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Implementation of Visual, Auditory, and Kinesthetic (VAK) Differentiated Learning to Improve Scientific Communication Skill in Science Subjects

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ABSTRACT
This study aims to improve students' scientific communication skills through the implementation of differentiated VAK (Visual, Auditory, and Kinesthetic) learning in the "Motion and Force" topic for Grade VII of junior high school, in response to the demands of the Independent Curriculum, which emphasizes student-centered learning by accommodating diverse learning needs. This quantitative research employed a quasi-experimental approach with a Nonequivalent Pretest-Posttest Control Group Design. The study involved 100 students from SMPN 1 Tembilahan, divided into experimental and control groups. Data analysis was conducted both descriptively and inferentially to assess the impact of VAK-differentiated learning compared to conventional scientific learning methods on the enhancement of scientific communication skills. Scientific communication abilities were evaluated based on six indicators: information retrieval, scientific reading, scientific writing, listening and observation, information representation, and knowledge presentation. Pretests and posttests were administered to both groups. The results showed that the average posttest scores of the experimental group were significantly higher than those of the control group. Furthermore, the MANOVA test confirmed a significant difference in the improvement of scientific communication skills between the groups, indicating that VAK-differentiated learning effectively supports the development of scientific communication competencies among students.

Keywords*: scientific communication, VAK differentiation*

INTRODUCTION

The Programme for International Student Assessment (PISA), initiated by the Organisation for Economic Co-operation and Development (OECD), is an international survey that evaluates student performance at the secondary education level in three domains: numeracy, literacy, and science. Countries with high achievement indices are regarded as having educational systems that meet international market standards (Pratiwi, 2019). The results of PISA provide critical recommendations for the Indonesian education system, urging continuous evaluation and improvement of educational quality in schools nationwide. Consequently, PISA outcomes significantly influence the educational planning strategies of participating countries (Sjøberg, 2018). In Indonesia, PISA results are used as benchmarks for formulating educational programs. Administered every three years, PISA not only assesses students' competencies in reading, mathematics, and science but also gathers comprehensive data on students' backgrounds, learning environments, learning styles, and digital literacy (Schleicher, 2009).

The implementation of the Independent Curriculum represents the Indonesian government's response to the learning recovery period, simultaneously introducing new challenges for educators. Teachers are now expected to master digital competencies and address diverse student learning needs to foster 21st-century skills. Among these skills, commonly referred to as the "4Cs," are critical thinking, creativity, collaboration, and communication (Sudirtha et al., 2021). The curriculum underscores the importance of adaptive teaching strategies that encourage higher-order thinking in science education.

Within Phase D of junior high school science learning under the Independent Curriculum, two principal elements are emphasized: scientific understanding and inquiry-based process skills. However, teachers often encounter challenges in nurturing these competencies, particularly in promoting higher-level thinking skills (Siswanto et al., 2023). While some educators argue that such skills can emerge naturally through experiential learning, others maintain that structured, explicit, and intentional instruction is essential (Scherz et al., 2005). Evidence suggests that without guided teaching, students struggle to develop scientific skills independently, highlighting the necessity of active teacher involvement.

One effective strategy for developing students' scientific communication skills is the implementation of differentiated instruction within science education. Differentiated learning represents a proactive approach by which teachers address the diverse needs of students in the classroom. According to Tomlinson (2000), differentiation occurs when a teacher intentionally modifies instruction to create optimal learning experiences for individuals or small groups. Effective differentiated instruction requires that teachers identify and respond to students' prior knowledge, readiness levels, linguistic abilities, learning preferences, and interests (Huebner, 2010).. The diversity inherent in today's classrooms challenges educators to foster environments that prioritize personalized learning pathways. Tailoring instruction to accommodate varying learning styles—visual, auditory, and kinesthetic—can significantly enhance individual student engagement and achievement (Aranda & Zamora, 2017). Differentiation involves adapting three key elements of instruction: content (what students learn), process (how students acquire knowledge), and product (how students demonstrate their learning) (Tomlinson, 2001) (Fitra, 2022). By thoughtfully adjusting these components, teachers create inclusive classrooms that support diverse learners in obtaining information, exploring ideas, and effectively expressing their understanding.

Scientific communication encompasses a wide range of competencies, including reading and interpreting graphs, drawing conclusions from experimental data, writing structured scientific reports, and presenting findings clearly and systematically (Nurlaelah et al., 2020). According to Spektor-Levy et al. (2009), scientific communication involves six key skills: information retrieval, scientific reading, scientific writing, listening and observation, information representation, and knowledge presentation. Each of these skills includes specific sub-skills essential for mastering scientific discourse (Spektor-Levy et al., 2008).

This research focuses specifically on differentiated learning based on students' preferred modalities—visual, auditory, and kinesthetic (VAK). The primary aim is to investigate the effectiveness of VAK-differentiated instruction in improving students' scientific communication abilities, as conceptualized by (Spektor-Levy et al., 2009), among junior high school students.

METHODOLOGY

This research employs a quantitative methodology utilizing a quasi-experimental approach. Such an approach is particularly well-suited to educational settings, where the subjects—students or teachers—are human participants whose behaviors and conditions cannot be fully controlled (Rukminingsih et al., 2020). Specifically, the study adopts a Nonequivalent Pretest-Posttest Control Group Design, involving both an experimental group and a control group (Creswell, 2014). This design allows for the assessment of changes in outcomes by comparing pretest and posttest results between the two groups, despite the absence of random assignment. The detailed research design is presented in Table 1.

Table 1. Pretest-Posttest Control Group Design

Group	Pretest	Treatment	Postest
Experiments	O_1	X	O_3
Control	O_2	-	O_4

In this method, both the experimental and control groups were administered a pretest (denoted as O1 and O2, respectively) to assess baseline scientific communication skills. The experimental group then received an intervention (denoted as X) through the application of VAK (Visual, Auditory, and Kinesthetic) differentiated learning strategies, while the control group engaged in conventional scientific learning. Both groups utilized teaching modules aligned with the learning objectives outlined in the Independent Curriculum. Following the intervention, posttests were conducted to measure scientific communication skills, symbolized by O3 for the experimental group and O4 for the control group.

This study was conducted at SMP Negeri 1 Tembilahan, involving a research population of 316 seventh-grade students. A total of 100 students were selected as the sample, distributed across two experimental classes and two control classes. Initial data collection involved administering a pretest on scientific communication skills, followed by statistical analyses using SPSS version 26 for Windows to assess the normality and homogeneity of the sample. Based on the prerequisite tests, four classes were selected, and group assignment (experimental or control) was determined by rolling a die—the first two resulting numbers were assigned to the experimental group, and the last two to the control group.

Within the experimental group, a learning style assessment was conducted prior to the intervention. The instrument for this assessment, developed by counseling teachers at SMPN 1 Tembilahan, consisted of 14 multiple-choice questions. The learning style test aimed to organize students into groups based on their dominant learning styles: visual, auditory, or kinesthetic.

All instruments utilized in this study—including the teaching modules, the learning style test, and the scientific communication test—were validated by three expert lecturers. Subsequently, the scientific communication test, constructed based on indicators proposed by Spektor-Levy (2009), was piloted on a population class that had already studied the "Motion and Force" material, involving 30 student respondents. The initial test comprised 18 items, with three items representing each of the six indicators of scientific communication. Item validity and reliability were analyzed using SPSS version 26. Based on the analysis, 12 questions were retained for use in the final scientific communication assessment, with detailed information presented in Table 2.

Tabel 2. Details about Scientific Communication

Indicators of Scientific Communication	Number of Question	Question Number	Poin
Information retrieval	2	1,2	6

Indicators of Scientific Communication	Number of Question	Question Number	Poin
Scientific reading	2	3,4	6
Observing	2	5,6	6
Scientific writing	2	7,8	6
Information representation	2	9,10	6
Knowledge presentation	2	11,12	6

This study employs both descriptive and inferential data analysis techniques. Descriptive statistics are utilized to analyze and present data by summarizing and illustrating the collected information without attempting to make broader generalizations or inferential conclusions (Bengtsson, 2016). Quantitative data obtained from students' written tests are analyzed descriptively to assess their scientific communication skills. The students' total scores are calculated and subsequently converted to a standardized scale ranging from 10 to 100 (Craig A, 2002). The criteria for evaluating scientific communication skills are presented in Table 3.

Table 3. Criteria for Scientific Communication Skills

Score	Criteria	Categori
81 < x ≤ 100	Excelent	A
61 < x ≤ 80	Good	B
41 ≤ x ≤ 60	Enough	C
x < 40	Need Guidance	D

(Arikunto, 2013)

Inferential statistics, a method used to draw conclusions and generalizations about a population based on sample data, were also employed in this study (White & Gorard, 2017). In particular, inferential data analysis was conducted to determine whether significant differences existed in the scientific communication abilities of junior high school students who received VAK differentiated instruction (experimental group) compared to those who received traditional scientific instruction (control group). The inferential analysis utilized the MANOVA (Multivariate Analysis of Variance) test, supported by the SPSS version 26 for Windows software, with a confidence level set at 95%. Although the MANOVA procedure originally involved one independent variable and two dependent variables, the present article focuses specifically on examining the impact of VAK differentiated learning on a single dependent variable—students' scientific communication skills.

RESULT AND DISCUSSION

This study generated achievement data based on the post-test results of scientific communication skills from a total of 100 students, divided equally between the experimental and control groups. Scientific communication tests were administered both before and after the intervention. The comparative results of the pretest and post-test scores for the experimental and control groups are presented in Table 3.

Table 3. Descriptive Data of Scientific Communication

Element Descriptive	Experimental Groups		Control Groups	
	Pretest	***Postest***	***Pretest***	***Postest***
N	50	50	50	50
Mean	47,24	85,12	45,70	72,70
Variance	41,982	47,210	28,296	35,071
St.Deviasi	6,479	6,871	5,319	5,922
Min	36	70	36	61
Max	61	100	56	83
Range	25	30	20	22

The pretest results for the experimental group showed an average score of 47.24, with a variance of 41.982 and a standard deviation of 6.479. The range between the maximum and minimum scores was 25. Following the implementation of VAK differentiated learning, the post-test results of the experimental group revealed an increased average score of 85.12, with a variance of 47.210 and a standard deviation of 6.871. The score range expanded slightly to 30. Based on the scientific communication skills criteria, the average post-test score of 85.12 falls within the "Excellent" category (Arikunto, 2013).

For the control group, the pretest results indicated an average score of 45.70, with a variance of 28.296 and a standard deviation of 5.319. The range between the maximum and minimum scores was 20. Meanwhile, the post-test results showed an improved average score of 72.70, with a variance of 4.557 and a standard deviation of 2.135, indicating considerable data variation. The range of scores in the control group was 22. Based on the assessment criteria, the control group's average post-test score of 72.70 is categorized as "Good." The comparison of mean scores between the experimental and control groups across each indicator of scientific communication skills is presented in Table 4.

Table 4. Average of Indicator Scientific Communication

Scientific Communication Indicator by *Spektor-Levy*	Experimental Grop				Control Group			
	Pretest	***Categori***	***Postest***	***Categori***	***Pretest***	***Categori***	***Postest***	***Categori***
Information retrieval	50,50	Sufficient	84,50	Excelent	53,00	Sufficient	75,00	Good
Scientific reading	54,00	Sufficient	89,00	Excelent	54,00	Sufficient	79,00	Good
Scientific Writing	54,50	Sufficient	86,00	Excelent	52,50	Sufficient	78,00	Good
Observing	51,00	Sufficient	84,50	Excelent	49,00	Sufficient	72,00	Good
Information representation	46,50	Sufficient	83,50	Excelent	43,00	Sufficient	68,00	Good
Knowledge presentation	27,00	Need intervention	82,00	Excelent	22,00	Need intervention	62,00	Good
Average	**47,18**	**Sufficient**	**84,92**	**Excelent**	**45,58**	**Sufficient**	**72,33**	**Good**

Table 4 presents the mean scores of the experimental and control groups across each indicator of scientific communication skills, measured during both the pretest and post-test phases. During the pretest, both groups demonstrated scores within the range of $41 \leq x \leq 60$, corresponding to the "Sufficient" category for the indicators of Information Retrieval, Scientific Writing, Observation, and Information Representation. Among these, the lowest pretest scores were observed in the Knowledge Presentation indicator, while the highest scores were recorded for the Scientific Reading indicator.

Following the intervention, the post-test results indicated that the experimental group achieved an "Excellent" category, with average scores exceeding 81 across indicators, whereas the control group attained a "Good" category. The highest post-test scores were found in the Scientific Reading indicator, where the experimental group achieved an average score of 89 (Excellent), compared to 79 (Good) in the control group. Conversely, the lowest post-test scores occurred in the Knowledge Presentation indicator, where the experimental group attained a score of 82 (Excellent) and the control group obtained a score of 62 (Good). A comparative bar chart illustrating the pretest and post-test scores for each scientific communication indicator is provided in Figure 1.

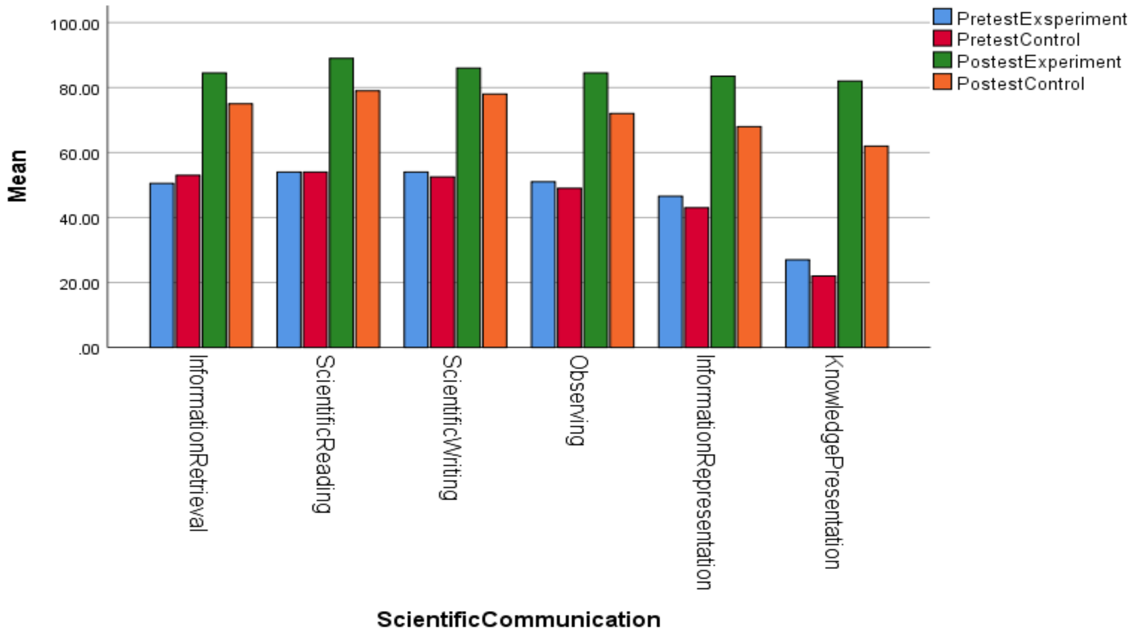

Figure 1. Pretest and Postest Scientific Communication Result Chart

The post-test results for scientific communication skills were subjected to a normality test using the Kolmogorov-Smirnov method in SPSS version 26 for Windows. The significance values for both the experimental and control groups were 0.105 ($p \geq 0.05$), indicating that the data are normally distributed. Subsequently, the MANOVA test was conducted, and the results of the M Box's test—an examination of homogeneity, which serves as a prerequisite for the MANOVA analysis—are presented in Table 4.

Table 4. *M Boxs Test*

Test	F	Sig
M boxs test	0,816	0,485

The significance value of 0.48 ($p \geq 0.05$) indicates that there is no significant difference in the covariance variance matrix between the groups, implying that the variance is homogeneous. The results of the MANOVA test are presented in Table 5.

Table 5. *Manova Test*

Test	F	Sig
Manova	93,737	0,000

The results of the MANOVA test yielded a significance value of 0.00 ($p \leq 0.05$), indicating that the null hypothesis (H_0) is rejected, while the alternative hypothesis (H_a) is accepted. This suggests that there are significant differences in the scientific communication abilities of students studying the Motion and Force materials, between those in the VAK differentiated learning (experimental group) and those in the traditional scientific learning (control group). These findings align with previous research, which demonstrates that flexible and contextual differentiation and integration learning strategies are more effective than undifferentiated learning modules (Variacion et al., 2021).

In VAK differentiated learning, scientific activities such as observing, questioning, data collection, making associations, and communication are facilitated through differentiated approaches in content, process, and product. This further supports the idea that differentiated learning can enhance motor skills development via stochastic resonance processes. This means that the internal state of the student, coupled with the learning environment, can reinforce their potential and foster skill acquisition (Henz & Schöllhorn, 2016). Differentiated learning is an approach that meets the diverse needs of students by addressing their readiness, interests, and learning preferences (Naibaho, 2023). The benefits of this approach include fostering creativity, reducing failure rates, promoting adjustments based on individual skills, and supporting consistent behavioral development (Santos et al., 2018).

CONCLUSION

Based on the analysis of both descriptive and inferential statistics, it can be concluded that the experimental group, which implemented VAK (Visual, Auditory, and Kinesthetic) differentiated learning, achieved higher average scores (Mean) in scientific communication compared to the control group, which employed traditional scientific learning. Furthermore, the parametric statistical analysis, specifically the Multivariate Analysis of Variance (MANOVA) test, yielded a significance value of 0.00 ($p \leq 0.05$), indicating a statistically significant effect of VAK differentiated learning on the improvement of students' scientific communication skills. Therefore, the implementation of VAK differentiated learning in science subjects, particularly in the context of the Motion and Force material, has proven to enhance students' scientific communication abilities.

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