfairly compare the behavior of students with DI to students without DI.

Our research results show that the placement of students with DI in special schools or inclusive classes is not done randomly so the influence of the environment on academic achievement cannot be investigated using a randomized treatment design (Cole et al., 2021). Propensity score matching procedures allow the selection of students with similar characteristics from different settings for further analysis and offer a methodological process that approximates a randomized control trial. (Cole et al., 2021). In this study, matching ensured that the samples in inclusive and special education were similar in terms of IQ, math achievement, and age. This matching also resulted in students with similar math abilities in both settings..

Impact of learning setting on mathematics achievement of students with DI

When matched samples were compared, students in inclusive classrooms made more progress in mathematics than students in special schools, controlling for IQ, age, and prior mathematics achievement. To our knowledge, this is the first study to demonstrate the impact of educational setting on mathematics achievement over the course of a single school year. The positive effects of inclusive education on the academic achievement of students with DI are consistent with findings from other studies examining progress in other subjects (Cole et al., 2021; Dessemontet et al., 2012; Peetsma et al., 2001). However, it is not clear which features of the setting account for this result. Students in inclusive classes receive more hours of math instruction per week than students in special schools.. Menurut Schnepel & Aunio (2022), The intensity (frequency) of instruction is an important factor in the success of mathematics education programs for students with DI. Teachers who have higher expectations for students in inclusive classrooms can also have a positive impact on student progress. (Klang et al., 2020). There is also a positive impact of inclusive education on the achievement of students with ID as a result of the stimulation provided by peers without disabilities through social learning mechanisms (Barth et al., 2004; Justice et al., 2014). This argument and the results of this study together suggest that the placement of students with DI in special schools can be interpreted as ability grouping that can hurt the achievement of students in low-ability groups. (Faber et al., 2018).

Limitations and implications for further research

This study has several limitations. DI diagnosis was based solely on IQ, and adaptive behavior was not considered. It is possible that the two groups differed in adaptive behavior which could have influenced the results. However, research has shown that mathematics progress is largely dependent on IQ and prior mathematics knowledge. Therefore, these important variables were included in the study. Regardless of background, many students made very little progress in mathematics over the course of the school year. This may be because the instrument chosen to assess mathematics achievement was designed to assess early numerical and computational abilities, and may not have been sensitive enough to assess the improvement in achievement of students with very low mathematics achievement. In addition, the larger number of students diagnosed with autism spectrum disorder in special schools may have influenced the results.

Given the multifaceted nature of comprehensive and extraordinary instruction classrooms, setting factors are naturally connected with a run of other relevant variables, such as the recurrence of arithmetic instruction, student-teacher proportions, and the composition of understudies with and without extraordinary instructive needs (SEN) inside a lesson. Besides, extra factors not inspected in this study—including guidelines systems, academic strategies, learning targets, educator desires, and asset availability—may considerably impact students' arithmetic learning results. It is basic to recognize that the next amount of arithmetic instruction conveyed by uncommon instruction instructors does not naturally decipher into higher guidelines quality. Hence, future investigations ought to receive a more comprehensive approach by gathering point-by-point information on understudy characteristics (e.g., dialect capability, cognitive capacities), guidelines hones (e.g., instructing strategies, materials, recurrence and setting of learning), and educator convictions and states of mind toward comprehensive instruction. Moreover, to optimize the effect of comprehensive classrooms for understudies with disabilities, there's a basic have to be development of educational approaches that are both versatile and separate. Procedures such as Widespread Plan for Learning (UDL), collaborative co-teaching models, and the integration of assistive innovations ought to be investigated and refined to guarantee impartial access to numerical concepts. Such methodological upgrades can enable understudies with mental incapacities to lock in more seriously within the learning handle and accomplish their full scholastic potential.

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