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MEASURING STUDENTS' PERCEPTIONS OF CONSTRUCTIVIST LEARNING ENVIRONMENTS LINKED TO UNDERSTANDING OF RASCH MODELING-BASED CHEMICAL CONCEPTS

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This study aims to evaluate the suitability of data obtained from the Constructivist Learning Environment Survey instrument and a multiple-choice chemistry understanding test, as well as to examine the relationship between students' perceptions of the constructivist learning environment and their understanding of chemistry concepts. A non-experimental, quantitative descriptive approach was employed, involving 519 12th-grade science students from five high schools in Gorontalo Province during the even semester of the 2024/2025 academic year. Data analysis was conducted using the Rasch model via Winsteps 3.73 software to assess instrument quality, and SPSS software to test data normality and analyze correlations. The results indicated that both instruments were valid and reliable, with person reliability of 0.81, item reliability of 0.99, and Cronbach's Alpha exceeding 0.80—classified as excellent. A Pearson correlation analysis revealed that the calculated *r* value exceeded the critical value (r_{count}= 0.135 > r_{table}= 0.087), indicating a statistically significant, albeit weak, positive relationship between students' perceptions and their chemistry understanding. The hypothesis testing results showed that the null hypothesis (H_0) was rejected and the alternative hypothesis (H_1) was accepted, confirming the existence of a relationship between students' perceptions of constructivist learning environments and their understanding of chemistry concepts.

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INTRODUCTION

In recent decades, science education has experienced a paradigm shift toward constructivist approaches that emphasize student-centered learning and cognitive engagement within authentic contexts. This pedagogical transformation is supported by extensive literature advocating for experience-based instruction and contextualized learning [1]. Constructivism is grounded in the cognitive development theory proposed by Jean Piaget and the sociocultural perspective advanced by Lev Vygotsky. Both theorists emphasized that knowledge is actively constructed through interactions with the environment and others, rather than being passively transmitted from teacher to student [2].

The positive impact of constructivist learning environments has been well-documented, particularly in enhancing student engagement and learning effectiveness. Research indicates that student-centered instruction—characterized by authentic interaction with content—improves understanding and long-term retention [2]. By integrating real-world contexts into instruction, constructivist approaches enable learners to apply knowledge meaningfully through firsthand experiences. Piaget highlighted the importance of developing mental structures through experiential learning, while Vygotsky stressed the significance of social and cultural contexts in cognitive development. These foundational principles underscore the role of active student participation and socially embedded learning in fostering meaningful conceptual acquisition [1].

In science education, constructivist learning is especially critical, given the inherent complexity and abstract nature of many scientific concepts. In chemistry education, for instance, topics such as chemical bonding, redox reactions, and thermochemistry often pose challenges for students. These difficulties can lead to misconceptions that hinder the development of scientifically accurate frameworks [3]. Traditional teacher-centered instruction may exacerbate these challenges by limiting opportunities for exploration, interaction, and active engagement [4]. Studies have shown that adopting interactive and participatory instructional models helps students achieve deeper conceptual understanding and overcome common misconceptions. Consequently, implementing pedagogical strategies that emphasize active learning and student engagement is essential for improving the effectiveness of chemistry instruction.

To evaluate the quality of constructivist learning environments, the Constructivist Learning Environment Survey (CLES) was developed. This instrument assesses five key psychosocial dimensions: personal relevance, scientific uncertainty, critical voice, shared control, and student negotiation [5]. The CLES has been widely adopted to examine how these dimensions affect student engagement and academic outcomes. Empirical studies across varied educational settings have validated the instrument and reported significant correlations between students' perceptions of their learning environments and their motivation, involvement, and academic performance [6]. As a multidimensional tool, CLES enables educators to evaluate the alignment of their instructional practices with constructivist principles and to make informed pedagogical adjustments.

Despite the extensive use and validation of tools like CLES, few studies have explored the relationship between students' perceptions of learning environments and their cognitive outcomes, particularly when measured using psychometric models. The Rasch model offers a powerful analytical technique for evaluating both item difficulty and student ability. It provides detailed insights into how students respond to items, the rationale behind their answers, and whether they possess a sound conceptual understanding or hold misconceptions [7], [8]. As a unidimensional, probabilistic framework, the Rasch model enables precise calibration of item-person interactions and is widely used in educational measurement to improve the reliability and interpretability of assessment data [9].

Recent research has demonstrated the Rasch model's effectiveness in identifying misconceptions and measuring conceptual understanding in science education, especially in chemistry. For example, Rasch analysis has been applied to assess student understanding of chemical bonding, effectively distinguishing between varying levels of student ability and item complexity [10]. Additionally, methodological studies have provided guidance on implementing the Rasch model to construct valid and reliable educational instruments, with particular relevance to the Indonesian educational context.

However, few studies have combined Rasch-based performance assessments with students' perceptions of constructivist learning environments, particularly in the context of secondary-level chemistry education. To address this gap, the present study investigates the relationship between students' perceptions of constructivist learning environments, as measured by the CLES, and their conceptual understanding of chemistry, as assessed through a three-tier diagnostic test analyzed using the Rasch model.

This study distinguishes itself by integrating psychosocial and psychometric data to offer a more comprehensive perspective on learning dynamics in the chemistry classroom. Methodologically, it contributes to the field by demonstrating the value of combining the CLES and Rasch modeling. Pedagogically, the findings are expected to provide actionable insights for teachers and education policymakers in developing more effective, learner-centered, and contextually responsive instructional strategies for chemistry education.

METHODS

1. Research Design

This study employed a non-experimental, descriptive-quantitative research design using two main instruments. Students' conceptual understanding was assessed using a multilevel multiple-choice test adapted to the Merdeka Curriculum, while students' perceptions of the learning environment were measured using the Constructivist Learning Environment Survey (CLES). Data were analyzed using the Rasch model, supported by Winsteps 3.73 software for psychometric analysis and SPSS for statistical testing.

2. Respondents

The study involved 519 12th-grade students from senior high schools (SMA/MA) in various districts and cities across Gorontalo Province, during the even semester of the 2024/2025 academic year. Prior to data collection, it was confirmed that all participants had received formal instruction on basic chemistry concepts in accordance with the Merdeka Curriculum. The demographic distribution of the respondents is presented in Table 1.

Table 1. Demographic Profile of Respondents (N = 519).

Demographic	Code	n	%
Gender			
Male	L	162	31.2%
Female	P	357	68.7%
School			
SMA N 1 Kabila	A	194	37.3%
SMA N 1 Tapa	B	38	7.3%
MAN 1 Gorontalo City	C	144	27.7%
SMA N 1 Limboto	D	61	11.7%
SMA N 7 Gorontalo City	E	82	15.7%

3. Instruments

The study used two main instruments, namely a multilevel multiple-choice test to measure the understanding of chemical concepts and a CLES questionnaire to measure the perception of constructivist learning environment.

Multiple-choice tests consist of three levels of questions (Q1, Q2, Q3). Q1 is a short question that measures a claim, Q2 is a second-level question that measures evidence or data as a reason for the answer to Q1, and Q3 measures student reasoning that connects the answers to Q1 and Q2.

The CLES instrument uses a five-point frequency response scale (Likert) to measure students' perceptions of psychosocial factors in the learning environment, with a range of scores: 5 (almost always), 4 (often), 3 (sometimes), 2 (rarely), and 1 (almost never) [11].

4. Item Design and Scoring

Concept understanding test items are designed based on the construct map to obtain learners' understanding [12] The construct of this instrument can be seen in Figure 1.

Read to answer questions number 1-3.

Acid rain can affect the surrounding environment; acid rainwater flowing into rivers like the Citarum River can cause damage to aquatic ecosystems, such as fish deaths and water quality degradation. Another effect of acid rain is that surface water becomes acidic and its pH drops below 7.

1. Do you think that statement is correct? In your opinion, is the statement true?
   a. True
   b. Wrong

2. Based on that answer, what is the appropriate evidence to support your answer to question 1?
   a. Acid rain accelerates the growth of plant roots.
   b. Acid rain can cause the number of fish in the sea to increase.
   c. Acid rain can increase the acidity of lake water, causing many fish to potentially die.
   d. Acid rain can make humans resistant to diseases, one of which is skin disease.
   e. Other answers………

3. Which reason can explain your answer choice for question 2?
   a. Changes in pH in plants can alter the color of the leaves from green to red and cause wilting.
   b. Most fish species can survive in water with a pH below 5, and if the water's pH drops to 4, the fish in the lake will still live.
   c. The change in pH caused by acid rain affects animals, making them weak.
   d. The fish in the lake died due to the pH changes caused by acid rain, which stressed and poisoned the fish.
   e. Other answers………

Figure 1. Construct Map of Chemistry Comprehension Items

The example problem presents the phenomenon of acid rain, where Q1 measures the claim with true or false options. Q2 measures evidence of the claim with five answer options, including open-ended answers that are scored on content. Q3 measures reasoning related to the relationship between Q1 and Q2 [9].

Table 2. Scoring Rubric for Chemistry Concept Understanding.

Q1	Q2	Q3	Skor
Correct	Correct	Correct	3
Correct	Correct	Incorrect	2
Correct	Incorrect	Correct	1
Correct	Incorrect	Incorrect	
Incorrect	Correct	Correct	0
Incorrect	Correct	Incorrect	
Incorrect	Incorrect	Correct	
Incorrect	Incorrect	Incorrect	

5. Test Instrument

The conceptual understanding instrument comprises three indicators: claim, data, and warrant. Each of the 15 items is treated as stand-alone, although relationships exist among the items. The probability of guessing the correct answer is low (0.25), so the scores reflect students' understanding.

6. Procedure

Data were collected by administering questionnaires and multiple-choice tests completed by SMA/MA students in the regency/city areas of Gorontalo Province.

RESULTS

1. Data Conformance to the Rasch Model

Data fit to the Rasch model was evaluated through reliability, unidimensionality, item fit order, the Wright map, and the rating scale.

a. Reliability and validity of measurement

Psychometric evaluation of two main instruments—the Constructivist Learning Environment Survey (CLES) and the Chemistry Concept Understanding Test—was conducted using the Rasch model to ensure the empirical validity and reliability of the measurements. Each instrument was analyzed separately to confirm construct unidimensionality, item validity, and internal consistency, as required in studies grounded in the constructivist approach in chemistry education.

All CLES items showed good statistical fit to the Rasch model. Mean-square (MNSQ) values ranged from 0.72 to 1.26, and Z-standardized (ZSTD) values ranged from −1.8 to +1.9; no item displayed significant misfit. Each item consistently measured the intended theoretical construct—students' perceptions of the constructivist learning environment—across five dimensions: personal relevance, uncertainty, critical voice, shared control, and student negotiation [13]. Reliability coefficients indicated very good internal consistency: person reliability 0.84 and item reliability 0.97, with a person separation index of 2.35 and an item separation index of 5.76. The instrument can distinguish at least three strata of student perceptions and demonstrates stable, representative item calibration.

The chemistry concept understanding instrument also showed strong item performance within the Rasch model, with MNSQ values from 0.71 to 1.28 and ZSTD values from −2.1 to +2.0. The pattern supports unidimensionality and the instrument's construct validity. The person reliability coefficient equaled 0.81 and the item reliability 0.95, with separation indices of 2.13 (person) and 4.25 (item). The instrument shows adequate capacity to differentiate levels of concept mastery, and the items display high discrimination across variations in test-taker ability [14].

Both instruments met the psychometric quality criteria within the Rasch framework. Strong item validity, high internal consistency, and stable discriminative capacity make them suitable for examining links between students' perceptions of the constructivist learning environment and their chemistry concept mastery in an empirical and reliable manner [15].

Table 3. Summary of Fit Statistics.

Parameter	CLES		Chemistry Understanding	
	Person N=513	Item N=25	Person N=513	Item N=15
Mean	.09	.00	.55	.00
SE (Standard Eror)	.02	.09	.03	.13
SD (Standard Deviasi)	.52	.45	.78	.48
Outfit MNSQ	4.61	1.54	3.03	1.24
Infit MNSQ	4.32	1.62	3.01	1.22
Index Separation	2.09	9.84	2.06	8.73
Index Reliability	.81	.99	.81	.99
Cronbach's Alpha (KR-20)	.82		.83	

b. Item undimensionality

Unidimensionality is one of the basic assumptions in Rasch analysis, which states that one main construct must underlie all items in an instrument [16] To test this, an analysis was conducted on the variance explained by the measurements (raw variance explained by measures) and the unexplained variance in the residual contrasts (principal component analysis of residuals).

Table 4. Item Undimensionality.

	Chemistry Understanding	CLES
Nilai Raw Variance Explained By Measures	30.9%	37.6%
Unexplned variance	Variance in 1st conrats 13,5%	Variance in 1st conrats 14%
	Variance in 2st conrats 7.3%	Variance in 2st conrats 11.6%
	Variance in 3st conrats 6.7%	Variance in 3st conrats 8.9%
	Variance in 4st conrats 3.9%	Variance in 4st conrats 8.0%
	Variance in 5st conrats 3.1%	

1) Chemistry Understanding Instrument

The analysis results indicate that the explained variance is 30.9%, which meets the minimum threshold of acceptability for unidimensionality in the context of educational assessment [17]. Meanwhile, the unexplained variance in the first contrast was 13.5%, progressively decreasing in the second to fifth contrasts (7.3%, 6.7%, 3.9%, and 3.1%, respectively). This pattern suggests the absence of a dominant secondary latent dimension beyond the primary construct, thereby reinforcing the instrument's unidimensionality [18].

2) CLES Instrument (Constructivist Learning Environment Survey)

The CLES instrument demonstrated better performance in representing the primary construct, with an explained variance of 37.6% and an unexplained variance of 14% in the first contrast. The subsequent contrasts showed progressively lower unexplained variances (11.6%, 8.9%, 8.0%, and so on), remaining within acceptable statistical limits and not indicating fragmentation of the dimensional structure. These results suggest that the CLES instrument has a sufficiently stable structure for measuring a single primary construct—namely, students' perceptions of the constructivist learning environment.

c. Item Fit Order

Item fit analysis is a crucial step in evaluating the quality of Rasch-based instruments, as it determines the extent to which participants' responses to items align with model expectations. In this study, three criteria were applied to assess item fit: (1) Outfit Mean Square Residual (MNSQ) values between 0.5 and 1.5, (2) Z-standardized Outfit (ZSTD) values between –2.0 and +2.0, and (3) point-measure correlation (PT MEA CORR) values between 0.4 and 0.85, with no negative correlations. Items were considered misfitting if they failed to meet all three criteria simultaneously or exhibited a negative correlation with the participants' ability estimates [19].

Table 5. Output item fit order of CLES questionnaire.

No Item	Measure	OUTFIT MNSQ	OUTFIT ZSTD	PT. *Mean Corr*
1	-0.20	0.86	-2.6	0.39
2	0.41	1.41	6.7	0.20
3	-0.13	0.86	-2.5	0.44
4	-0.33	0.81	-3.4	0.40
5	-0.34	0.85	-2.8	0.38
6	0.02	0.82	-3.5	0.40
7	0.06	0.95	-0.9	0.40
8	0.23	0.99	-0.1	0.35
9	0.05	1.04	0.7	0.36
1O	-0.41	1.14	2.2	0.46
11	0.04	1.01	0.3	0.45
12	0.14	0.83	-3.3	0.47
13	-0.04	0.84	-3.1	0.47
14	0.09	1.00	0.0	0.36
15	-0.27	0.85	-2.8	0.48
16	0.57	1.16	2.8	0.37
17	0.78	1.24	3.9	0.38
18	0.72	1.25	4.1	0.40
19	0.64	1.05	0.8	0.43
20	0.78	1.20	3.3	0.42
21	-0.91	1.54	7.0	0.38
22	-0.69	1.01	0.1	0.46
23	-0.40	0.88	-2.2	0.47
24	-0.57	0.95	-0.8	0.45
25	-0.24	0.91	-1.6	0.44

Table 6. Statistic: Misfit Order Understanding Chemistry.

No	Measure	OUTFIT MNSQ	OUTFIT ZSTD	PT. Measue Cor
1	-0.80	1.22	2.3	0.50
2	-0.81	1.24	2.4	0.52
3	0.46	1.13	2.2	0.50
4	-0.63	0.89	-1.4	0.64
5	0.37	0.84	-3.0	0.51
6	0.21	0.81	-3.5	0.59
7	-0.34	0.83	-2.7	0.66
8	-0.17	0.96	-0.7	0.62
9	0.01	0.99	-0.1	0.53
10	0.39	1.11	1.9	0.50
11	0.73	0.97	-0.5	0.35
12	-0.15	0.67	-6.0	0.65
13	-0.14	1.06	1.0	0.54
14	0.23	1.24	3.9	0.39
15	0.64	1.05	0.8	0.40

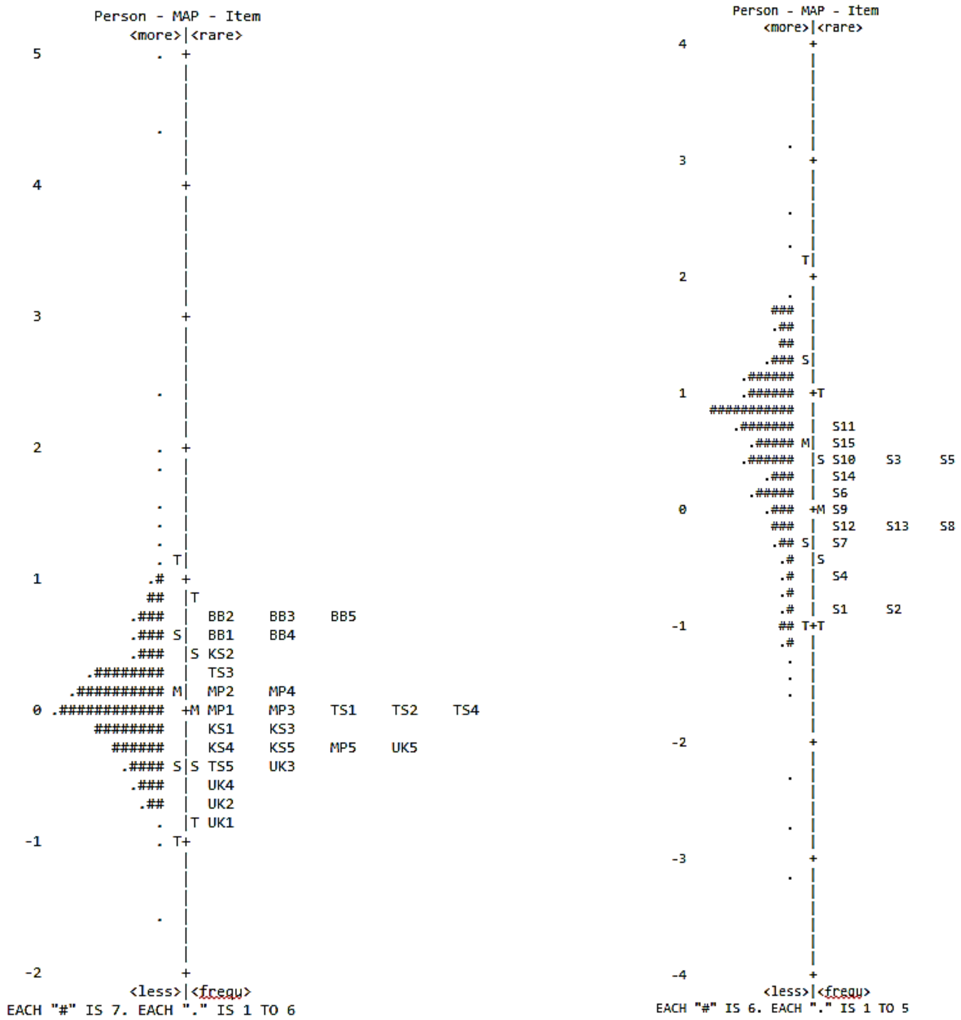
On the CLES instrument, the analysis results indicate that most of the 25 items are consistent with the Rasch model. However, two items—Item 2 and Item 21—exhibit significant misfit. Item 2 has an MNSQ value of 1.41, a ZSTD value of 6.7, and a low PT MEA CORR of 0.20, while Item 21 shows an MNSQ value of 1.54, a ZSTD value of 7.0, and a PT MEA CORR of 0.38. The very high ZSTD values indicate that participants' response patterns deviate substantially from the model's expectations, and the low correlation values suggest poor alignment with students' estimated abilities. Additionally, several borderline items—such as Items 17, 18, and 20—have ZSTD values above the threshold (3.9; 4.1; 3.3); however, their MNSQ and PT MEA CORR values remain within acceptable limits, so they are not conclusively classified as misfits. Conversely, most items—such as Items 7, 8, 14, and 22–25—exhibit strong stability, with all three indicators falling within the ideal range. Overall, the CLES instrument is considered to possess a robust measurement structure, with the exception of two items that require revision or further evaluation [20].

Meanwhile, in the Chemistry Concept Understanding instrument, out of a total of 15 items, two were identified as misfitting: Item 12 and Item 14. Item 12 displayed an MNSQ value of 0.67 and an extreme ZSTD of –6.0, although the PT MEA CORR remained high at 0.65. The highly negative ZSTD suggests that the item is overly easy or too predictable, resulting in overfitting and disrupting measurement balance. Item 14 recorded an MNSQ of 1.24, a ZSTD of 3.9, and a low PT MEA CORR of 0.39, thereby meeting all three misfit criteria. Additionally, borderline items—such as Items 5, 6, and 7—exhibited negative ZSTD values ranging from –2.7 to –3.5; however, as their MNSQ and PT MEA CORR values are still within the acceptable range, they remain valid but require interpretive caution. Most other items demonstrated strong stability, with correlation values ranging from 0.50 to 0.66 and appropriate MNSQ and ZSTD values.

Thus, both instruments generally exhibit valid item performance within the Rasch measurement framework. The number of misfit items is minimal relative to the total number of items and does not suggest systemic distortion of the underlying construct. Nevertheless, revision or further analysis of the identified misfit items is strongly recommended to enhance measurement precision and the validity of inferential results.

d. Wright Map (Peta Wright)

The following section presents a systematic and separate explanation of the analysis results using the Wright Map for each instrument: the Constructivist Learning Environment Survey (CLES) and the Chemistry Concept Understanding Test.



a b

Figure 2. a. Wright Map Item CLES and **b.** Wright Map Item Understanding of Chemistry

The Wright Map provides a graphical representation of the distribution of student abilities (on the left side) and item difficulty levels (on the right side) along the same logit scale. It is used to assess the alignment between student ability levels and the difficulty levels of the items. A higher logit value corresponds to a higher student ability level and item difficulty, whereas a lower logit value indicates lower levels for both [21].

Figure 2a illustrates the distribution of items in the CLES instrument, which evaluates the classroom learning environment through five indicators: knowledge about life outside of school (KS), learning about science (TS), expressing opinions (MP), learning how to learn (BB), and communication (UK). These indicators are displayed on the right side of the Wright Map, while the left side depicts students' perceived learning environment scores, ranked based on their logit values. A higher student position on the logit scale reflects a more positive perception of the learning environment. On the item side (right), a higher item position indicates a lower likelihood of agreement from students, implying greater difficulty, and vice versa [22].

The results of the Wright Map analysis for the CLES instrument show that several indicators were easily agreed upon by respondents. For instance, the communication indicator (UK1) appears below the 0 logit line, indicating that this statement received a lower score relative to other indicators and was easier for students to agree with. In contrast, the "learning how to learn" indicator—represented by items BB2, BB3, and BB5—is located above the 0 logit line, suggesting greater difficulty for students to agree with these items.

Figure 2b displays the Wright Map for the Chemistry Concept Understanding Test. The distribution of student abilities (left side) is concentrated between logits 0 and +1, indicating that most students possess moderate conceptual understanding. On the right side, test items (S1 to S15) are arranged based on their difficulty. Items S11 to S15, positioned between logits +1 and +2, are relatively difficult, whereas S1 and S2, located at logit –1, are relatively easy for the majority of students. Most items are clustered between logits 0 and +1, suggesting that the instrument is effective in measuring the dominant range of participant abilities.

However, there is a limitation: the very dense cluster of student abilities is not entirely matched by the range of item difficulty—particularly at the lower extreme (logits –2 to –4), where several students with low ability are not adequately addressed by sufficiently easy items. It is therefore recommended that additional low-difficulty items be developed to better accommodate the full spectrum of student abilities.

Both Wright Maps provide valuable visual insights into the alignment between student ability and item difficulty, contributing to the evaluation of instrument reliability and construct measurement. Minor discrepancies observed at the extreme ends of the logit spectrum suggest opportunities for targeted item refinement to enhance measurement precision [23].

e. Rating Scale Test

Rating scale testing was conducted to ensure that each response category in the Constructivist Learning Environment Survey (CLES) instrument functioned hierarchically and logically within the Rasch measurement framework. The instrument employed five response categories: *Almost Never* (1), *Rarely* (2), *Sometimes* (3), *Often* (4), and *Almost Always* (5). The evaluation of this rating scale involved two main indicators: the Observed Average and the Rasch-Andrich Threshold. Validation of the Likert scale was carried out using the Rasch model, a psychometric analysis method designed to confirm that each response category operates in a hierarchical and logically ordered manner. The Observed Average indicates the average level of respondent ability or perception for each response category, while the Rasch-Andrich Threshold represents the level of ability or perception required for respondents to transition from one category to the next.

Overall, the results indicate that the rating scale meets the monotonicity criterion, with values increasing consistently from category 1 to 5. Specifically, the Observed Average ranged from –0.46 to +0.75, while the Rasch-Andrich Threshold ranged from –0.93 to +1.06. This consistent upward trend demonstrates that respondents with a higher perception of the constructivist learning environment tend to select higher response categories in a predictable and logical manner, thereby supporting the structural validity of the CLES instrument in terms of its rating scale performance [24].

Table 7. Scale rating test value.

Alternatif jawaban	**Rating skala**	***Observed Average***	***Rasch-Andrich Threshold***
Almost Never	1	-0.46	NONE
Rare	2	-0.26	-0.93
Sometimes	3	0.03	-0.42
Often	4	0.32	0.28
Almost Always	5	0.75	1.06

Category 1 (*Almost Never*) has the highest negative Observed Average value (–0.46) and does not display a threshold, which is common for the initial category in Rasch analysis. Category 2 (*Rarely*) has a Rasch-Andrich threshold of –0.93, followed by Category 3 (*Sometimes*) at –0.42, and Category 4 (*Often*) at +0.28. The highest threshold is observed in Category 5 (*Almost Always*), with a value of +1.06, indicating that only respondents with a very high perception of the constructivist learning environment tend to select this response category. This distribution confirms that the response scale can proportionally differentiate between varying levels of student perception. No reversed thresholds (i.e., disordered category functioning) or illogical progression in Observed Average values were found, indicating that all categories are interpreted and used consistently by the participants.

The progression across the scale can be visualized along a conceptual continuum representing levels of perception. At the far left lies Category 1 (*Almost Never*), representing the lowest level of perceived constructivist learning. Slightly to the right is Category 2 (*Rarely*), with the –0.93 threshold marking the shift to Category 3 (*Sometimes*), which is situated at the midpoint of the scale and transitions to Category 4 (*Often*) at a threshold of –0.42. Category 4, located to the right of center, marks the progression to Category 5 (*Almost Always*) at the +0.28 threshold. Finally, Category 5, positioned at the far right end of the continuum, signifies the highest level of perception, with its threshold at +1.06.

In conclusion, the rating scale in the CLES instrument demonstrates effective and valid functioning within the Rasch measurement model. It successfully captures the gradation of student perceptions of the learning environment. The positive correlation between category scores and respondent abilities further supports the appropriateness of the five-point scale for measuring perceptions in the context of constructivist learning environments.

2. Relationship between Students' Perception of Constructivist Learning Environment and Student Understanding

To confirm the relationship between students' perception of constructivist learning environment and students' understanding, it is necessary to conduct normality test and hypothesis test.

a. Normality of Perception Data and Chemistry Concept Comprehension Tests

Normality testing was conducted on two primary variables, namely the chemistry concept comprehension test scores (*Test*) and students' perceptions of the constructivist learning environment (*Perception*). The results revealed significance values (Sig.) for both variables of less than 0.001, which is below the critical threshold of α = 0.05. The Kolmogorov–Smirnov statistical value for the *Test* variable was 0.089, while that for *Perception* was 0.124, both with degrees of freedom (df) equal to 513. Since the significance values for both variables are less than 0.05, it can be statistically concluded that the distributions of both datasets deviate from normality.

Table 8. Person Normality Results.

	Kolmogorov-Smirnov Statistic	df	Sig.
Test	.089	513	<. 001
Perception	.124	513	<.001

Consequently, parametric statistical methods (such as Pearson correlation or linear regression) should not be applied directly without conducting further data transformation or normality correction. As an alternative, non-parametric techniques such as Spearman correlation or robust regression are more appropriate, as they reduce the risk of violating the normality assumption.

In conclusion, these findings highlight the importance of careful selection of analytical techniques, particularly when the empirical data do not fulfill the normality assumption required by most parametric statistical procedures.

b. Non-parametric Hypothesis Test

Based on the results of the Spearman non-parametric correlation test, the relationship between students' perceptions of the constructivist learning environment (*Perception*) and their understanding of chemistry concepts (*Understanding_Chemistry*) was examined. This test was employed because the data for both variables did not follow a normal distribution, as previously indicated by the Kolmogorov–Smirnov normality test.

The analysis yielded a Spearman's rank correlation coefficient (ρ) of 0.135, with a significance level of $p = 0.002$ ($p < 0.01$), indicating a statistically significant positive relationship between students' perceptions of the constructivist learning environment and their understanding of chemical concepts

Table 9. Spearman Correlation between Students' Perception and Chemistry Concept Understanding.

Variables	Correlation Coefficient (ρ)	Sig. (2-tailed)	N
Perception × Chemistry Concept Understanding	0.135**	0.002	513

Note: ρ = Spearman's rho Correlation is significant at the 0.01 level (2-tailed).

With a sample size of *n* = 513, the test has sufficient statistical power to produce reliable and stable estimates. The observed ρ value of 0.135 exceeds the critical table value (r_t) of 0.087, confirming statistical significance at the 1% level [25]. While the strength of the relationship is classified as very weak, it is nevertheless meaningful, suggesting that students who perceive the learning environment more positively tend to demonstrate a slightly higher level of understanding in chemistry.

These results support the alternative hypothesis (H_1), which posits a relationship between the two variables, and thus reject the null hypothesis (H_0) at the 1% significance level. Substantively, these findings align with core principles of constructivist learning theory, which emphasize that interactive, meaningful, and socially-mediated learning environments contribute to improved conceptual understanding in science education

c. Participant Logit Value Category (LVP)

The grouping of participants' logit values (Logit Value Person/LVP) for both chemistry concept understanding and perceptions of the constructivist learning environment (CLES) was conducted based on the mean and standard deviation of each instrument. For the chemistry concept understanding instrument, the person logit scores were categorized into four levels based on a mean of 0.55 and a standard deviation of 0.78, as follows: (a) *Very Difficult* group (LVP ≥ 1.33), (b) *Difficult* group (0.55 ≤ LVP < 1.33), (c) *Easy* group (–0.23 ≤ LVP < 0.55), and (d) *Very Easy* group (LVP < –0.23).

Similarly, the CLES logit scores were grouped based on a mean of 0.09 and a standard deviation of 0.52 into four levels: (a) *Very Difficult to Agree* group (LVP ≥ 0.61), (b) *Difficult to Agree* group (0.09 ≤ LVP < 0.61), (c) *Easy to Agree* group (–0.43 ≤ LVP < 0.09), and (d) *Very Easy to Agree* group (LVP < –0.43).

Table 10. Person Comprehension Level Category.

Demographics	Chemistry Understanding (Very Difficult)	CLES (Very Easy Approve)
School A	030PA, 091PA,108LA	030PA, 091PA,108LA
School B	02 LB, 03PB	02 LB, 03PB
School C	113PC,059PC, 062PC,020PC, 005LC	113PC,059PC, 062PC,020PC, 005LC
School D	25LD, 24PD	25LD, 24PD
School E	17LE, 67LE, 02PE, 16LE, 10PE, 30PE.	17LE, 67LE, 02PE, 16LE, 10PE, 30PE.

Based on Table 10, participants across the five schools demonstrated a relatively consistent distribution pattern in both chemistry understanding and perception of the learning environment. A notable finding is that most students classified in the *Very*

Difficult category for chemistry concept understanding were also categorized in the *Very Easy to Agree* group regarding the constructivist learning environment. This indicates that even though their conceptual mastery of chemistry was low, their perception of the quality of the classroom environment remained positive.

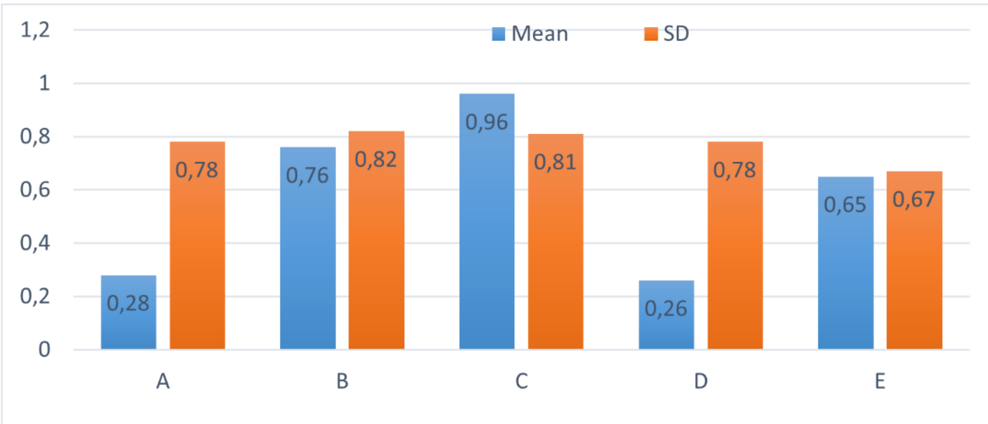
These findings suggest that a high level of agreement or acceptance of a constructivist learning environment does not necessarily correlate with a high level of conceptual mastery in chemistry. This implies the potential presence of mediating factors or other influencing variables that affect learning outcomes beyond classroom perception alone. Furthermore, the diversity in student perceptions indicates variability in classroom learning experiences, which may be attributed to differences in instructional strategies employed by teachers or variations in school learning contexts

d. Overall average ability of learners

The instruments employed in this study were designed to measure two main dimensions: (1) students' conceptual understanding of chemistry material and (2) students' perceptions of the constructivist learning environment (CLES). The study was conducted among 12th-grade students in five senior high schools (SMA/MA) located across the Gorontalo Regency and City.

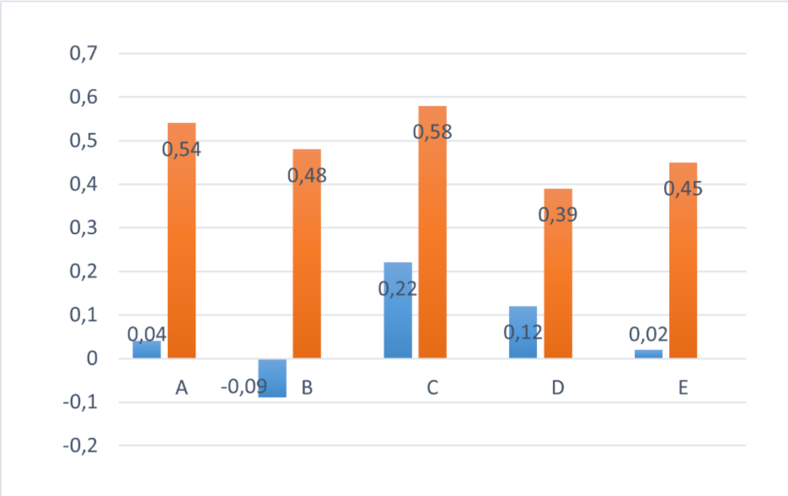
Conceptual understanding was assessed using a three-tier multiple-choice test. The first tier measured students' conceptual knowledge; the second tier evaluated the scientific reasoning that supported their responses in the first tier; and the third tier examined the students' rationalizations connecting the previous two levels [26]. This multi-level approach was intended to differentiate between answers based on deep understanding and those given through guessing or misconceptions.

In addition, students were asked to complete a CLES questionnaire, which reflected their perceptions of the instructional practices they encountered in the classroom. The results from both instruments provided a comprehensive overview of the extent to which students' conceptual understanding correlated with the constructivist characteristics of their learning environment



(Source: Processed by the author)

Figure 3. Average ability of school students A to E.



(Source: Processed by the author)

Figure 4. Average Perception of School Student A to E

As illustrated in Figure 3, students from School C demonstrated the highest average level of conceptual understanding, with a logit value of 0.96 and a standard deviation of 0.81. Correspondingly, Figure 4 shows that the same group of students reported an average perception score of 0.22—also the highest among the participating schools. These findings suggest that students at School C not only exhibited strong conceptual understanding but also held a more positive perception of their learning environment.

Field observations support these quantitative results. Students at School C were found to be more actively engaged in learning activities, participated in frequent discussions, and received intensive guidance from their teachers. In contrast, the relatively low achievement observed at School D may be attributed to a limited number of available teachers and a low intensity of academic interactions. Overall, the data indicates that students' conceptual understanding is influenced not only by their perception of the learning environment but also by the quality of direct interactions, the intensity of instructional activities, and the availability of educational support resources.

DISCUSSION

The findings of this study consistently demonstrate that the relationship between students' perceptions of the constructivist learning environment and their understanding of chemistry concepts is statistically significant but weak. The Spearman correlation coefficient of 0.135 (p = 0.002) indicates a positive correlation between the two variables, although its strength is relatively low. This result aligns with prior studies suggesting that students' perceptions of constructivist learning dimensions—such as shared control, critical voice, and personal relevance—do influence cognitive engagement but do not necessarily ensure deeper conceptual understanding [7].

These results imply the presence of mediating factors that influence the relationship between perception and understanding. First, teachers' instructional strategies play a critical role; while students may have positive perceptions of the learning environment, deep conceptual understanding cannot be guaranteed without the application of appropriate pedagogical approaches, such as cognitive scaffolding. Second, the limited number of teachers and reduced academic interaction may contribute to low student achievement, particularly in under-resourced schools. Third, inconsistencies in classroom learning experiences—as reflected in varied student perceptions across different schools—may result from differences in teaching approaches or the contextual characteristics of each learning environment.

The logit distributions derived from the Wright Map and the participant grouping based on logit values reveal an imbalance between item difficulty levels and student abilities. On the Wright Map for the CLES instrument, most students are positioned below the difficulty level of the items, indicating that their perceptions of constructivist elements in the classroom are still relatively low. In contrast, the Wright Map for the chemistry concept understanding instrument shows that students are primarily clustered around the middle of the logit scale, suggesting a more balanced alignment between item difficulty and students' conceptual ability.

Notably, although the CLES instrument exhibits high statistical validity and reliability, the results from the Rasch rating scale analysis indicate that ambiguity in the lower response categories (1 and 2) may hinder the linearity of students' interpretations. The disordered Rasch-Andrich threshold for category 2 reflects potential inconsistencies in students' understanding of the response scale—an issue also noted by previous researchers in the development of Rasch-based Likert instruments [9].

From an inter-school comparison perspective, School C stands out as the only institution where a balance is evident between high conceptual understanding (mean logit = 0.96) and relatively positive perceptions of the learning environment (mean logit = 0.22). This indicates that students in School C not only possess strong cognitive mastery of chemistry concepts but also perceive their learning environment as supportive of active and reflective participation. In contrast, School D recorded the lowest average scores in both conceptual understanding and perception of constructivist learning. This finding is consistent with field observations pointing to a shortage of qualified educators and limited dialogic instructional practices in the school.

The discrepancy observed in certain schools—where students report high perceptions of constructivist learning but demonstrate low conceptual understanding—suggests that a positive view of the learning environment does not automatically translate into improved academic outcomes. Rather, effective learning requires the integration of constructivist perceptions with instructional strategies that specifically support conceptual development and cognitive engagement.

CONCLUSION

This study concludes that students' perceptions of the constructivist learning environment generally contribute positively to their understanding of chemistry concepts, but this contribution is limited and non-linear. The Rasch model successfully revealed the unidimensionality, validity, and discriminatory power of the two instruments used, and showed that perceptions of the learning environment do not always directly reflect students' cognitive understanding levels. Schools with active learning support, responsive teachers, and consistent application of constructivist strategies showed a better correlation between perceptions and student achievement. Therefore, improving the quality of chemistry learning is not sufficient by relying solely on declarative constructivist strategies but must also be accompanied by instructional quality, fair teacher distribution, and the strengthening of an academic culture that enables consistent reflective and exploratory interactions.

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