



# Effect of sensory integration ability on the academic achievement of elementary students in grades I to III

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## ABSTRACT

To examine the effect of sensory integration on the academic achievement of elementary school students. This study was conducted on 151 elementary students in grades I to III in elementary schools in Gunungsitoli City, North Sumatra Province, using the sensory integration development rating scale. The development of students' sensory integration ability was relatively stable in early elementary school and there were significant gender differences ( $F = 6.632, p = 0.01$ ); sensory integration ability explained 16.9% of the variance in students' academic achievement and 27.8% of the variance in girls' academic achievement; the learning ability dimension of sensory integration ability significantly affected students' academic achievement ( $p = 0.005$ ). The proprioceptive dimension ( $p = 0.012$ ) had a significant effect on girls' academic achievement. There were gender differences in the performance of sensory integration skills between male and female elementary school students in grades I to III and the effect on academic achievement.

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## INTRODUCTION

Sensory integration skills is the basic ability for children to begin to develop early. With the growth of age, children's sensory integration ability continues to develop and promote their effective learning and life (Ashori et al., 2018; Harefa & Gulo, 2024; Harefa & Huang, 2023; Pfeiffer et al., 2018). May-Benson et al. (2022) stated that when individuals with childhood sensory processing and integration with motor coordination challenges report that their sensori-motor issues were largely resolved in adulthood, those adults have a good quality of life. Ayres, an American clinical psychologist, was the first to put forward the concept of sensory integration (Ayres, 1972; Schoen et al., 2019). He believed that sensory integration is the ability of the human brain to analyze and comprehensively process the sensory information transmitted from various sensory organs for many times, and make correct responses, so that individuals can operate harmoniously and effectively in the stimulation of the external environment. Schaaf et al. (2018) then proposed that sensory integration integrates a variety of sensory system information, involving audio-visual sense, touch, taste, smell, vestibular sense, proprioception, etc. It is a process of information

interaction between the body and the surrounding environment through brain integration. There is a close relationship between sensory integration and students' academic achievements (Mallory & Keehn, 2021). The research of Butera et al. (2020) showed that there is a corresponding relationship between the assessment of students' academic performance and sensory integration disorder. Many studies have also confirmed the close relationship between students' sensory integration skills and academic achievement (Famarazi et al., 2016; Harefa, 2023; Kantor et al., 2022; van der Wurff et al., 2021). However, Lin et al. (2013), Parham et al. (2019), and Roley et al. (2015) used the tracking research method to investigate children aged 6-8 and 10-12 respectively, and found that the sensory integration performance of children aged 6-8 was significantly related to their academic achievements in the same period, and could predict their later learning achievements, while the sensory integration ability of children aged 10-12 was not significantly related to their academic achievements in the same period. They proposed that the middle and lower ages might be the period when children's sensory integration ability was most closely related to their academic achievements. Moreover, the literature provides mixed findings regarding learning outcomes not only with the use of static versus dynamic resources but also with added factors such as gender and spatial ability (Berney & Bétrancourt, 2016). On the other hand, the previous research did not discuss in detail the specific relationship between various dimensions of sensory integration and different disciplines and gender differences. In this regard, this study took the middle and low age children in elementary schools as the research object to further explore the relationship between the dimensions of pupils' sensory integration ability and academic achievements in specific disciplines.

## RESEARCH METHODOLOGY

This study used a quantitative model research and using random sampling to select sample (Creswell, 2017). 151 students (7-9 years old) from grade one to grade three in a elementary schools in n Gunungsitoli City, North Sumatra Province, were investigated by questionnaire. Among them, 49 were in the first grade (32.45% of the total), 47 in the second grade (31.13% of the total), and 55 in the third grade (36.42% of the total). There were 81 boys (53.64% of the total) and 70 girls (46.36% of the total). The study had obtained the informed consent of teachers, parents and students themselves. The research objects are all normal enrollment objects of compulsory education, without intellectual disorder, physical disorder and other psychological or physiological diseases.

In this study, a comprehensive measure of children's sensory integration abilities was conducted using the Sensory Integration Development Rating Scale for Children. This scale was introduced and revised by the Institute of Mental Health of Beijing Medical University from the Children Brain Development Consortium in Taiwan, and is applicable to the measurement of students' sensory integration abilities between the ages of 6 and 11. The measure includes five dimensions: large muscles and balance, tactile over-defense, poor proprioception and body coordination, underdeveloped or poorly coordinated learning ability, and age-specific problems, with a total of 58 questions.. The options are scored at five levels, including "never", "occasionally", "sometimes", "often" and "always". "never" is the highest score, and "always" is the lowest score. The scale was scored by parents according to students' behavior, and the sum of scores of each dimension is the total score of children's sensory integration ability. In this study, the reliability of the scale Cronbach alpha was 0.951, which has high reliability.

At the same time, this study collected the language and mathematics academic achievements of the elementary school students participating in the survey. The students' academic achievements were the average of the standard scores. This study used SPSS 27.0 for data analysis, mainly including descriptive statistics, analysis of variance, correlation analysis, regression analysis, and so on.

## RESULTS AND DISCUSSIONS

### Sensory Integration Ability of Elementary School Students in Grades I to III

The results of the descriptive statistics showed that the mean value of the sensory integration ability of elementary school students in grades I to III was 253.6 (out of 290), which indicated that the overall sensory integration ability of elementary school students in the lower and middle grades was good, as shown in Table 1. The results of the one-way ANOVA showed that there were no significant differences in the overall sensory integration ability, balance, tactile sensitivity, proprioception, learning ability, and special activities, indicating that the development of the sensory integration ability of the lower and middle grade elementary school students was stable.

**Table 1.** Analysis of the current situation of sensory integration ability in elementary students from grades I to III.

Dimensions	M	SD	Grades			F	p
			1 <sup>st</sup> Grade	2 <sup>nd</sup> Grade	3 <sup>rd</sup> Grade		
Balance ability	60.08	7.33	59.18±7.82	59.98±7.18	61.05±6.87	2.214	0.859
Tactile sensitivity	93.63	9.48	93.31±9.38	93.45±7.17	93.97±9.87	0.168	0.111
Proprioception	53.78	6.44	53.78±5.69	54.05±5.83	53.52±7.57	0.225	0.845
Learning ability	33.37	6.05	33.14±5.58	33.64±5.43	33.32±6.89	0.223	0.798
Special activities	12.64	2.41	12.82±2.14	12.82±2.17	12.34±2.77	1.723	0.801
Sensory integration	253.71	26.55	252.52±24.75	254.07±25.14	254.16±29.37	0.154	0.182

### Gender Differences in the Sensory Integration Abilities of Elementary School Students in Grades I to III

In order to examine whether there were gender differences in the sensory integration abilities of the lower and middle school students, a multivariate analysis of variance (ANOVA) was used to compare the differences in children's sensory integration scores in the gender dimension. The results are shown in Table 2. There was a significant difference in children's sensory integration ability between the middle and lower grades in terms of gender [ $F(1,379) = 6.632, p = 0.01$ ], indicating that there was a significant effect of gender on children's sensory integration ability. In addition, there was no significant difference in the interaction between gender and grade level dimensions [ $F(2,379) = 6.632, p = 0.216 > 0.05$ ], and the sensory integration scores of girls in grades I to III were significantly higher than those of boys.

**Table 2.** Analysis of variance of gender and grade factors on sensory integration ability.

Dimensions	Sum of squares	Degree of freedom	Mean square	F	p
Gender	4603.41	1,00	4603.41	6,64	0.01**
Grade	174.54	2,00	87,28	0,13	0.88
Gender x Grade	2136.13	2,00	1068,06	1.54	0.21
Tolerance (error)	263,086.69	379,00	694,16		

Note: \*represents  $p < 0.05$ , \*\* represents  $p < 0.01$ , and \*\*\* represents  $p < 0.001$ .

In addition, this study used independent sample *t*-test to compare the balance ability, tactile sensitivity, proprioception, and body sense of elementary school students in grades I to III, respectively. to third grade elementary school students' balance ability, tactile sensitivity, proprioception The gender differences in the dimensions of balance, tactile sensitivity, proprioception, learning ability, and special activities were compared using independent sample *t*-tests. The results showed that The results showed that there were significant gender differences in the dimensions of proprioception and special activities ( $p < 0.01$ ), There were no significant gender differences in the dimensions of balance, tactile sensitivity, and learning ability. There were no

significant gender differences in balance, tactile sensitivity and learning ability dimensions, as shown in Table 3.

The present study found that the development of sensory integration skills was relatively stable among elementary school students in grades I to III, and there were no significant differences between grades. This result is consistent with previous studies. For example, Yuan et al. (2022) studied the sensory integration ability of children aged 6-9 years in elementary school and found that the development of sensory integration ability of children aged 6-9 years was relatively stable and there was no significant age difference in their sensory integration ability. The development of children's sensory integration skills is early, with rapid development during infancy and early elementary school years slowing down (Barakat et al., 2021). Therefore, there is no significant difference in the overall sensory integration ability and dimensions among students in different grades in the early elementary school.

Sensory integration skills were significantly associated with the academic achievement of elementary school students in grades 1 to 3. The dimensions of sensory integration ability were closely related to the achievement of elementary school students in a mathematics course. Moreover the dimensions of proprioception and learning ability were significantly related to the achievement of language. Sakamoto & Watanabe (2017) and (Costa-López et al., 2021) concluded that the dimensions of balance, tactile sensitivity, learning ability and proprioception were significantly associated with elementary school students' achievement in mathematics, while learning ability was closely related to language achievement. On the other hand, the present study found that proprioception was also significantly related to language achievement. The possible reason is that language learning in early elementary school is mainly about learning phonological sounds and writing, which makes proprioception more involved in language learning (Milankov et al., 2021). In the early years of elementary school, children's small muscle motor control is slow to develop, and finger and wrist movements are not flexible and coordinated enough, resulting in the phenomenon of first graders often poking their books when they first learn to write.

**Table 3.** Comparison of gender differences in sensory integration among elementary students from grades 1 to 3

Dimensions	Gender		<i>t</i>	<i>p</i>
	Male	Female		
Balance ability	59.01±7.37	61.31±7.04	-3.104	0.066
Tactile sensitivity	93.11±10.01	94.18±8.83	-1.103	0.302
Proprioception	53.17±7.12	54.45±5.47	-2.005	0.005**
Learning ability	32.54±6.33	34.27±5.51	-2.824	0.071
Special activity	12.27±2.67	13.06±2.04	-3.361	0.000**
Sensory integration	250.11±27.81	257.45±24.41	-2.758	0.015**

Regarding the relationship between sensory integration ability and mathematics achievement, the results of this study were consistent with previous studies, which concluded that dimensions such as balance ability and tactile sensitivity were closely related to elementary school students' mathematics learning, and that perceptual-body movement facilitated elementary school students' mathematics learning. For example, Shvarts et al. (2021) and Tran et al. (2017) in their analysis of research on embodied mathematics teaching in elementary schools, they concluded that physical movement is beneficial for improving students' academic performance in mathematics. Aldugom et al. (2020) and Wakefield et al. (2019) argued that figurative gestures help students to understand mathematical concepts, mathematical symbols, and mathematical ideas. In addition, mathematics learning requires perceptual-tactile integration (Trisnawati et al., 2018). For example, teachers can help elementary school students recognize numbers through real objects such as apples and sticks.

### The Relationship Between Sensory Integration Ability and Academic Achievement of Elementary Students

In order to explore the relationship between academic achievement and the dimensions of sensory integration ability, this study found that the total scores of sensory integration ability were significantly correlated with the scores of language, mathematics and academic achievement, as shown in Table 4. The five dimensions of sensory integration ability were significantly correlated with mathematics achievement, and the two dimensions of proprioception and learning ability were significantly correlated with language and academic achievement, respectively. Based on this, the study further analyzed the correlation between academic achievement and sensory integration ability of primary school students by gender. The results showed that boys' mathematics achievement and total academic achievement were significantly and positively correlated with the dimensions of sensory integration ability and total score, while boys' language achievement was significantly correlated with the total score of sensory integration ability and the dimensions of tactile sensitivity, proprioception, learning ability and special activities, but not with the dimension of balance ability.

The language scores of girls were not significantly correlated with the total score of sensory integration ability and each dimension, while the mathematics scores were significantly correlated with the total score of sensory integration ability and the dimensions of balance, proprioception, and learning ability, and the total score of academic achievement was significantly correlated with the dimensions of proprioception and learning ability. The results indicated that girls' mathematics scores were closely related to the balance, proprioception, and learning ability dimensions of sensory integration ability, and girls' total academic achievement scores were closely related to the proprioception and learning ability dimensions.

**Table 4.** Gender correlation between different dimensions of sensory integration ability and language, mathematics and academic achievements

Gender	Indicator	Dimensions					
		Balance ability	Tactile sensitivity	Proprioception	Learning ability	Special activity	Sensory integration
All	Scores in language	0.05	0.11	0.21**	0.23**	0.11	0.16**
	Scores in mathematics	0.26**	0.21*	0.34**	0.46**	0.19*	0.35**
	Academic achievement	0.17	0.17	0.28**	0.34**	0.14	0.26**
Male	Scores in language	0.19	0.26**	0.38**	0.38**	0.27*	0.34**
	Scores in mathematics	0.31**	0.25*	0.31**	0.54**	0.32**	0.39**
	Academic achievement	0.28*	-0.32*	0.36*	0.44**	0.31*	0.38**
Female	Scores in language	-0.07	-0.03	0.06	0.12	-0.04	0.012
	Scores in mathematics	0.31*	0.23	0.52**	0.52**	0.13	0.41**
	Academic achievement	0.08	0.06	0.32*	0.32*	0.23	0.19

Note: \*represents  $p < 0.05$ , \*\* represents  $p < 0.01$ , and \*\*\* represents  $p < 0.001$ .

**Table 5.** Regression analysis of the dimensions of sensory integration ability and academic achievement of boys from grade one to grade three

Dependent variable	Dimensions	B	SE	Beta	t	p
Scores in language	Balance ability	-0.04	0.14	-0.04	-0.28	0.78
	Tactile sensitivity	-0.06	0.14	-0.07	-0.48	0.66
	Proprioception	0.34	0.19	0.31	1.78	0.08
	Learning ability	0.38	0.21	0.29	1.77	0.08
	Special activity	-0.35	0.50	-0.11	-0.69	0.49
Scores in mathematics	Balance ability	-0.01	0.17	-0.01	-0.37	0.94
	Tactile sensitivity	0.06	0.16	0.06	-1.07	0.73
	Proprioception	-0.25	0.21	-0.24	3.72	0.24
	Learning ability	1.30	0.27	4.90	3.39	0.00**
	Special activity	-1.26	0.61	-0.37	-2.08	0.04*
Academic achievement	Balance ability	-0.04	0.19	-0.03	-0.18	0.86
	Tactile sensitivity	0.11	0.17	0.16	0.65	0.52
	Proprioception	-0.06	0.25	-0.07	-0.22	0.82

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Learning ability	0.71	0.34	0.63	2.09	0.04*
Special activity	-0.04	0.14	-0.04	-0.28	0.78

Note: \*represents  $p < 0.05$ , \*\* represents  $p < 0.01$ , and \*\*\* represents  $p < 0.001$ .

### Regression Analysis of Sensory Integration Ability on Academic Achievement of Elementary School Students by Gender

To further understand the effect of sensory integration ability on the academic achievement of primary school students in grades I to III, regression analyses were conducted for boys and girls with the academic achievement score as the dependent variable and the dimensions of sensory integration ability as the independent variables. As shown in Table 5, the learning ability dimension of sensory integration was a significant predictor of academic achievement for boys in grades I to III, and the learning ability and special activities dimensions were significant predictors of mathematics achievement for boys in grades I to III. Therefore, improving the learning ability and special activity ability of 1st-3rd grade boys can significantly improve their academic achievement in mathematics. As shown in Table 6, the proprioceptive and learning ability dimensions of sensory integration were significant predictors of girls' total academic achievement scores. In addition to the proprioceptive and learning ability dimensions, the special activities dimension significantly predicted girls' performance in mathematics, but only the learning ability dimension significantly predicted girls' performance in language. The results indicate that improving girls' proprioception and learning ability can improve girls' academic achievement, and improving girls' learning ability is beneficial to their language achievement. The results in Table 6 also show that improving girls' competence in special activities is beneficial for improving girls' performance in mathematics.

**Table 6.** Regression analysis of the dimensions of sensory integration ability and academic achievement of girls from grade one to grade three

Dependent variable	Dimensions	B	SE	Beta	t	p
Scores in language	Balance ability	0.59	0.41	0.25	1.42	0.16
	Tactile sensitivity	0.69	0.34	0.28	2.04	0.044*
	Proprioception	-0.70	0.87	-0.11	-0.80	0.43
	Learning ability	-0.20	0.53	-0.07	-0.37	0.71
	Special activity	0.33	0.31	-0.19	-1.07	0.29
Scores in mathematics	Balance ability	1.92	0.52	0.66	3.72	0.000**
	Tactile sensitivity	1.23	0.36	0.45	3.39	0.001**
	Proprioception	-2.36	0.93	-0.37	-2.53	0.014*
	Learning ability	-0.55	0.64	-0.20	-0.86	0.39
	Special activity	-0.55	0.44	-0.30	-1.31	0.20
Academic achievement	Balance ability	1.66	0.63	0.57	2.62	0.012*
	Tactile sensitivity	1.06	0.47	0.43	2.29	0.027*
	Proprioception	-1.54	1.29	-0.26	-1.19	0.24
	Learning ability	0.59	0.41	0.25	1.42	0.16
	Special activity	0.69	0.34	0.28	2.04	0.044*

Note: \*represents  $p < 0.05$ , \*\* represents  $p < 0.01$ , and \*\*\* represents  $p < 0.001$ .

Analysis of the relationship between sensory integration abilities and the academic achievement of elementary school students by gender revealed that the learning ability and special activities dimensions of sensory integration abilities significantly affected the mathematics achievement of boys, the balance, proprioception, and learning ability dimensions of sensory integration abilities significantly affected the mathematics achievement of girls, and the proprioception and learning ability dimensions significantly affected the overall academic achievement of girls. Special activities involve activities in which children actually use tools. Rademaker et al. (2014) and Schettler et al. (2019) found that there is interaction between the body, tools and external objects and that it requires knowledge and experiences such as mechanical and

conceptual dynamics, which require multiple low levels of sensory integration. Thus, the use of tools and multisensory integration in learning are strongly associated with children's learning.

Jiang et al. (2018) suggested that the development of proprioception is closely related to children's control of large and small muscles, hand-eye and ear coordination, and motor coordination skills. The development of proprioception is closely related to children's control of large and small muscles, hand-eye and ear coordination, and motor coordination skills. Children with proprioceptive disorders exhibit poor learning abilities and have difficulties in reading, dictation, and language. This suggests that motor skills in proprioception are also closely related to language development. There is a difference in the rate of language development between boys and girls, and thus girls develop activities closely associated with mouth movements, such as verbal expression, earlier and influence language and mathematics performance. In conclusion, this study confirms that there is a strong association between sensory integration skills and academic achievement in elementary school students in grades I to III, and that learning in different subjects is influenced differently by sensory integration skills. Gender differences in the relationship between sensory integration and academic achievement were significant.

## CONCLUSION

To sum up, this study confirmed that the sensory integration ability of primary school students from grade one to three is closely related to their academic achievements, and the learning of different disciplines is affected differently by the sensory integration ability. In the relationship between sensory integration and academic achievement, gender differences are significant. The research is a recommendation for teachers to implement learning that can activate sensory abilities in improving learning outcomes and the integration of media and interactive learning models really needs to be done and can be researched further. This study suggests that multisensory experiences (visual, auditory, tactile, kinesthetic) lead to better retention and deeper learning, teachers can integrate multiple senses into daily lessons. Moreover, the importance of sensory input in maintaining focus or creating an optimal learning atmosphere (e.g., reducing noise levels or providing calm, tactile experiences), schools can design classrooms to support sensory needs.

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