Indonesian Education Journal
Volume 13, Number 4, 2024 pp.831-841
P-ISSN : 2303-288X E-ISSN : 2541-7207
Open Access: https://doi.org/10.23887/jpiundiksha.v13i4.83526

Student Mistakes in Solving PISA Model Questions in Content Domains Based on Learning Style

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ARTICLE INFO

Article history:
Received July 29, 2024
Accepted November 13, 2024
Available online December 25, 2024

Kata Kunci:
Analisis Kesalahan, Soal Pisa, Domain Konten, Gaya Belajar.

Keywords:
Error Analysis, Pisa Problem, Content Domain, Learning Style.

ABSTRAK

Hasil PISA siswa Indonesia pada bidang matematika masih tergolong rendah serta siswa belum terbiasa dengan soal berkarakteristik konteks nyata seperti soal PISA sehingga siswa masih sering melakukan kesalahan dalam menyelesaikan soal model PISA.Penelitian ini bertujuan untuk mendeskripsikan kesalahan siswa dalam menyelesaikan soal model PISA dalam domain konten yang yang ditinjau dari gaya belajarnya. Penelitian ini merupakan penelitian deskriptif eksploratif dengan pendekatan kuantitatif dan kualitatif. Sampel pada penelitian ini adalah siswa SMA. Sampel dalam penelitian ini ditentukan dengan teknik pengambilan sampel acak proporsional bertingkat. Analisis data dilakukan dengan menghitung persentase kesalahan berdasarkan hasil tes siswa, menguji perbedaan banyak kesalahan siswa dalam menyelesaikan soal model PISA ditinjau dari gaya belajar dengan menggunakan uji Anova. Hasil penelitian menunjukkan bahwa secara keseluruhan, kesalahan siswa dengan gaya belajar visual berada pada kategori sedang sementara kesalahan siswa dengan gaya belajar auditorial dan kinestetik berada pada kategori tinggi. Namun secara inferensial, tidak terdapat perbedaan yang signifikan dari banyaknya kesalahan siswa dalam menyelesaikan soal model PISA antara siswa dengan gaya belajar visual, auditorial, dan kinestetik. Oleh karena itu, studi ini menyarankan guru sebaiknya memberikan soal non-rutin dalam pembelajaran. Hal tersebut untuk mengurangi kesalahan yang dilakukan siswa ketika menyelesaikan masalah. Dengan kata lain, pemberian soal non-rutin dapat meningkatkan kemampuan pemecahan masalah siswa. Implikasi penelitian ini adalah mampu mengidentifikasi jenis kesalahan berdasarkan gaya belajar siswa, sehingga intervensi pembelajaran yang diberikan dapat lebih tepat sasaran dan efektif.

ABSTRACT

Indonesian students' PISA results in the field of mathematics are still relatively low and students are not yet accustomed to questions characterized by real contexts such as PISA questions, so students often make mistakes in solving PISA model questions. This research aims to describe students' mistakes in solving PISA model questions in the content domain. in terms of learning style. This research is an exploratory descriptive research with a quantitative and qualitative approach. The sample in this study was high school students. The sample in this research was determined using techniques *stratified proportional random sampling*. Data analysis was carried out by calculating the percentage of errors based on student test results, testing differences in the number of students' errors in solving PISA model questions in terms of learning styles using the Anova test. The research results show that overall, the errors of students with a visual learning style are in the medium category while the errors of students with auditory and kinesthetic learning styles are in the high category. However, inferentially, there is no significant difference in the number of student errors in solving PISA model questions between students with visual, auditory and kinesthetic learning styles. Therefore, this study suggests that teachers should provide non-routine questions in learning. This is to reduce errors made by students when solving problems. In other words, giving non-routine questions can improve students' problem solving abilities. The implications of this research are able to identify types of errors based on student learning styles, so that the learning interventions provided can be more targeted and effective.

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1. INTRODUCTION

Mathematics is an excellent source of anecdotes to provide evidence about specific mathematical concepts that students have difficulty understanding and strategies they can use to facilitate their understanding. What is important in the context of mathematics is students' reasoning abilities (Amir-Mofidi et al., 2022; Yanuarto, 2019). The role of mathematics as a universal science is very important for various scientific disciplines and for advancing human thought. Mathematics is a science that is commonly used to solve problems in everyday life, and is also a basis for understanding other sciences. Learning mathematics can train students to think logically, critically and creatively, so that in the end students are used to facing and solving problems. In the process of learning mathematics at school, teachers often emphasize material and practice questions taken from available textbooks. The majority of students tend to experience difficulties when faced with problems that are different from those taught and exemplified by the teacher. In fact, currently countries compete with each other in the field of education through various international tests prepared by people between countries. One of the international assessments organized and participated in by Indonesian students is PISA (Program for International Student Assessment). PISA focuses on measuring students' abilities in reading, mathematics and science. There are 3 domains tested in PISA, namely the situation and context domain, content domain, and process domain In implementing PISA 2022, mathematics is again the main focus where the assessment measures the extent to which old students can reason mathematically and are able to solve mathematical problems, most of which are presented in real-world contexts. Based on the PISA 2022 mathematics framework, the domains tested in PISA contain 3 aspects, namely mathematical processes (process domain), content knowledge relevant to the assessment of 15 year old students (content domain), and the context that students will face. (context domain) (O.E.C.D., 2018, 2019). The aim of PISA (Program for International Student Assessment) is to assess students' ability to solve real problems. The questions given in PISA include mathematical content related to everyday phenomena. This means that PISA questions are designed to measure the extent to which students can apply mathematical concepts and skills in real and relevant situations, not only in academic or theoretical contexts. Through this approach, PISA seeks to assess and improve students' capacity to use mathematics to solve problems they face in everyday life. Indonesia has taken part in the PISA assessment since 2000. Indonesian students' PISA mathematics scores have never exceeded the international average score until the last assessment. Indonesian students' mathematics score in PISA 2018 was 379 and ranked 73rd out of 77 countries. Indonesian students' mathematics achievement was level 1 at 31.3%, level 2 at 18.6%, level 3 at 6.8%, level 4 at 2.3%, level 5 at 0.4%, and level 6 at 0.0%.

Based on the PISA results, it shows that Indonesian students still experience difficulties or make many mistakes in working on PISA questions. Most Indonesian students have difficulty understanding context-based questions (Johar, 2020; Wijaya et al., 2014). Most students are able to carry out the first stage of the Newman model (Read and Recode) but they have difficulty in carrying out stages two to five (Comprehension, Transformation, Process Skills and Encoding). The errors that occur are students' ignorance regarding the purpose of the problem, lack of understanding regarding mathematical modeling, lack of student accuracy, students' inaccuracy in using their knowledge to change equations into equivalent equations, students' inability to calculate the solution to an equation. , students deviate from previously used formulas and students' ignorance regarding units of measurement in mathematics (Agoestanto et al., 2018; Alhassora et al., 2017). It is important for Indonesian students to learn to solve PISA questions so they can improve their abilities and get better results in the next PISA test. Every mathematics question that is developed based on the domain tested on PISA is called a PISA model mathematics question (Dasaprawira et al., 2018; Hidayah, 2022). PISA model questions require students to be able to apply, process, predict and interpret contextual problems ((Cassidy, 2019; Munfarikhatin et al., 2019). Mistakes are an indicator of student misunderstanding. When students make mistakes, gaps in their understanding become apparent, and students gain understanding by bridging those gaps (Akram, 2020; Ganesen et al., 2018). One method that can be used to identify types of student errors is Newman error analysis, which consists of reading errors, comprehension errors, transformation errors, process skills errors, and coding errors (Clements, 2019; Dewantara, 2019). Learning style is a person's way of obtaining, processing and responding to information from their environment. Various terms have been used in the literature, such as learning styles, cognitive styles, sensory preferences, and personality types. Some of these terms are sometimes used interchangeably, but on other occasions they are differentiated (Adnan et al., 2021; Oluremi, 2018). Learning styles are defined as the complex ways in which, and the conditions under which, learners most effectively understand, retain, and remember what they are trying to learn. Broadly speaking, learning styles can be categorized into three main types: cognitive, personality (psychology) and sensory. Cognitive includes analytical/global, field-dependent/independent, impulsive/reflective learning styles, Kolb's learning style model, and the Ehrman and Leavers construct. Personality learning styles include extrovert/introvert, random-intuitive/concrete sequential, and open/closed oriented. (Imamuddin et al.,

2019; Zales & Vasquez, 2021). Students' choice of learning style can help them improve their concentration and understanding of certain subjects. When someone has identified their learning style, it will facilitate the learning process and get better results. Learning outcomes are influenced by students' learning styles. Students' learning styles influence their ability to learn mathematics, and have a positive impact on their learning outcomes (Sukmadinata, 2020; Ulu, 2018). Visual learning style is the ability to organize, arrange and give meaning to visible objects. (Philomiraj dkk., 2017). The visual learning style also helps students to develop visual thinking, which is a learning style in which students learn to understand and retain information better by associating ideas, words and concepts with images (Sulistyoningrum et al., 2018; Wildani, 2019). The visual learning style learns best when information is presented visually and in image or design format in the classroom. Meanwhile, the auditory learning style learns best when information is presented in spoken language format. In a classroom environment, they benefit from listening to lectures and participating in group discussions (Sriphai et al., 2019; Usman & Hussaini, 2020) Auditory learners obtain information through aural channels such as verbal discussions and listening to other people's conversations.

Learning models that consider learning styles as a factor influencing mathematics learning achievement have a coefficient of determination that is greater than learning models that do not consider learning styles. Students only have one type of learning style and no other learning style. Learning style is an important element that can influence a student's ability to achieve something better. (Sheromova et al., 2018; Ulfah & Fuad, 2020). Students' lack of problem-solving skills is often directly related to the mistakes they make. This shows that a student's learning style can influence the frequency and type of errors that occur. In other words, the way students learn can have a big impact on the mistakes they make in the learning process. Although much research has been conducted regarding the analysis of student errors, most focus on the identification and categorization of errors without considering the underlying individual factors. These studies often emphasize errors in general or in specific contexts without linking error outcomes to variables such as student learning styles. In other words, much research focuses on the types of errors that occur but does not relate them to the way students learn or their approach to the material. This research is different because it focuses on the relationship between the types of errors students make and their learning styles. With this approach, researchers try to reveal how different learning styles influence the types of errors that appear in the learning process. This provides deeper insight into how different learning strategies can lead to certain types of errors, as well as how adjusting teaching methods can help reduce the errors that occur. This focus aims to provide a more comprehensive and focused understanding of specific ways to increase learning effectiveness according to students' individual learning styles.

2. METHOD

In this research, the type of research used is exploratory descriptive with a quantitative and qualitative approach. Exploratory descriptive research to describe or describe existing phenomena, both natural and man-madé (Reid, 2019; Sukmadinata, 2020). A quantitative approach in this research was used to analyze data in the form of test scores and questionnaires to obtain the percentage of types of student errors in solving PISA model questions with content domains in learning styles. The sample selection technique used is the stratified proportional random sampling technique which is a combination of the stratified sampling technique and the proportional sampling technique which is then continued using the random sampling technique. The research was conducted at 5 high schools and the sample in this study was grade 10 students. The sample selection technique used was the stratified proportional random sampling technique which is a combination of stratified sampling techniques and proportional sampling techniques which were then continued using random sampling techniques. Data collection techniques are a method used by researchers to obtain data objectively from various sources for research. In this research, 2 data collection techniques will be carried out, namely tests, questionnaires. In this research, the validity used is content validity. Content validity is divided into two types, namely face validity or face/view validity and logical validity or logical validity. Both types of validity are obtained based on expert judgment. Face validity is assessed based on the relevance of the format or appearance of the instrument being developed, while logical validity is used to see the suitability between the instrument items being developed and the grid or indicators being measured. The data analysis technique in this research was carried out using data reduction and data presentation stages. Data reduction was carried out by grouping students based on their learning styles, then correcting and recapitulating student work and identifying any errors made by students based on Newman's error indicators. Data presentation was carried out using the anova test.

3. RESULT AND DISCUSSION

Result

In this research, student errors were obtained through a test using PISA model questions which consisted of 8 units, where 1 unit consisted of 5 questions which referred to indicators for each type of student error. The types of errors in this research refer to the types of errors according to Newman, namely reading errors, comprehension errors, transformation errors, process skills errors, and coding errors. The percentage of types of errors in each learning style is presented in Table 1.

Table 1. Percentage of Error Types in Each Learning Style

Learning Style	Error Type										Total	%
	R		C		T		PS		AND			
	N	%	N	%	N	%	N	%	N	%		
Visual	53	9,6	280	50,72	380	68,84	416	75,36	423	76,63	**1552**	**56,23**
Auditory	92	28,75	151	47,19	197	61,56	259	80,94	260	81,25	**959**	**59,94**
Kinesthetic	37	20,11	100	54,35	126	68,48	144	78,26	146	79,35	**553**	**60,11**
Total	**182**	**17,23**	**531**	**50,28**	**703**	**66,57**	**819**	**77,56**	**829**	**78,5**	**3064**	**58,03**

Information:
n : Number of Errors
R: Reading error
C: Misunderstanding
Q : Transformation Error
PS: Skill Process Error
E : Coding Error

The percentage results are obtained from the number of errors divided by the total possible answers for each learning style, namely the visual learning style has 2760 answers, the auditory has 1600 answers, and the kinesthetic has 920 answers. The percentage of student errors in each learning style is presented more clearly in Figure 1.

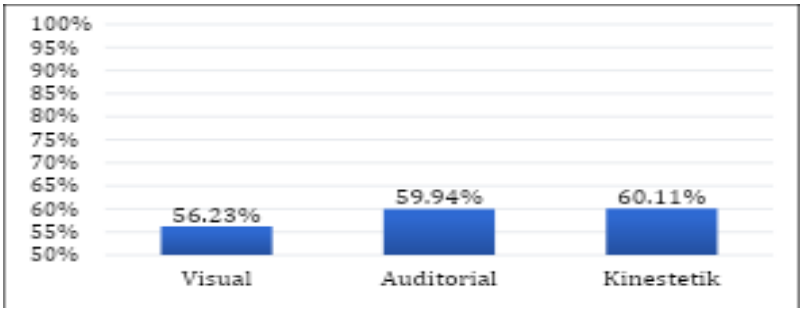

Figure 1. Diagram of Percentage of Errors for Each Learning Style

Next, the most common mistakes are analyzed inferentially to find out in more detail the differences in many mistakes in terms of learning style. The test used to determine whether there is a difference in the number of errors in each learning style is the Anova test. Before carrying out the Anova test, an assumption test is first carried out, namely the normality and homogeneity test. The assumption of normality in this study is seen from the skewness and kurtosis values. The homogeneity test used in this research is the Levene Test. Based on the tests carried out, the sig value was obtained. <0.05 so it can be concluded that the variance between groups is not homogeneous. After the assumption test is fulfilled, it can be continued with the Anova test to test the difference in the average number of errors in terms of learning style. The hypothesis was tested using the F test with a significance level of 5%. Decision making criteria are based on the significance value of the test results. If the significance value is below 0.05 then the null hypothesis is (H_0) rejected. The results of data analysis are presented in Table 2.

Table 2. Anova Test Results: Many Errors in Learning Style Responses

	Sum of Squares	Df	Means Square	F	Say.
Between Groups	0.047	2	0.023	1.111	0.333

Based on Table 2, the significance value is more than 0.05. This shows that there is no significant difference in the number of errors in terms of learning style. In other words, differences in student learning styles (visual, auditory and kinesthetic) do not affect the number of errors made in solving PISA model questions. Table 1 also shows the number of errors in each error type. The percentage results are obtained from the number of errors in each type of error divided by the number of possible answers for each type of error made by students, namely 1056 answers. The percentage of student errors in each type of error is presented more clearly in Figure 2.

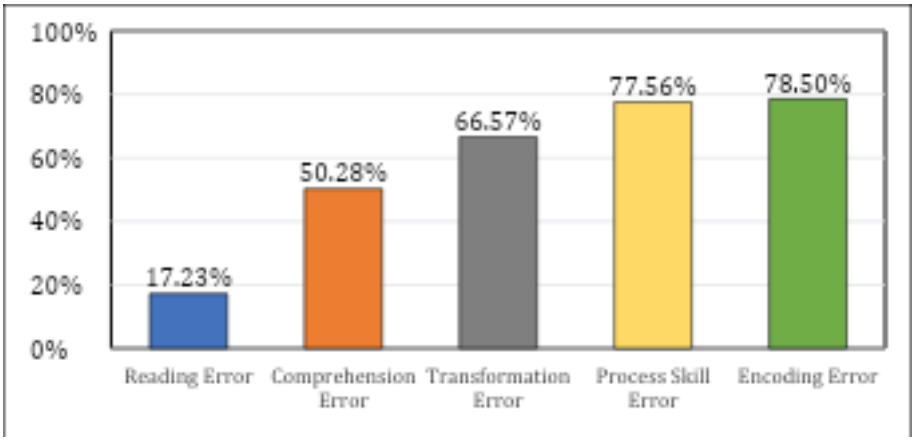

Figure 2. Error Percentage Diagram for Each Type of Error

Based on Figure 2, it can be seen that for each type of error there is a different percentage of errors. Respectively, the most dominant types of errors are coding errors, process skills errors, transformation errors, understanding errors, and finally reading errors. Based on these percentages, reading errors are in the very low category, the percentage of comprehension errors is in the medium category, the percentage of transformation errors is in the high category, while processing skills errors and coding errors are in the very high category. A clearer description of the above percentages can be presented below Figure 3.

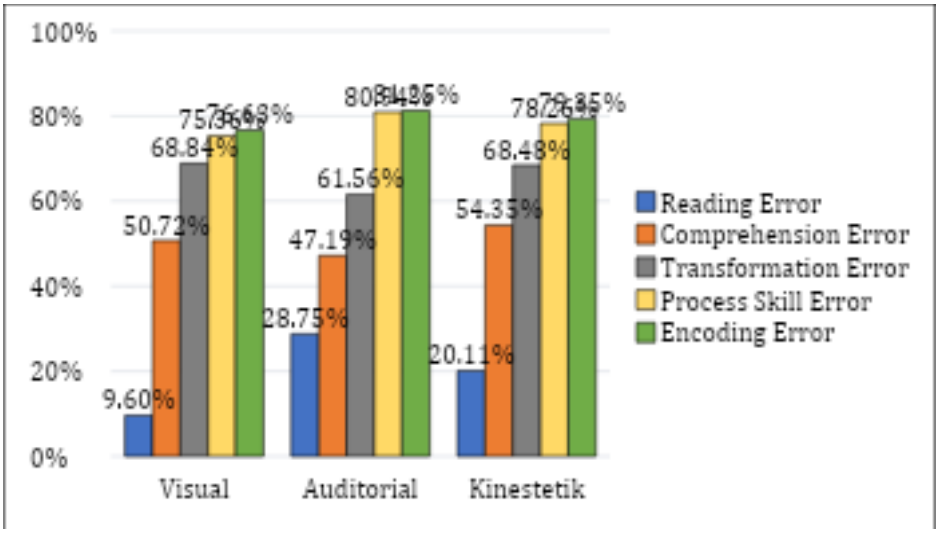

Figure 3. Percentage Diagram of Error Types for Each Learning Style

Furthermore, the results of inferential data analysis to determine the differences in the number of errors in each type of error when viewed from learning style are presented in Table 3. For the homogeneity test using Levene's Test, the sig value was obtained. < 0.05 for reading errors, while for other types of errors the sig value is obtained. > 0.05. So it can be concluded that the variance between learning style groups is not homogeneous in reading errors, while in other types of errors it is homogeneous. However, the Anova test can still be carried out. The results of the ANOVA test for the number of errors for each type of error in the review of learning styles are presented in Table 3.

Table 3. ANOVA Test Results Number of Errors for Each Type of Error Review of Learning Styles

Error Type	Sum of Squares	df	Means Square	F	Say.
Reading Errors	0.951	2	0.476	23.355	0.000
Misunderstanding	0.078	2	0.039	0.739	0.480
Transformation Error	0.144	2	0.072	2.144	0.121
Process Skills Errors	0.080	2	0.040	1.411	0.248
Coding Error	0.056	2	0.028	0.841	0.434

Based on Table 3 It can be seen that the significance value of reading errors is less than 0.05, so it can be concluded that there is a significant difference in the number of reading errors between students with visual, auditory and kinesthetic learning styles. Meanwhile, in understanding errors, transformation errors, process skill errors, and coding errors, there is no significant difference in the number of errors because the significance value is more than 0.05. Next, a post hoc test was carried out on the number of reading errors using the Games-Howell test because the Homogeneity of Variance test showed that the group variance results were heterogeneous (different) or equal variances were not assumed. The results of post hoc tests for multiple reading errors are presented in Table 4.

Table 4. Post Hoc Test Results Number of Errors for Each Type of Error Based on Learning Style

Error Type	(I) Learning Style	(J) Learning Style	Mean Difference (I–J)	Std. Error	Say.
Reading Errors	Visual	Auditory	-0.1915*	0.02836	0.000
	Visual	Kinesthetic	-0.1051*	0.03436	0.002
	Auditory	Kinesthetic	0.0864	0.03735	0.056

Based on Table 4 It can be seen that there is a significant difference in the number of reading errors between students with visual and auditory learning styles and between students with visual and kinesthetic learning styles. In this research, the PISA model questions used contain 4 contexts based on the PISA framework consisting of personal, occupational, scientific and social. The error percentage results for each content domain can be presented below Table 5.

Table 5. Percentage of Errors in Each Content Domain and Learning Style

Learn StyThat	Content Domains								Total	%
	Q		SS		NOK		OUT			
	N	%	N	%	N	%	N	%		
Visual	366	53.04	356	51.59	486	70.43	344	49.86	**1552**	**56.23**
Auditory	241	60.25	212	53	281	70.25	225	56.25	**959**	**59.94**
Kinesthetic	153	66.52	126	54.78	151	65.65	123	53.48	**553**	**60.11**
Total	**760**	**57.58**	**694**	**52.58**	**918**	**69.55**	**692**	**52.42**	**3064**	**58.03**

Information:
n : Number of Errors
Q: Quantity
SS: Form & Space
CR: Change & Relationships
UD : Uncertainty & Data

Table 5 shows the number of errors in each content domain. The percentage results are obtained from the number of errors in each type of error divided by the total possible answers in each content domain, namely 1320 answers. The percentage of student errors in each content domain is presented more clearly in Figure 4. Based on Figure 4, it can be seen that in each content there is a different percentage of errors. Respectively, the contents with the most errors are change & relationship, quantity, shape & space, and uncertainty & data. Based on these percentages, shape & space content and uncertainty & data content are in the medium category, while quantity and change & relationship content are in the high category. A clearer explanation regarding percentages is presented below Figure 5.

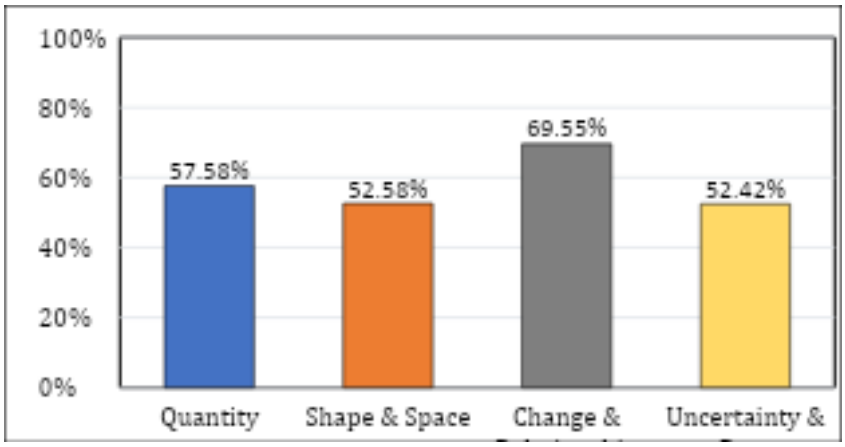

Figure 4. Chart of the Percentage of Errors in Each Content Domain Overall

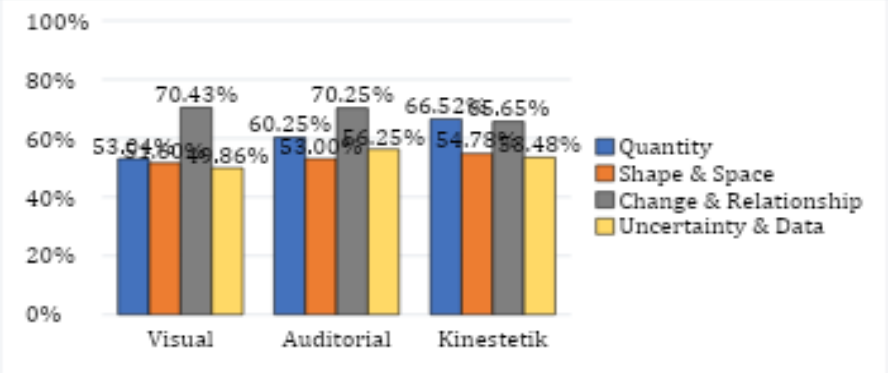

Figure 5. Error Percentage Diagram in Each Content Domain and Learning Style

Inside Figure 5 It can be seen that the most mistakes made by the visual and auditory learning style groups are in the content of changes & relationships, while the kinesthetic learning style group makes the most mistakes in the quantity content. The fewest mistakes made by students in the visual and kinesthetic learning style groups were uncertainty & data content, while in the auditory learning style group it was form & space content. Furthermore, the results of inferential data analysis to determine differences in the number of errors in each content domain when viewed from learning styles are presented in Table 6. To test homogeneity using Levene's Test, a sig value was obtained. < 0.05 for reading errors, while for other types of errors the value is sig. > 0.05. So it can be concluded that the variance between learning style groups is not homogeneous in quantity and uncertainty & data content, while in other content it is homogeneous. However, the Anova test can still be carried out.

Table 6. Anova Test Results Number of Errors for Each Content Domain Judging from Learning Style

Content Domains	Sum of Squares	df	Means Square	F	Say.
Quantity	0.354	2	0.177	40.601	0.012
Form & Space	0.019	2	0.009	0.144	0.866
Change & Relationships	0.042	2	0.021	0.436	0.647
Uncertainty & Data	0.107	2	0.053	0.617	0.541

Based on Table 6 It can be seen that the significance value of quantity content is less than 0.05, so it can be concluded that there is a significant difference in the number of quantity content errors between students with visual, auditory and kinesthetic learning styles. Meanwhile, in the content of shape & space, changes & relationships, and uncertainty & data, there is no significant difference in the number of errors because the significance value is more than 0.05. Furthermore, the post hoc test for many errors in the quantity content was carried out using the Games-Howell test because the Homogeneity of Variance test showed that the group variance results were heterogeneous (different) or equal variances were not assumed. Post Hoc test results for multiple errors in quantity content are presented in Table 7.

Table 7. Post Hoc Test Results Number of Errors for Each Content Domain Judging from Learning Style

Content Domains	(I) Learning Style	(J) Learning Style	Mean Difference (I–J)	Std. Error	Say.
Quantity	Visual	Auditory	-0.0721	0.03612	0.119
	Visual	Kinesthetic	-0.1348*	0.04528	0.012
	Auditory	Kinesthetic	-0.0627	0.04372	0.333

Based on Table 7, it can be seen that there is a significant difference in the number of reading errors between students with visual and kinesthetic learning styles.

Discussion

This also shows that learning style does not have a significant influence on students' ability to solve mathematical problems. Even though students have certain learning preferences, this does not mean that this learning style will affect their ability to solve mathematical problems. So it can also be said that there is no particular learning style that is better for solving mathematical problems, because students can solve mathematical problems in different ways depending on their individual preferences and abilities. Students with a visual learning style tend to have superior mathematical problem solving abilities. In the context of PISA-oriented mathematics questions, students with a visual learning style show high ability, students with an auditory learning style are in the medium category, and students with a kinesthetic learning style are in the low category. This shows that the visual learning style is more effective in solving mathematical problems than other learning styles. The results of inferential data analysis do not show differences in average errors between students with visual, auditory and kinesthetic learning styles, but the results of descriptive data analysis show that the highest percentage of student errors are students with kinesthetic and auditory learning styles, respectively. , then visual learning style. In solving PISA-oriented mathematics problems, the abilities of students with visual, auditory and kinesthetic learning styles are in the high, medium and low categories respectively. (Ishartono et al., 2021; Nariyati et al., 2018; Parawansa & Siswanto, 2021).

Then, based on the results of the analysis, it is known that the most dominant types of errors made by students in solving PISA model questions are coding errors (17.23%), process skills errors (50.28%), transformation errors (66.57%), process skills errors. (77.56%), and (78.5%). These results are in line with research by Susanti (2019) which found that the most dominant student errors in solving PISA equivalent questions were coding errors (80%), process skills errors (78.1%), transformation errors (73%) respectively. , misunderstanding. (47%), and reading errors (37.1%). Coding errors are common among students, regardless of learning style, and affect their ability to solve math problems (James & Gardner, 2021; Pritchard, 2019). In reading errors, it was found that students with an auditory learning style made the most errors. Reading error is a type of error in the form of misreading the information in the question. In other words, students with an auditory learning style make many mistakes in reading the information in the questions. Students with an auditory learning style tend to only be able to focus on a little written information. This shows that the auditory learning style has limitations in absorbing large amounts of written information, which can affect its ability to solve complex mathematical problems. (Pangestu et al., 2019; Safegi et al., 2020). In understanding errors, it was found that students with a kinesthetic learning style made the most mistakes. Understanding errors are a type of error in the form of errors in determining the problem being sought or asked about in the question. In other words, students with a kinesthetic learning style make many mistakes in determining the problem they are looking for or asking about in the question. Students with a kinesthetic learning style are the only group who make comprehension errors. This suggests that students with a kinesthetic learning style may face special challenges in understanding and processing written information, which affects their ability to solve mathematical problems correctly. In transformation errors, it was found that students with a visual learning style made the most errors (Philominraj et al., 2016; Raiyn, 2018). Transformation error is a type of error in the form of an error in determining the solution steps or in modeling the problem in mathematical form. In other words, students with a visual learning style make many mistakes in determining solution steps or modeling problems in mathematical form. While students with a visual learning style may have advantages in some areas, they also face special challenges in developing plans and overcoming transformation errors in mathematics (Safitri et al., 2018; Sari & Valentino, 2020). Regarding processing skills errors and coding errors, it was found that students with an auditory learning style made the most errors. Process skill errors are a type of error in the form of errors in carrying out calculations, errors in completing expressions or algebraic forms, and not being able to continue the solving procedure. Coding errors are a type of error in the form of errors in determining conclusions. Students with auditory learning style errors in processing skills errors and

coding errors are in the very high category when compared with other learning styles (Saidah, 2018; Sarwandianto et al., 2017). The content domains in PISA consist of quantity, shape & space, change & relationships, and uncertainty & data. Based on the percentage obtained, respectively, the most errors are in the content of changes & relationships, magnitude, shape & space, and uncertainty & data. This is supported by the results of statistical tests which found a significant difference in the number of errors made by students in terms of the PISA content domain. Change & Relationship is the content with the most mistakes made by students, so it can be said that students tend to experience difficulties when solving problems in this content. Students find it most difficult to solve PISA questions on change and relationships (Ganesen et al., 2018; Rasitullah & Wahyu, 2020). Then, if we look at learning styles, we found a significant difference in the number of students' errors on quantity content, but there was no significant difference in the number of students' errors on changes & relationships, shape & space, and uncertainty. & data content.

In quantity content, it was found that students with a kinesthetic learning style made the most mistakes. This content is related to size, number patterns, and everything related to numbers in everyday life. In this research, the questions containing quantity content are related to social arithmetic questions as well as rows and series. This means that it can be said that students with a kinesthetic learning style experience many obstacles in solving social arithmetic problems and rows and series. Students with a kinesthetic learning style experience the most obstacles when solving social arithmetic problems when compared to other learning styles (Akram, 2020; O.E.C.D., 2019). In the form & space material, it was found that students with a kinesthetic learning style made the most mistakes. This content includes phenomena related to the visual world and the physical world involving patterns, object properties, position and orientation, object representation, coding of visual information, navigation, and dynamic interactions related to real forms. Students with a kinesthetic learning style often face special challenges in understanding and solving geometric problems (Alhassora et al., 2017; Oluremi, 2018).

In the content of changes & relationships, it was found that students with a visual learning style made the most mistakes. This material is related to aspects of functions and algebra, one of which is the material on systems of linear equations in two variables. Although the visual learning style can cause more errors in certain types of problems such as systems of equations, this learning style is not significantly different compared to the auditory learning style in dealing with other problems such as change and relationships (Safegi et al., 2020; Wijaya et al., 2014). Based on the uncertainty & content of the data, it was found that students with an auditory learning style made the most mistakes. This material is related to statistics and probability theory, but in this research the questions used are only about statistics. Learning styles influence the types of errors that occur in various types of mathematics material, with visual students more likely to make errors in statistics and kinesthetic students in geometry (Amir-Mofidi et al., 2022; Reid, 2019; Wildani, 2019). The implications of this research have several important points that can be utilized in learning. These findings indicate that students' different learning styles, such as visual, auditory, and kinesthetic, influence the error patterns they make in solving competency-based questions. Therefore, teachers need to adopt a more varied and differentiated learning approach, for example by providing problem representations in various formats (visual, audio and direct practice) so that all learning styles can be facilitated. In addition, the development of learning tools, such as modules or interactive learning media, needs to be adapted to the characteristics of students' learning styles to reduce errors that arise due to incompatibility of material delivery methods. This implication is also relevant for curriculum developers, where enriched PISA-based questions can be designed to be more adaptive to the needs of students with diverse learning styles. Finally, further research can be focused on developing diagnostic instruments that are able to identify types of errors based on student learning styles, so that the learning interventions provided can be more targeted and effective. The limitation of this research is that this research analyzes each error without paying attention to the hierarchy of problem solving. Hierarchically, students fail to solve a problem when their first step is wrong. When conducting tests and filling out questionnaires, researchers were unable to control factors that might influence research subjects, such as honesty, physical health, and students' psychological conditions such as emotions, fatigue, and students' unpreparedness. Therefore, suggestions for further research are to pay attention to hierarchy in analyzing student answers.

4. CONCLUSION

Overall, students with a visual learning style tend to make mistakes in the medium category, while students with auditory and kinesthetic learning styles tend to make mistakes in the high category. Even though there are differences in error rates between learning styles, inferential analysis shows that the number of students' errors in solving PISA model questions is not significantly different between visual, auditory and kinesthetic learning styles. This suggests that although learning style may influence error frequency, the difference is not significant enough to indicate a large difference in overall problem-solving

ability. However, there were significant differences in error types, particularly in reading errors and in the content quantity domain. Learning styles influence how students read and understand problems, with students with different learning styles showing different levels of reading errors. Apart from that, learning style also influences the number of errors in quantity content, while no significant differences were found in other content. This emphasizes the importance of considering learning styles in learning design and assessment, but also shows that learning approaches tailored to learning styles are not always effective in dealing with all types of errors.

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