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# What are students' thoughts on their activities and thinking skills in learning science?

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**ABSTRACT**

This study aimed to analyze and correlate students' perceptions of their activities and thinking skills in learning science, as well as compare these perceptions based on school levels. Using descriptive, correlational, and comparative methods, data were collected from 127 students from senior high school and university through a questionnaire containing 52 statements. Descriptive statistics provided an overview of the data, while Pearson's test analyzed the relationship between students' perceptions of their activities and thinking skills. An independent sample t-test compared data based on school levels. The results indicated that students perceived their activities as active (mean value of 3.52) and their thinking skills as experienced (mean value of 3.51). A perception of learning activities was correlated with a more perception of thinking skills, although the relationship was not strong ($r = 0.357, \rho = 0.000$). University students generally had higher perceptions across most activities compared to high school students, suggesting that high school educators might consider adopting some university-level strategies, particularly for motor, emotional, and visual activities, to enhance student engagement and perception. However, there were no significant differences in average perceptions of thinking skills between high school and university students, except for a significant result in likelihood and uncertainty analysis, which highlights a specific area for further investigation. Understanding students' perceptions of their thinking skills can help educators focus on specific areas for improvement and comprehend how educational transitions impact students' views on their thinking abilities.

**Keywords:** activity, high school students, perception, science learning, thinking skills, university students

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## INTRODUCTION

Learning is considered effective when what the instructor teaches aligns with what the students learn and learning outcomes. If this alignment occurs, the learning process will positively impact overall learning outcomes. However, in reality, many learning experiences indicate that what instructors teach may not necessarily align with what students learn (Biggs, 2012; Biggs et al., 2013). As a result, students may become disengaged (Putri et al., 2024), disinterested and bored during learning activities (Putri & Pranata, 2023; Utami et al., 2024).

For students, learning activities involve gathering knowledge and information, enhancing understanding, developing skills, and changing attitudes (Cahyani & Pranata, 2023). Activities that are appropriate for students' conditions and needs can have various positive impacts on student learning, supporting the improvement of their abilities. Therefore, educators should be aware of various types of learning activities, especially in science, to be applied (Putri et al., 2024). So, the learning focus should be changed. The focus should not be on what the teacher teaches but on what the students learn (Mayer, 2011). Therefore, learning should be designed according to students' conditions, needs (Cahyani & Pranata, 2023), and behaviors (Chi & Wylie, 2014).

The results of students' learning activities are usually indicated by changes in knowledge, abilities, and/or attitudes. Then the learning outcomes and changes that occur in students are expected to be applied to improve their quality of life. It is the essential aspect of learning. But most students are more concerned with the form of learning activities and not paying much attention to the topics and learning objectives (Swarat et al., 2012). Therefore, it is important to know the activities that are effective to support students' learning in various topics and conditions.

Varied learning activities can help in the development of students' learning (Chi, 2009). There are various forms of learning activities. Diedrich concluded that activities in learning can be divided into eight aspects, namely motor, writing, mental, emotional, visual, oral, listening, and drawing activities (Sardiman, 2008). Each aspect of activity contributes with varying degrees to the success of the learning process. Varied learning activities are needed to achieve different learning goals (Hodson, 2014). Issues related to activities are necessary to determine the range of interesting activities, effective activity

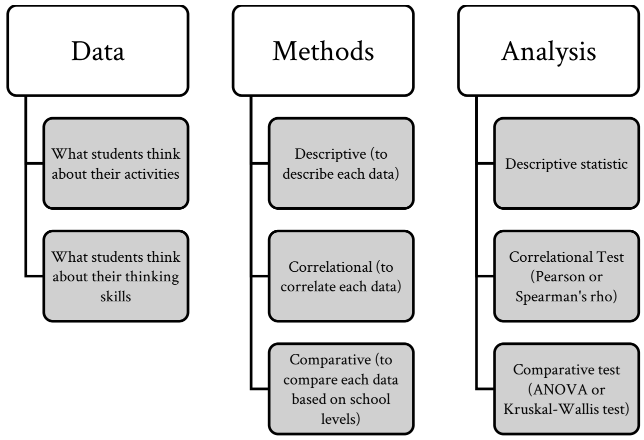



**Figure 1.** Research design (Source: Authors' own elaboration)

**Table 1.** Aspects indicators of students' perception about their activities (Cahyani & Pranata, 2023)

| Aspects | Code | Indicators |
|---|---|---|
| *Motor activities* | A1 | 1. Do observation and experiment in laboratory<br>2. Solve puzzles, playing games, joining ice breaking, etc.<br>3. Make a project or product (poster, writing, props, and etc.) |
| *Writing activities* | A2 | 1. Make a notes<br>2. Make observation and laboratory experiment reports<br>3. Make a written task |
| *Mental activities* | A3 | 1. Make a decision<br>2. Follow learning schema<br>3. Apply concepts in different case or situation |
| *Emotional activities* | A4 | 1. Feel boring in learning<br>2. Feel enthusiasm for learning<br>3. Feel nervous doing something in class |
| *Visual activities* | A5 | 1. Observe teacher's explanation<br>2. Read a book with visualization (diagram, picture, etc.)<br>3. Observe natural phenomena or experiment in lab or via video demonstration |
| *Oral activities* | A6 | 1. Ask a question to teacher<br>2. Discuss ideas in class<br>3. Respond to friends' ideas |
| *Listening activities* | A7 | 1. Listen to teacher's explanation<br>2. Interact actively in class discussion<br>3. Listen to friend's explanation |
| *Drawing activities* | A8 | 1. Make a figure about concept<br>2. Make table or graph<br>3. Draw a diagram or concept map |

sequences, suitable activity forms for different topics and learning objectives, and activity choices for different student populations (Swarat et al., 2012).

In addition to unique perceptions of activities in learning for each student, they also have uniqueness in thinking. Different activities in science learning have different impacts on each student. Even what each student thinks varies as they engage in science learning. Studies reveal that the most effective way to teach thinking skills is not to separate subjects but to infuse them into content-based learning (Wegerif, 2017), such as science or other disciplines. In other words, students' thinking skills will be closely tied to the learning activities in which they participate.

Therefore, it is essential to understand the best activities in class from the students' perspective, along with their correlation to thinking skills. Students' perception and perspective has long term impact on students' career and life (Putri et al., 2024). Additionally, comparing students' perceptions of activities and thinking skills across different levels of schools in science learning is also valuable for exploration.

# METHODS

## Research Design

The main method is based on quantitative methodology. Descriptive, correlational, and comparative methods were applied, as shown in **Figure 1**. The study aimed to describe and analyze what students think about their activities and thinking skills in learning science. The research also explored the correlation between students' activities and thinking skills. Lastly, the study compared students' activities and thinking skills based on school levels.

## Population and Sample

The population in this study consists of one school for each level senior high school and higher education. The applied sampling technique is purposive sampling. Sample selection is in accordance with specific needs and objectives (Cohen et al., 2018). The samples in this study are 127 students from senior high school and university in the program and department of science education.

## Research Instruments

A survey will be conducted in this research. The survey is designed to collect data with the goal of describing a specific condition (Cohen et al., 2018). The condition under consideration in this study is the students' perceptions of their activities and thinking abilities in science learning at senior high school and higher education.

The survey was conducted to collect data about:

(1) *what do students think about their activities* and

(2) *what do students think about their thinking skills* in learning science.

A questionnaire was used to gather those data. There are 52 statements consisting of 8 statements related to science learning in general, 24 statements regarding *what do students think about their activities* which are divided into eight aspects of activity, as shown in **Table 1** (Cahyani & Pranata, 2023), and 20 statements regarding what do students think about their thinking skills which are divided into five aspects of thinking skills, as shown in **Table 2** (Tiruneh et al., 2015). Statements related to science learning are used as supports to describe science learning in general.

**Table 2.** Aspects indicators of students' perception about thinking skills (Halpern, 2014; Tiruneh et al., 2015)

| Aspects | Code | Indicators |
|---|---|---|
| *Reasoning* | T1 | 1. Evaluate the validity of data<br>2. Recognize errors of measurement<br>3. Interpret the results of an experiment<br>4. Detect ambiguity and misuse of definitions |
| *Hypothesis testing* | T2 | 1. Recognize the need for more information in drawing conclusions<br>2. Identify when causal claims can and cannot be made<br>3. Draw valid inferences from a given tabular or graphical information<br>4. Check for adequate sample size and possible bias when a generalization is made |

**Table 2 (Continued).**

| Aspects | Code | Indicators |
|---|---|---|
| *Argument analysis* | T3 | 1. Identify key parts of an argument<br>2. Criticize the validity of generalizations in an experiment<br>3. Judge the credibility of an information source<br>1. Infer a correct statement from a given data set |
| *Likelihood and uncertainty analysis* | T4 | 1. Predict the probability of event<br>2. Use probability judgments to make decisions<br>3. Compute expected values in situations with known probabilities<br>4. Identify assumptions (e.g. recognize what assumptions have to be) |
| *Problem-solving and decision making* | T5 | 1. Identify the best among a number of alternatives in solving problems<br>2. Examine the relevance of procedures in solving scientific problems<br>3. Recognize the features of a problem and adjust solution plan accordingly<br>4. Evaluate solutions to a problem & make sound decisions on the basis of evidence |

**Table 3.** Conversion scale

| Answer choices | Conversion scale | |
|---|---|---|
| | Positive statement (+) | Negative statement (-) |
| Strongly agree (SA) | 5 | 1 |
| Agree (A) | 4 | 2 |
| Neutral (N) | 3 | 3 |
| Disagree (D) | 2 | 4 |
| Strongly disagree (SD) | 1 | 5 |

**Table 4.** Data classification scale

| Average (mean) | Classification | |
|---|---|---|
| | What do students think about the learning activity? | What do students think about their thinking skills? |
| $4 \leq M \leq 5$ | Very active | Expert |
| $3 \leq M < 4$ | Active | Experienced |
| $2 \leq M < 3$ | Less active | Intermediate |
| $1 \leq M < 2$ | Passive | Beginner |

Note. M: Average

**Table 5.** Descriptive statistics for all data

| Students think about ... in learning science | Min | Max | Mean | | Standard deviation | Skewness | |
|---|---|---|---|---|---|---|---|
| | | | Statistic | Standard error | | Statistic | Standard error |
| A1. Motor activity | 2.33 | 5.00 | 4.21 | 0.05 | 0.56 | –0.53 | 0.22 |
| A2. Writing activity | 1.00 | 5.00 | 3.40 | 0.05 | 0.62 | –0.85 | 0.22 |
| A3. Mental activity | 1.33 | 4.67 | 2.92 | 0.06 | 0.68 | 0.20 | 0.22 |
| A4. Emotional activity | 1.67 | 5.00 | 3.22 | 0.06 | 0.71 | 0.22 | 0.22 |
| A5. Visual activity | 2.00 | 5.00 | 3.52 | 0.06 | 0.65 | –0.47 | 0.22 |
| A6. Oral activity | 1.33 | 5.00 | 3.69 | 0.07 | 0.78 | –0.36 | 0.22 |
| A7. Listening activity | 1.00 | 5.00 | 3.83 | 0.07 | 0.77 | –0.59 | 0.22 |
| A8. Drawing activity | 1.00 | 5.00 | 3.38 | 0.08 | 0.90 | 0.03 | 0.22 |
| Average activity | 2.42 | 4.67 | 3.52 | 0.04 | 0.44 | 0.22 | 0.22 |
| T1. Reasoning | 1.75 | 4.75 | 3.53 | 0.05 | 0.55 | –0.09 | 0.22 |
| T2. Hypothesis testing | 2.00 | 5.00 | 3.57 | 0.05 | 0.57 | –0.11 | 0.22 |
| T3. Argument analysis | 2.00 | 5.00 | 3.45 | 0.05 | 0.59 | 0.07 | 0.22 |
| T4. Likelihood and uncertainty analysis | 1.00 | 5.00 | 3.30 | 0.05 | 0.61 | –0.51 | 0.22 |
| T5. Problem-solving and decision making | 2.00 | 5.00 | 3.71 | 0.05 | 0.56 | –0.40 | 0.22 |
| Average thinking skills | 1.90 | 4.65 | 3.51 | 0.04 | 0.43 | –0.60 | 0.22 |

The statements in the questionnaire were designed with five choices or scale of answer: strongly agree, agree, neutral, disagree, and strongly disagree. After we collect the student answer based on questionnaire, the answers are converted into numbers or quantitative data. Conversion is based on two ways depending on whether the statements in the instrument are positive or negative (**Table 3**).

### Data Analysis

The collected data was analyzed using descriptive statistics to provide an overview of the data. The average for each data, aspect, and indicator can be classified based on the scale (**Table 4**).

Then, the data on what students think about their activity will be analyzed in relation to the data on what students think about their thinking skills. Correlation tests were used based on the data: Pearson test for parametric analysis and Spearman's rho for nonparametric analysis.

In addition to correlation, the collected data will also be compared based on school levels. Comparative analysis will be processed using independent sample t-test for parametric analysis and Mann-Whitney U test for nonparametric analysis. The selection of tests depends on the conditions of the collected data.

Both tests will be processed using specialized computer software for data processing and analysis, namely SPSS.

## RESULTS AND DISCUSSION

### Descriptive Results and Discussion

The collected data were then analyzed using descriptive statistics to obtain a general overview of what students think about their activities and thinking skills. This analysis was conducted for all data, including all students and groups of students at different educational levels (senior high school and university). The results are presented sequentially in **Table 5**, **Table 6**, and **Table 7**.

An initial comparison between the mean statistics on what students think about their activities and thinking skills presents interesting findings as summarized in **Figure 2**.

First, overall, students have an average perception of their activities in the active category (3.52) and an average perception of their thinking skills in a comparable category, experienced (3.51).

**Table 6.** Descriptive statistic for senior high school students

| Students think about ... in learning science | Min | Max | Mean | | Standard deviation | Skewness | |
|---|---|---|---|---|---|---|---|
| | | | Statistic | Standard error | | Statistic | Standard error |
| A1. Motor activity | 2.33 | 5.00 | 4.11 | 0.07 | 0.57 | –0.54 | 0.28 |
| A2. Writing activity | 1.00 | 5.00 | 3.33 | 0.08 | 0.66 | –1.10 | 0.28 |
| A3. Mental activity | 1.67 | 4.33 | 2.94 | 0.07 | 0.64 | 0.17 | 0.28 |
| A4. Emotional activity | 1.67 | 5.00 | 2.99 | 0.08 | 0.67 | 0.74 | 0.28 |
| A5. Visual activity | 2.00 | 4.67 | 3.39 | 0.07 | 0.64 | –0.38 | 0.28 |
| A6. Oral activity | 2.00 | 5.00 | 3.63 | 0.08 | 0.67 | –0.17 | 0.28 |
| A7. Listening activity | 1.00 | 5.00 | 3.73 | 0.09 | 0.75 | –0.83 | 0.28 |
| A8. Drawing activity | 1.33 | 5.00 | 3.30 | 0.09 | 0.81 | 0.03 | 0.28 |
| Average activity | 2.42 | 4.38 | 3.43 | 0.05 | 0.40 | 0.29 | 0.28 |
| T1. Reasoning | 2.25 | 4.75 | 3.46 | 0.06 | 0.50 | 0.51 | 0.28 |
| T2. Hypothesis testing | 2.00 | 4.50 | 3.49 | 0.06 | 0.50 | –0.24 | 0.28 |
| T3. Argument analysis | 2.25 | 5.00 | 3.41 | 0.06 | 0.53 | 0.43 | 0.28 |
| T4. Likelihood and uncertainty analysis | 2.00 | 4.75 | 3.40 | 0.06 | 0.50 | –0.17 | 0.28 |
| T5. Problem-solving and decision making | 2.25 | 5.00 | 3.69 | 0.06 | 0.50 | –0.27 | 0.28 |
| Average thinking skills | 2.35 | 4.50 | 3.49 | 0.04 | 0.36 | –0.37 | 0.28 |

**Table 7.** Descriptive statistic for university students

| Students think about ... in learning science | Min | Max | Mean | | Standard deviation | Skewness | |
|---|---|---|---|---|---|---|---|
| | | | Statistic | Standard error | | Statistic | Standard error |
| A1. Motor activity | 3.33 | 5.00 | 4.35 | 0.07 | 0.50 | –0.41 | 0.33 |
| A2. Writing activity | 2.33 | 5.00 | 3.50 | 0.07 | 0.55 | –0.06 | 0.33 |
| A3. Mental activity | 1.33 | 4.67 | 2.89 | 0.10 | 0.73 | 0.26 | 0.33 |
| A4. Emotional activity | 1.67 | 5.00 | 3.53 | 0.09 | 0.66 | –0.40 | 0.33 |
| A5. Visual activity | 2.00 | 5.00 | 3.70 | 0.08 | 0.61 | –0.68 | 0.33 |
| A6. Oral activity | 1.33 | 5.00 | 3.79 | 0.13 | 0.91 | –0.61 | 0.33 |
| A7. Listening activity | 2.00 | 5.00 | 3.99 | 0.11 | 0.78 | –0.41 | 0.33 |
| A8. Drawing activity | 1.00 | 5.00 | 3.50 | 0.14 | 1.02 | –0.11 | 0.33 |
| Average activity | 2.63 | 4.67 | 3.66 | 0.06 | 0.46 | –0.03 | 0.33 |
| T1. Reasoning | 1.75 | 4.75 | 3.64 | 0.08 | 0.61 | –0.74 | 0.33 |
| T2. Hypothesis testing | 2.00 | 5.00 | 3.68 | 0.09 | 0.63 | –0.22 | 0.33 |
| T3. Argument analysis | 2.00 | 5.00 | 3.52 | 0.09 | 0.66 | –0.30 | 0.33 |
| T4. Likelihood and uncertainty analysis | 1.00 | 5.00 | 3.17 | 0.10 | 0.72 | –0.40 | 0.33 |
| T5. Problem-solving and decision making | 2.00 | 5.00 | 3.75 | 0.09 | 0.65 | –0.56 | 0.33 |
| Average thinking skills | 1.90 | 4.65 | 3.55 | 0.07 | 0.51 | –0.81 | 0.33 |

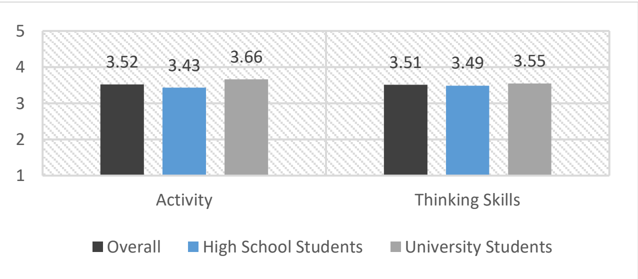



**Figure 2.** Mean scores (Source: Authors' own elaboration)

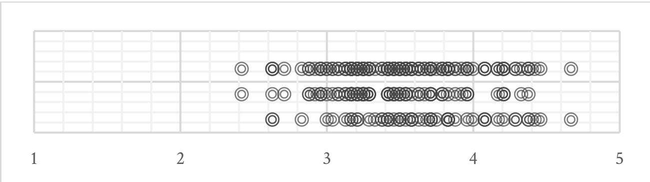



**Figure 3.** Scores distribution on what students think about their activity: all (top), senior high school (middle), and university student (bottom) (Source: Authors' own elaboration)

Second, when differentiated by educational level (senior high school and university), as shown in **Figure 2**, it was found that university students had slightly better perceptions of their activities (mean value of 3.66) compared to senior high school students (mean value of 3.43), both falling within the active category.

This comparison is further supported by the distribution of average perception scores for each student and the classification of students' perceptions, as shown in **Figure 3** and **Figure 4**.

The distribution of university students' perceptions of learning activities tends to be more to the right (towards higher scores) compared to that of high school students. Additionally, based on the classification, a larger proportion of university students (24.53%) are classified as very active compared to high school students (8.11%). Conversely, a smaller proportion of university students (5.66%) are classified as less active compared to high school students (12.16%).

Also, the comparison of perceptions between student groups can also be confirmed based on the average perception of activity indicators, as shown in **Figure 5**. University students were found to have higher perceptions in seven out of eight activities, with the exception of mental activity. Interestingly, mental activity received the lowest perception scores for both student groups. Both groups of students also agreed on the four best activities for learning science, ranking them as motor, listening, oral, and visual activities, respectively.

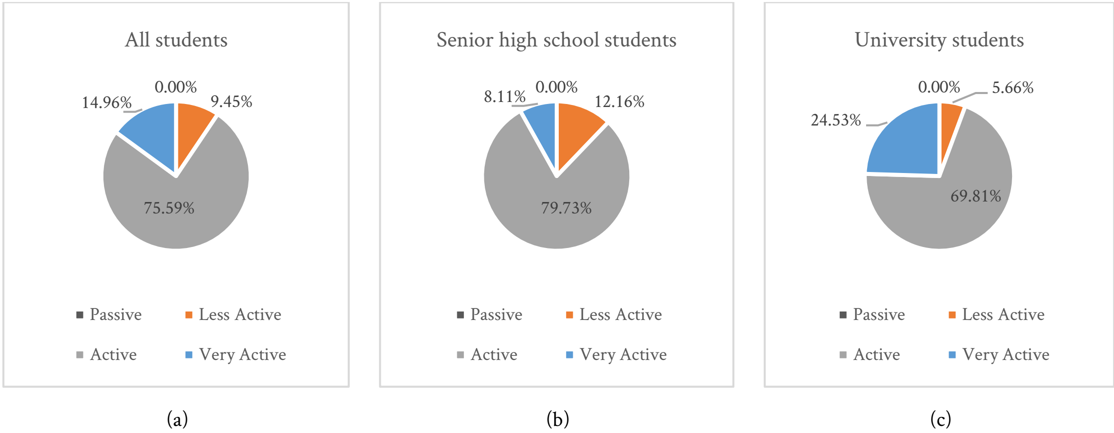



**Figure 4.** Classification on what students think about their activity (Source: Authors' own elaboration)

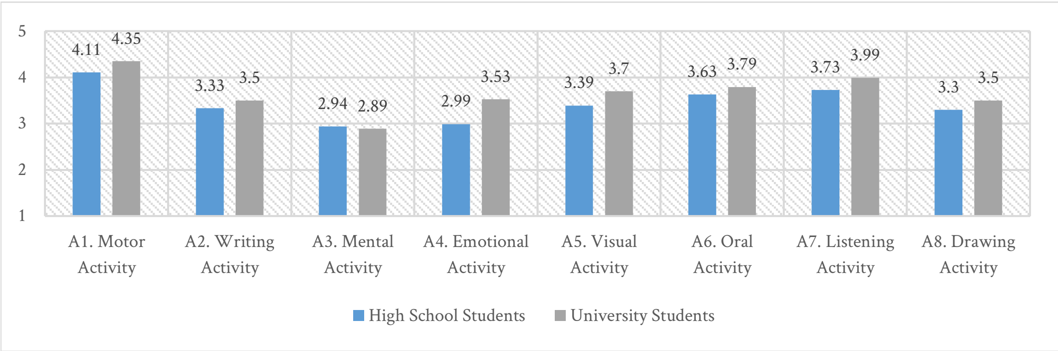



**Figure 5.** Mean scores on what students think about their activity (Source: Authors' own elaboration)

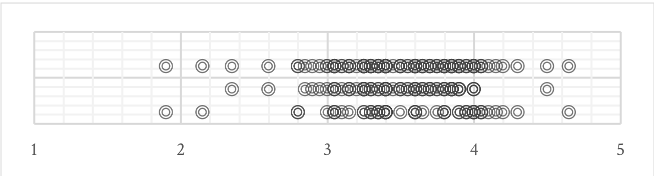



**Figure 6.** Scores distribution on what students think about their thinking skills: all (top), senior high school (middle), and university student (bottom) (Source: Authors' own elaboration)

However, among all the indicators, only motor activity had an average perception greater than 4, which is considered very high or very active, in line with previous research (Cahyani & Pranata, 2023). Activities involving motor skills, such as conducting observations, demonstrations, and creating projects or artifacts, are favored by both high school and university students. In line with previous research that found that hands-on is most favorable for students (Swarat et al., 2012). Active learning methods like these have been proven effective for science education, whether through direct observation or using technology (Pranata, 2023a; Pranata & Seprianto, 2023; Swarat et al., 2012), interactive demonstrations (Pranata et al., 2017) or creating and presenting projects like science posters (Pranata et al., 2023).

However, what students enjoy the most about motor activities is the inclusion of ice-breaking activities during lessons. This finding is based on the highest average perceptions reported by high school and university students for ice-breaking activities in science learning. These activities include participating in quizzes, solving challenges or puzzles (Pranata, 2021, 2023c), playing educational games (Pranata, 2023b), and other similar activities.

Third, using the same comparison, as shown in **Figure 2**, it was found that university students had slightly perceptions of their thinking skills (mean value of 3.55) compared to high school students (mean value of 3.49), both failing in the experienced category. This comparison is further supported by the distribution of average perception scores for each student and the classification of students' perceptions regarding their thinking skills, as shown in **Figure 6** and **Figure 7**.

The distribution of university students' perceptions of their thinking skills tends to be more to the right (towards higher scores) compared to that of high school students. Furthermore, based on the classification, a larger proportion of university students (24.53%) are classified as expert compared to high school students (5.41%). Conversely, a smaller proportion of university students (67.92%) are classified as beginners compared to high school students (87.84%).

Furthermore, the comparison of perceptions between student groups can also be confirmed based on the average perception of thinking skills indicators, as shown in **Figure 8**. University students were found to have higher perceptions in four out of five thinking skills indicators, except for the fourth indicator, which is likelihood and uncertainty analysis. Interestingly, this indicator had the lowest perception scores for both student groups. On the other hand, the highest average perception was represented by indicator T5, which is problem-solving and decision-making.

There was also a similarity between the two groups of students. Although the average perception varies for each indicator, both groups have the same order of average perception, which is T5, T2, T1, T3, and T4. Thus, both groups agreed on the order of perceptions based on the average value for all thinking skills indicators. However, none of the

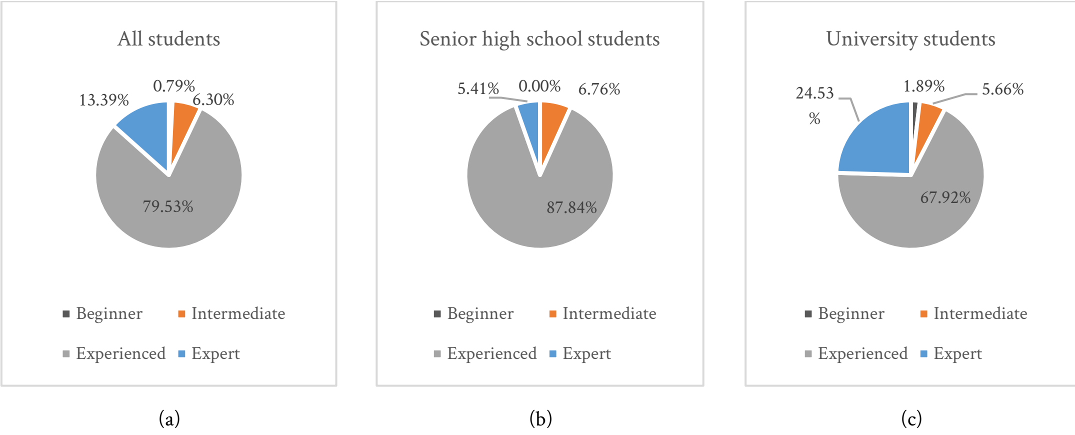



**Figure 7.** Classification on what students think about their thinking skills (Source: Authors' own elaboration)

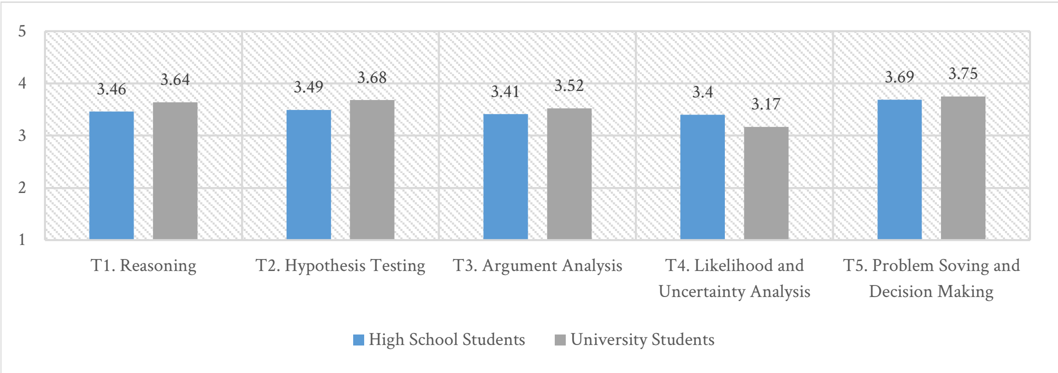



**Figure 8.** Mean scores on what students think about their thinking skills (Source: Authors' own elaboration)

indicators of perceptions of thinking skills had an average considered very high (greater than 4). The highest scores only reached mean values of 3.75 and 3.69 for T5 (problem-solving and decision-making) for university and high school students, respectively.

Regarding indicator T5 (problem-solving and decision-making), both groups of students agreed that they could solve problems according to plan, evaluate solutions to problems, and make decisions. Despite having similarly high average perceptions, high school students had a slightly higher perception of their ability to solve problems according to plan (3.81) compared to university students (3.79). Conversely, university students had a higher perception regarding their ability to evaluate solutions to problems and make decisions (3.92) compared to high school students (3.70). These differences, though subtle, highlight the varying strengths perceived by students at different educational levels. High school students feel more adept at adhering to plans, while university students feel more skilled in the critical evaluation and decision-making processes.

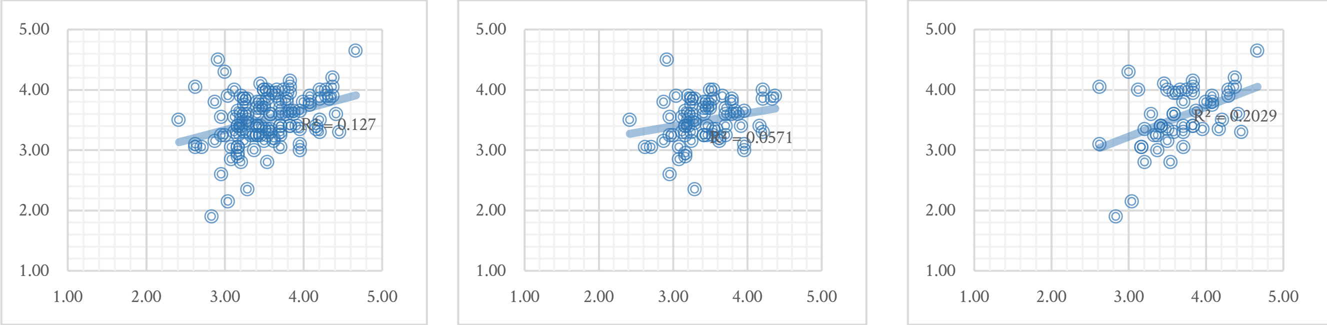
Next, for indicator T2 (hypothesis testing), both groups of students agreed on their ability to identify cause-and-effect relationships, with average perceptions of 3.70 and 3.92 for high school and university students, respectively. This result indicates that high school students feel confident in their ability to identify cause-and-effect relationships, though this confidence is not as pronounced as in university students. This suggests that university students are more adept at understanding and identifying cause-and-effect relationships, likely due to their more advanced coursework and greater exposure to scientific methods.

A similar agreement between the two groups was also shown for the next indicator, T1 (reasoning). Both groups agreed on their ability to recognize errors in measurement or observation, with average perceptions of 3.57 and 3.94 for high school and university students, respectively. This result reflects that high school students feel reasonably confident in their ability to recognize errors in measurement or observation. This is a positive indication of their developing analytical skills, although there's room for improvement. The higher average perception of 3.94 indicates that university students feel more assured in their reasoning abilities.

For indicator T3 (argument analysis), both groups agreed on the highest and lowest average perceptions. They agreed on a high perception of their ability to identify important parts of an argument (with averages of 3.55 and 3.62 for high school and university students, respectively). The lowest average perception was related to their ability to interpret data (with averages of 3.35 and 3.23 for high school and university students, respectively). However, the lowest averages were still above 3.

Finally, indicator T4 (likelihood and uncertainty analysis) had the lowest perceptions of all indicators thinking skills. This finding aligns with the generally low average scores for the statements within this indicator. Both groups agreed on their lowest perception within this indicator, which was their ability to perform calculations involving uncertainty (with averages of 3.24 and 2.83 for high school and university students, respectively). The next lowest perception differed between the two groups: the ability to identify assumptions for high school students (3.30) and the ability to predict the likelihood of an event for university students (3.15).

The data reveals a consistent pattern where university students have higher average perceptions of their abilities in problem-solving




(a) Average activity and thinking skills

(b) Average activity and thinking skills (senior high schools)

(c) Average activity and thinking skills (university students)

**Figure 9.** Scatterplot between average activity and thinking skills: (a) all students, (b) senior high school students, and (c) university students (Source: Authors' own elaboration)

and decision making, hypothesis testing, reasoning, and argument analysis compared to high school students. The only exception is their abilities in likelihood and uncertainty analysis, where high school students have higher average perceptions. Although there are differences in perceptions across these five indicators, the significance of these differences cannot be confirmed until a comparative test is conducted. This test and its results will be presented in section C.

The interim conclusions are presented separately for perceptions of activities and thinking abilities in science learning. The conclusions focus on the practical benefits obtained and how they can be applied in learning based on descriptive data analysis. According to Bonwell and Eison's (1991), definition of active learning, there are two main activities central to active learning: the experiences students gain and what students think about what they have done and learned (Fink, 2013). The experiences for students are divided into two main activities: doing something and observing. Reflections, or what students think, are also divided into two types: self-reflection and reflection with others, including teachers or peers, both within and outside the learning activities.

Based on these findings, it can be concluded that students' perceptions of their activity or experience in learning science are essential to support active learning. According to Fink's (2013) definition, active learning activities in the category of doing something can be directed by involving activities that encourage students to be physically active (motor activity) and engage in argumentation (oral activity). For the category of observing, active learning activities can involve students absorbing information through listening (audio activity) and visual (visual activity). These four activity indicators are concluded based on the study's findings as the indicators with the highest averages for both high school and university students.

However, regarding thinking abilities, to support the effectiveness of science learning, educators should emphasize problem-solving and decision making. This involves planning problem resolution, providing various alternatives for solving problems, evaluating those alternatives, and making decisions. Additionally, aspects of hypothesis testing and reasoning should be included. Reflective thinking abilities can also be explored by considering how students view, think about, and reflect on their learning experiences.

## Correlation Results and Discussion

Before conducting the correlation test between the two groups of data regarding students' perceptions of their activity and thinking skills in learning science, assumption tests are needed as a basis for determining the appropriate correlation test. Pearson correlation can be applied when each data set is normally distributed and there is a linear correlation between variables.

The distribution of data can be determined based on the skewness statistic for various groups of data in **Table 5**, **Table 6**, and **Table 7**. Data can be concluded to be normally distributed when the skewness statistic is within the range of −1 to 1 (Leech et al., 2005; Morgan et al., 2004). Thus, it can be concluded that the data are normally distributed. For example, the average perception score data on what students think about their activity and thinking skills for all students with skewness statistics of 0.22 and −0.60, as shown in **Table 5**. Then 0.29 and −0.37 for senior high school students (**Table 6**) and −0.03 and −0.81 for university students (**Table 7**).

The first assumption (normality of data) has been met. Next, the second assumption (linearity of correlation) can be determined through the mapping of the two groups of data on a scatterplot, as shown in **Figure 9**. The results show that all correlations are linear, represented by a linear line.

With the assumptions (normality of data and linearity of correlation) fulfilled, the level and significance of the relationships between the data can be determined using the Pearson correlation test. This test is processed with the help of SPSS software. The Pearson correlation test is conducted with several different approaches and will be discussed separately, as follows.

First, the correlation test between data regarding students' perceptions of their activity and thinking skills in learning science. This test is conducted for all students and separately for student groups based on their education level. The results are shown in **Table 8**.

All correlations in **Table 8** were found to be positive and significant between students' perception of their activity and thinking skills in learning science, both for the data group of all students and the data groups of students at different education levels. For all students, a correlation coefficient of 0.357 was found and significant at the 0.01 level ($\rho = 0.000$) between students' perception of their activity and thinking skills in learning science. This correlation level falls into the medium category (Cohen, 1988). A lower correlation level (categorized as small) was found for the senior high school student data group ($r = 0.239, \rho = 0.040$) and a higher correlation level (but still in the medium category) was found for the university students data group ($r = 0.541, \rho = 0.001$).

**Table 8.** Correlation between average activity and thinking skills

| Variables | Parameter | Value |
|---|---|---|
| All students | Pearson correlation | 0.357** |
| | Sig. (2-tailed) | 0.000 |
| Senior high school students | Pearson correlation | 0.239* |
| | Sig. (2-tailed) | 0.040 |
| University students | Pearson correlation | 0.451** |
| | Sig. (2-tailed) | 0.001 |

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

These findings suggest that, to some extent, when students view their learning activities positively, they also tend to perceive their thinking skills more positively, although the relationship is medium category. A smaller relationship observed at high school level. The small correlation suggests that other factors may also play significant roles. Thus, educators should consider a comprehensive approach that includes other strategies, and a variety of learning activities might slightly improve their perception of their thinking skills. However, since the correlation is small, activities should be designed thoughtfully to maximize potential benefits. Lastly, it is crucial to investigate and address other influences on students' thinking skills, such as teaching methods, classroom environment, learning media, and individual student support.

Then university students who view their learning activities more positively are more likely to also perceive their thinking skills positively, and this relationship is stronger compared to high school students. Enhancing learning activities can have a more substantial impact on their self-perceived thinking skills. Curriculum planners should focus on designing activities that are challenging, engaging, and thought-provoking to foster better perceptions of thinking skills. Incorporating active learning strategies, such as problem-based learning, collaborative projects, and inquiry-based activities, can be particularly effective in improving university students' perceptions of their thinking skills. Providing continuous and constructive feedback during learning activities can help reinforce the connection between engaging in these activities and developing thinking skills. Encouraging university students to take an active role in their learning through self-directed activities and research projects can further enhance their perceptions of their thinking skills.

The differing levels of correlation between high school and university students suggest that educational strategies should be tailored to the specific needs and contexts of each group. Previous study found that the students' perceptions of the learning environment in various institutional contexts differ significantly (Lizzio et al., 2002). This area will be explored in the second and third correlation test. Then comparison between the groups of students will also give more detail and information about how learning should apply for them.

Second, a correlation test between data regarding students' perception of their activity and thinking skills indicators in learning science. This test was conducted for all students and separately for student groups based on their education level (senior high school and university). The results are shown in **Table 9**.

The correlation test results show that overall, perceptions of activity correlate positively and significantly with all thinking skills indicators, except for the fourth indicator (likelihood and uncertainty analysis). All positive and significant correlations ($\rho \leq 0.01$) found are in the medium category (Cohen, 1988). Then, for different student

**Table 9.** Correlation between average activity and thinking skills indicators

| Activity | Parameter | Thinking skills indicators | | | | |
|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 | T5 |
| All students | Pearson correlation | 0.339** | 0.347** | 0.304** | 0.042 | 0.313** |
| | Sig. (2-tailed) | 0.000 | 0.000 | 0.001 | 0.641 | 0.000 |
| High school students | Pearson correlation | 0.263* | 0.258* | 0.143 | 0.053 | 0.132 |
| | Sig. (2-tailed) | 0.023 | 0.026 | 0.225 | 0.655 | 0.261 |
| University students | Pearson correlation | 0.361** | 0.379** | 0.437** | 0.131 | 0.479** |
| | Sig. (2-tailed) | 0.008 | 0.005 | 0.001 | 0.350 | 0.000 |

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

groups, significant correlations between average activity perceptions and thinking skills indicators were found to be better for university students. The findings are identical to the correlations for all students. University students' perceptions have a positive and significant correlation between average activity and all thinking skills indicators ($\rho \leq 0.01$), except for the fourth indicator (likelihood and uncertainty analysis). Next, for high school students, positive and significant correlations ($\rho \leq 0.05$) were only found with the first and second indicators, namely reasoning and hypothesis testing.

Third, the correlation test between data on students' perceptions of their thinking skills and activity indicators in learning science. This test was conducted for all students and separately for student groups based on their educational level (senior high school and university). The results are shown in **Table 10**. The results of the correlation test show that for all students, perceptions of thinking skills are positively and significantly correlated with all activity indicators, except for the second (writing activity) and third (mental activity) activity indicators. However, the level and coefficient of correlation vary. There are two levels of significance, namely 0.05 and 0.01, as shown in **Table 10**. The highest level of correlation is indicated by a correlation coefficient of 0.320 between perception on thinking skills and the sixth activity indicator (oral activity). This correlation is categorized at a medium level. It is followed by the correlation between perception on thinking skills and the fifth (visual activity) and first (motor activity) activities, both with correlation coefficients of $r = 0.286$ and $r = 0.252$. Both are categorized as low-level correlations (Cohen, 1988).

For different student groups, significant correlations between average thinking skills perception and activity indicators were found to be better for university students. However, only four positive and significant correlations were found, namely between average thinking skills perception and four activity indicators, which are A2 (writing activity), A4 (emotional activity), A5 (visual activity), and A6 (oral activity). Interestingly, overall, there was no positive and significant correlation with A2 (writing activity) for all students, but it was found to be positive and significant for university students.

Unfortunately, only one positive and significant correlation was found out of the eight correlations tested between average thinking skills and activity indicators for high school students. The positive and significant correlation was only found between average thinking skills and the first activity indicator (writing activity).

**Table 10.** Correlation between average thinking skills and activity indicators

| Thinking skills | Parameter | Activity indicators A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
|---|---|---|---|---|---|---|---|---|---|
| All students | Pearson correlation | 0.252** | 0.142 | 0.169 | 0.193* | 0.286** | 0.320** | 0.192* | 0.217* |
| | Sig. (2-tailed) | 0.004 | 0.112 | 0.057 | 0.030 | 0.001 | 0.000 | 0.031 | 0.014 |
| High school students | Pearson correlation | 0.309** | –0.049 | 0.199 | 0.004 | 0.090 | 0.203 | 0.217 | 0.173 |
| | Sig. (2-tailed) | 0.007 | 0.678 | 0.090 | 0.976 | 0.448 | 0.083 | 0.064 | 0.140 |
| University students | Pearson correlation | 0.182 | 0.362** | 0.152 | 0.363** | 0.484** | 0.398** | 0.155 | 0.241 |
| | Sig. (2-tailed) | 0.191 | 0.008 | 0.278 | 0.008 | 0.000 | 0.003 | 0.267 | 0.083 |

* Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

**Table 11.** Independent sample t-test for average activity and thinking skills

| | | Levene's test F | Sig. | t-test for equality of means t | df | Sig. (2-tailed) | Mean difference | Standard error difference | 95% confidence interval of the difference Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|
| Average activity | **EV assumed** | 1.05 | 0.31 | **–2.99** | **125.00** | **0.00** | **–0.23** | **0.08** | **–0.38** | **–0.08** |
| | EV not assumed | | | –2.92 | 102.25 | 0.00 | –0.23 | 0.08 | –0.39 | –0.07 |
| Average thinking skills | EV assumed | 5.55 | 0.02 | –0.81 | 125.00 | 0.42 | –0.06 | 0.08 | –0.21 | 0.09 |
| | **EV not assumed** | | | **–0.76** | **87.82** | **0.45** | **–0.06** | **0.08** | **–0.22** | **0.10** |

Note. EV: Equal variances

## Comparative Results and Discussion

The next data analysis focuses on comparative tests between the two student groups. The comparative test was conducted using an independent sample t-test three times to compare different data groups. The first comparative test was for each perception on activity and thinking skills in learning science between the two groups (high school students and university students). The results are shown in **Table 11**.

Before discussing the results of the comparative test using the independent sample t-test, the determination of the homogeneity of the data groups needs to be presented first based on Levene's test, as shown in **Table 11**. Variance can be considered equal when the Levene's test result is not significant ($\rho > 0.05$), as represented by the average activity. Conversely, variance is considered unequal when the Levene's test result is significant ($\rho \leq 0.05$), as represented by the average thinking skills. These results form the basis for determining which t-test score will be used (score in row 'eq assumed' or 'eq not assumed').

The comparison between the average perception of activity between high school students and university students shows $t = -2.99, df = 125$, and $\rho = 0.00$.These results provide a basis for concluding that there is a significant difference ($\rho \leq 0.05$) between students' perceptions of average activity in learning science. The mean difference is found to be –0.23 on a scale of 5. However, the difference is not significant for the average perception of thinking skills ($\rho > 0.05$). The mean difference is only –0.06 on a scale of 5.

These findings will be further explored by comparing perceptions of each activity and thinking skills indicator in learning science. The second comparative test was conducted to compare perceptions on each activity indicator between the two groups of students. The results are shown in **Table 12**.

With the same analytical procedure, starting with the results of Levene's test, it can be concluded that equal variance is assumed for most activity indicators, except for the sixth indicator (A6 oral activity) and the eighth (A8 drawing activity). The interpretation and discussion of comparisons are adjusted based on Levene's test results.

Based on the results of the independent sample t-test for all activity indicators, it is found that there are significant perception differences ($\rho \leq 0.05$) only in three activity indicators: A1 (motor activity), A4 (emotional activity), and A5 (visual activity). For A1 (motor activity), the test results show $t = -2.49, df = 125$, $\rho = 0.01$ and a mean difference of –0.24. For A4 (emotional activity), the test results show $t = -4.51, df = 125$, and $\rho = 0.00$ with a mean difference –0.54. Lastly, for A5 (visual activity), the test results show $t = -2.76, df = 125$, and $\rho = 0.01$ with a mean difference of –0.31. The negative values in the mean difference indicate that university students' perceptions are higher compared to high school students.

The significant differences in perceptions for motor, emotional, and visual activities highlight areas where high school and university teaching practices differ. University educators may be employing more effective strategies in these areas. High school educators can take insights from these findings to enhance their teaching practices by incorporating more motor, emotional, and visual activities. The findings also emphasize the importance of varied and engaging activities in promoting positive perceptions and potentially improving learning outcomes.

Additionally, five other indicators (listening, oral, writing, drawing, and mental activity) show varied mean differences but are not significant based on the results of the independent sample t-test. The lack of significant differences suggests that both high school and university students perceive these activities in a similar manner. This could imply that these activities are uniformly experienced or valued across educational levels. Educators at both levels might be using similar methods for these activities, leading to comparable student perceptions. There may be less need for intervention or change in these areas compared to motor, emotional, and visual activities.

Furthermore, only one indicator where high school students' perceptions are higher than university students', namely A3 (mental activity) with a mean difference of 0.05. This finding indicates that high school students perceive mental activities (e.g., problem-solving, critical thinking tasks) slightly more positively than university students.

**Table 12.** Independent sample t-test for activity indicators

| | | Levene's test | | t-test for equality of means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean difference | Standard error difference | 95% confidence interval of the difference: Lower | 95% confidence interval of the difference: Upper |
| A1 | **EV assumed** | 1.13 | 0.29 | **−2.49** | **125.00** | **0.01** | **−0.24** | **0.10** | **−0.44** | **−0.05** |
| | EV not assumed | | | −2.54 | 119.60 | 0.01 | −0.24 | 0.10 | −0.43 | −0.05 |
| A2 | **EV assumed** | 0.03 | 0.88 | **−1.57** | **125.00** | **0.12** | **−0.17** | **0.11** | **−0.39** | **0.05** |
| | EV not assumed | | | −1.62 | 122.29 | 0.11 | −0.17 | 0.11 | −0.39 | 0.04 |
| A3 | **EV assumed** | 0.27 | 0.60 | **0.39** | **125.00** | **0.70** | **0.05** | **0.12** | **−0.19** | **0.29** |
| | EV not assumed | | | 0.38 | 102.14 | 0.71 | 0.05 | 0.13 | −0.20 | 0.30 |
| A4 | **EV assumed** | 0.01 | 0.93 | **−4.51** | **125.00** | **0.00** | **−0.54** | **0.12** | **−0.77** | **−0.30** |
| | EV not assumed | | | −4.52 | 113.04 | 0.00 | −0.54 | 0.12 | −0.77 | −0.30 |
| A5 | **EV assumed** | 0.44 | 0.51 | **−2.76** | **125.00** | **0.01** | **−0.31** | **0.11** | **−0.54** | **−0.09** |
| | EV not assumed | | | −2.78 | 115.04 | 0.01 | −0.31 | 0.11 | −0.53 | −0.09 |
| A6 | EV assumed | 7.48 | 0.01 | −1.13 | 125.00 | 0.26 | −0.16 | 0.14 | −0.44 | 0.12 |
| | **EV not assumed** | | | **−1.08** | **90.76** | **0.28** | **−0.16** | **0.15** | **−0.45** | **0.13** |
| A7 | **EV assumed** | 0.40 | 0.53 | **−1.90** | **125.00** | **0.06** | **−0.26** | **0.14** | **−0.54** | **0.01** |
| | EV not assumed | | | −1.89 | 109.44 | 0.06 | −0.26 | 0.14 | −0.54 | 0.01 |
| A8 | EV assumed | 5.24 | 0.02 | −1.27 | 125.00 | 0.21 | −0.21 | 0.16 | −0.53 | 0.11 |
| | **EV not assumed** | | | **−1.22** | **95.31** | **0.22** | **−0.21** | **0.17** | **−0.54** | **0.13** |

Note. EV: Equal variances

**Table 13.** Independent sample t-test for thinking skills indicators

| | | Levene's test | | t-test for equality of means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean difference | Standard error difference | 95% confidence interval of the difference: Lower | 95% confidence interval of the difference: Upper |
| T1 | **EV assumed** | 1.30 | 0.26 | **−1.81** | **125.00** | **0.07** | **−0.18** | **0.10** | **−0.37** | **0.02** |
| | EV not assumed | | | −1.75 | 98.21 | 0.08 | −0.18 | 0.10 | −0.38 | 0.02 |
| T2 | EV assumed | 3.86 | 0.05 | −1.91 | 125.00 | 0.06 | −0.19 | 0.10 | −0.39 | 0.01 |
| | **EV not assumed** | | | **−1.84** | **95.82** | **0.07** | **−0.19** | **0.10** | **−0.40** | **0.02** |
| T3 | EV assumed | 4.85 | 0.03 | −1.05 | 125.00 | 0.30 | −0.11 | 0.11 | −0.32 | 0.10 |
| | **EV not assumed** | | | **−1.01** | **96.83** | **0.32** | **−0.11** | **0.11** | **−0.33** | **0.11** |
| T4 | EV assumed | 4.64 | 0.03 | 2.11 | 125.00 | 0.04 | 0.23 | 0.11 | 0.01 | 0.44 |
| | **EV not assumed** | | | **1.99** | **87.35** | **0.05** | **0.23** | **0.12** | **0.00** | **0.46** |
| T5 | EV assumed | 5.72 | 0.02 | −0.59 | 125.00 | 0.56 | −0.06 | 0.10 | −0.26 | 0.14 |
| | **EV not assumed** | | | **−0.56** | **93.92** | **0.58** | **−0.06** | **0.11** | **−0.27** | **0.15** |

Note. EV: Equal variances

The rest indicate that university students' perceptions are higher, including the three significant indicators discussed earlier.

The general trend that university students have higher perceptions across most activities (including the three significant indicators) suggests that learning activities at the university level might be more effectively designed or implemented to engage students. High school educators might consider adopting or adapting some of the strategies used at the university level, particularly for motor, emotional, and visual activities, to enhance student engagement and perception. The significant differences in the three key indicators (motor, emotional, and visual activities) underpin the overall differences in average perceptions of learning activities between high school and university students, as shown in **Table 11**.

These findings highlight the importance of activity design and implementation in shaping students' perceptions of learning activities. While high school and university students have similar perceptions of listening, oral, writing, and drawing activities, university students perceive motor, emotional, and visual activities more positively. The unique case of higher perception of mental activities among high school students suggests a need to explore how these activities are integrated at different educational levels. These insights can guide educators in enhancing activity design to improve student engagement and learning outcomes.

Next, the third comparative test was conducted for perceptions on each thinking skills indicator between the two groups of students. The results are shown in **Table 13**.

Using the same analytical procedure, starting with the results of Levene's test, it can be concluded that equal variance is assumed only for the first indicator, T1 (reasoning). Four other indicators were found to have unequal variance assumptions. Interpretation and discussion of the comparisons are adjusted based on these Levene's test results.

Based on the results of the independent sample t-test for all thinking skills indicators, it is found that significant differences in perceptions ($\rho \leq 0.05$) were only found for the fourth indicator, T4 (likelihood and uncertainty analysis). The test results show a t-value of $t = 2.11, df = 87.35$ , and $\rho = 0.05$ with a mean difference in perception of 0.23. Interestingly, this is the only indicator where high school students have higher average perceptions, and it is also significant. Other indicators show higher average perceptions for university students, but the differences in mean perceptions are found to be non-significant. These findings underpin the previous result that non-significant differences in average perceptions of thinking skills between high school and university students, as shown in **Table 11**.

The findings also highlight the progression in students' self-perceptions of their scientific thinking skills as they advance in their education. For high school students, the solid foundation in decision making, hypothesis testing, reasoning, and argument analysis is promising, indicating that they are on the right track. However, the significant increase in these perceptions at the university level emphasizes the importance of continued education and practice in developing these critical scientific skills. This trend underscores the impact of advanced education and increased exposure to scientific methodologies on students' confidence and competence in these areas.

These results align with the understanding that higher education plays a crucial role in enhancing students' scientific thinking skills. The noticeable improvement in perceptions from high school to university suggests that targeted educational strategies and increased practical experiences are effective in fostering these skills. Educators at the high school level can draw from these insights to better prepare students for higher education by focusing more on developing robust decision making, hypothesis testing, reasoning, and argument analysis.

The lack of significant differences suggests that high school and university students perceive their thinking skills similarly for these four other indicators beside T4. This could imply a consistent level of skill development across both educational levels for most thinking skills. As students transition to university, the complexity and depth of topics might increase, potentially making university students feel less confident in their skills compared to their high school counterparts. High school educators might be using more engaging or comprehensible methods to teach this particular skill, which could serve as a model for university educators to improve perceptions in this area.

The overall non-significant differences in other thinking skills indicators suggest that, generally, students at both educational levels have similar perceptions of their thinking skills. These findings support the conclusion that there are no broad, significant differences in average perceptions of thinking skills between high school and university students, as shown in **Table 11**. The significant result for T4 stands out as an exception, highlighting a specific area for further investigation. These insights can guide educators in focusing on specific areas for improvement and understanding how educational transitions impact student perceptions of their thinking skills.

## CONCLUSION

Based on the data and analysis conducted, several conclusions were drawn. First, students' perception of their activities in the active category (mean value of 3.52) and perception of their thinking skills in a comparable category, experienced (mean value of 3.51). University students had slightly better perceptions of their activities (mean value of 3.66) compared to senior high school students (mean value of 3.43), both falling within the active category. University students also had slightly better perceptions of their thinking skills (mean value of 3.55) compared to high school students (mean value of 3.49), both falling within the experienced category. Second, when students view their learning activities positively, they also tend to perceive their thinking skills more positively, although the relationship is not strong ($r = 0.357, \rho = 0.000$). This finding suggests that other factors may also play significant roles. Therefore, educators and lecturers should consider a comprehensive approach that includes other strategies to enhance students' perceptions of their activities and thinking skills in learning science.

Third, the general trend that university students have higher perceptions across most activities (including the three significant indicators). High school educators might consider adopting or adapting some of the strategies used at the university level, particularly for motor, emotional, and visual activities, to enhance student engagement and perception. Then there are no broad, significant differences in average perceptions of thinking skills between high school and university students. The significant result for T4 (likelihood and uncertainty analysis) stands out as an exception, highlighting a specific area for further investigation.

These findings highlight the importance of fostering an engaging and supportive learning environment to enhance students' perceptions of their activities and thinking skills in science education. Additionally, the results underscore the need for further research to explore the factors that influence the relationship between learning activities and thinking skills, particularly in different educational contexts and age groups. Comparative findings emphasize the significance of activity design and implementation in shaping students' perceptions of learning activities. While high school and university students have similar perceptions of listening, oral, writing, and drawing activities, university students perceive motor, emotional, and visual activities more positively. The unique case of higher perception of mental activities among high school students suggests a need to explore how these activities are integrated at different educational levels. These insights can guide educators in enhancing activity design to improve student engagement and learning outcomes. Furthermore, understanding students' perceptions of thinking skills can help educators focus on specific areas for improvement and comprehend how educational transitions impact students' views on their thinking abilities.

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## REFERENCES

Biggs, J. (2012). What the student does: Teaching for enhanced learning. *Higher Education Research and Development, 31*(1), 39–55. https://doi.org/10.1080/07294360.2012.642839

Biggs, J., Medland, E., & Vardi, I. (2013). Aligning teaching and assessing to course objectives. *Assessment & Evaluation in Higher Education, 38*(5), 1–16.

Bonwell, C. C., & Eison, J. A. (1991). Active learning: Creating excitement in the classroom. *Education Resources Information Center.* https://eric.ed.gov/?id=ED336049

Cahyani, V. D., & Pranata, O. D. (2023). Studi aktivitas belajar sains siswa di SMA Negeri 7 Kerinci [Study of students' science learning activities at SMA Negeri 7 Kerinci]. *Lensa: Jurnal Pendidikan IPA, 13*(2), 137–148. https://doi.org/10.24929/lensa.v13i2

Chi, M. T. H. (2009). Active-constructive-interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science 1, 1,* 73–105. https://doi.org/10.1111/j.1756-8765.2008.01005.x

Chi, M. T. H., & Wylie, R. (2014). The ICAP framework: Linking cognitive engagement to active learning outcomes. *Educational Psychologist, 49*(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Cohen, J. (1988). *Statistical power analysis for the behavioral science* (2nd ed.). Lawrence Erlbaum Associates.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge. https://doi.org/10.4324/9781315456539

Fink, L. D. (2013). *Creating significant learning experiences: An integrated approach to designing college courses.* Jossey-Bass.

Halpern, D. F. (2014). *Thought and knowledge. An introduction to critical thinking.* Psychology Press.

Hodson, D. (2014). Learning science, learning about science, doing science: Different goals demand different learning methods. *International Journal of Science Education, 36*(15), 2534–2553. https://doi.org/10.1080/09500693.2014.899722

Leech, N. L., Barret, K. C., & Morgan, G. A. (2005). *SPSS for intermediate statistics. Use and interpretation.* Lawrence Erlbaum Associates, Inc. All.

Lizzio, A., Wilson, K., & Simons, R. (2002). University students' perceptions of the learning environment and academic outcomes: Implications for theory and practice. *Studies in Higher Education, 27*(1), 27–52. https://doi.org/10.1080/03075070120099359

Mayer, R. E. (2011). *Applying the science of learning.* Pearson. https://doi.org/10.1016/B978-0-12-387691-1.00003-X

Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barret, K. C. (2004). *SPSS for introductory statistics. Use and interpretation.* Lawrence Erlbaum Associates, Inc. All. https://doi.org/10.4324/9781410610539

Pranata, O. D. (2021). Pelatihan kompetisi sains nasional (KSN) cabang matematika tingkat SMP/MTs melalui pembelajaran berbasis puzzle [National science competition (KSN) training for junior high school/Islamic junior high school mathematics through puzzle-based learning]. *Jurnal Pengabdian Masyarakat MIPA dan Pendidikan MIPA, 5*(2), 118–124.

Pranata, O. D. (2023a). Enhancing conceptual understanding and concept acquisition of gravitational force through guided inquiry utilizing PhET simulation. *Saintek: Jurnal Sains dan Teknologi, 15*(1), 44–52. https://doi.org/10.31958/js.v15i1.9191

Pranata, O. D. (2023b). Penerapan game-based learning sebagai alternatif solusi mengajar di kelas heterogen [Penerapan game-based learning sebagai alternatif solusi mengajar di kelas heterogen]. *Jurnal Pengabdian Al-Ikhlas, 8*(3), 337–350. https://doi.org/10.31602/jpaiuniska.v8i3.7597

Pranata, O. D. (2023c). Penerapan puzzle-based learning untuk mengajar matematika dan sains di pasantren dengan kelas heterogen [Penerapan puzzle-based learning untuk mengajar matematika dan sains di pasantren dengan kelas heterogen]. *Jurnal Penelitian dan Pengabdian Kepada Masyarakat UNSIQ, 10*(2), 109–115. https://doi.org/10.32699/ppkm.v10i2.4269

Pranata, O. D., & Seprianto, S. (2023). Pemahaman konsep siswa melalui skema blended learning menggunakan lembar kerja berbasis simulasi [Students' conceptual understanding through a blended learning scheme using simulation-based worksheets]. *Karst: Jurnal Pendidikan Fisika Dan Terapannya, 6*(1), 8–17. https://doi.org/10.46918/karst.v6i1.1724

Pranata, O. D., Sundari, P. D., & Sulaiman, D. (2023). Exploring project-based learning: Physics e-posters in pre-service science education. *Jurnal Fisika dan Pendidikan Fisika, 8*(2), 116–124. https://doi.org/10.20414/konstan.v8i02.387

Pranata, O. D., Yuliati, L., & Wartono. (2017). Concept acquisition of rotational dynamics by interactive demonstration and free-body diagram. *Journal of Education and Learning, 11*(3), 291–298. https://doi.org/10.11591/edulearn.v11i3.6410

Putri, A. L., Pranata, O. D., & Sastria, E. (2024). Students perception of science and technology in science learning: A gender comparative study. *Jurnal Pijar Mipa, 19*(1), 44–50. https://doi.org/10.29303/jpm.v19i1.6153

Putri, D. H., & Pranata, O. D. (2023). Eksplorasi kejenuhan siswa dalam pembelajaran sains setelah pandemi [Exploring student boredom in science learning after the pandemic]. *Jurnal Inovasi Pendidikan Sains, 4*(2), 62–70. https://doi.org/10.37729/jips.v4i2.3367

Putri, D. H., Pranata, O. D., & M, N. (2024). Analisis emosi siswa dalam lingkungan akademik: Studi deskriptif dan komparatif [Analysis of students' emotions in academic environments: A descriptive and comparative study]. *BIOSFER: Jurnal Biologi Dan Pendidikan Biologi, 9*(1), 9–20. https://doi.org/10.23969/biosfer.v9i1

Sardiman, A. M. (2008). *Interaksi dan motivasi belajar mengajar* [Interaction and motivation for teaching and learning]. Raja Grafindo Persada.

Swarat, S., Ortony, A., & Revelle, W. (2012). Activity matters: Understanding student interest in school science. *Journal of Research in Science Teaching, 49*(4), 515–537. https://doi.org/10.1002/tea.21010

Tiruneh, D. T., Weldeslassie, A. G., Kassa, A., Tefera, Z., De Cock, M., & Elen, J. (2015). Systematic design of a learning environment for domain-specific and domain-general critical thinking skills. *Educational Technology Research and Development, 64*(3), 481–505. https://doi.org/10.1007/s11423-015-9417-2

Utami, A. F., Pranata, O. D., & Angela, L. (2024). Analisis tingkat kejenuhan siswa sebelum, selama, dan setelah pembelajaran sains [Analysis of student saturation levels before, during, and after science learning]. *PENDIPA Journal of Science Education, 8*(1), 1–9. https://doi.org/10.33369/pendipa.8.1.1-9

Wegerif, R. (2017). Literature review in thinking skills, technology and learning report 2: Futurelab series. *NESTA Futurelab Series*. https://telearn.archives-ouvertes.fr/hal-00190219