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Considering Students' Propensity of Divergent or Convergent in Executing Science Project

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Abstract: This study examines student performance in project-based learning by assessing their tendencies toward divergent or convergent thinking. A questionnaire was developed to help teachers identify and maximize the thinking potential of individual students during the learning process. The research involved 149 junior high school students from West Lombok for validity and reliability testing and 84 respondents for the categorization trial. Instruments were validated by experts using descriptive methods and percentage scores. Validity was determined through product moment correlation coefficients, while reliability was assessed using alpha reliability coefficients. Categorization utilized non-level (nominal) categorization methods. The study employed a pre-experimental approach with a one-shot case study design, involving 33 eighth-grade students in a local natural pesticide project. Student performance was evaluated through practical skill assessments and comprehensive portfolios. Data analysis used percentage and comparative statistical methods. Results showed the questionnaire contained 40 items—20 each for divergent and convergent thinking—with an expert validation score of 89.50, rated excellent. All items were valid, with correlation values exceeding the critical threshold (r_{table} = 0.16). Reliability scores were high for divergent and convergent groups (0.64 and 0.72) and satisfactory for all items (0.55). The questionnaire effectively categorized up to 20% of subjects into divergent and convergent groups. The study revealed significant performance differences between the two groups and recommends mixing students with divergent and convergent propensity in group projects to enhance outcomes.

Keywords: Categorization; Convergent; Divergent; Science Project; Thinking Propensity.

Introduction

In the context of implementing the Merdeka curriculum in Indonesia, diagnostic assessments are recognized as a preliminary step before initiating learning activities (Badan Standar Kurikulum dan Asesmen Pendidikan, 2022; Kepmenpendikbudristek, 2022). The primary objective of diagnostic assessment is to enable teachers to gain insights into students' potential. However, based on the researchers' observations, it is evident that in most junior high schools (SMP) in the West Lombok district, West Nusa Tenggara Province, Indonesia, teachers still rely solely on previous subject scores as the reference for diagnostic assessments. Acquiring knowledge of students' initial potential can assist in optimizing their learning performance, both within the curriculum and in successfully completing collaborative learning projects with students who possess diverse potentials (Badan Standar Kurikulum dan Asesmen Pendidikan, 2022; Sufyadi et al., 2021).

Project-based learning is a learning model that uses problems as the first step in collecting and integrating new knowledge based on experience in real activities. Through Project Based Learning (PjBL), the inquiry process begins by raising a guiding question and guiding students in a collaborative project that integrates various subjects (materials) in the curriculum.

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PjBL is an in-depth investigation of a real-world topic, it will be valuable for students' attention and effort (Condliffe et al., 2017; Krajcik & Blumenfeld, 2005).

The problem-solving process and performance are influenced by individual psychological factors, such as mental attributes or thinking tendencies, which include divergent and convergent thinking patterns (Danili & Reid, 2006). These mental characteristics have an impact on students' performance in science education. Science education, aiming to foster conceptual and principled understanding while stimulating intellectual development, necessitates the inclusion of tasks that require both divergent and convergent thinking (Pavellch, 1982).

Divergent thinking entails a speculative and expansive approach, emphasizing brainstorming and exploring possibilities. It represents an individual's ability to generate multiple solutions in response to a given stimulus or problem (Guilford, 1959; Kaufman & Sternberg, 2010; Reiter-Palmon et al., 2019). Divergent thinkers initiate their thought processes with a few facts and expand them into a range of reasoned responses (Pavelich, 1982; Runco, 1993). Divergent thinking can be characterized as an individual's manner of thinking, which involves generating various alternative answers to a problem. It often involves considering different directions, alternatives, and sources of information (Coren, 1995).

Convergent thinking is characterized by individuals approaching problems with the belief that there is only one correct answer (Coren, 1995). Convergent thinkers not only possess factual knowledge but also exhibit an organized approach, drawing upon information from various sources to support their thinking and employing formulas to arrive at solutions (Pavelich, 1982). In the context of problem-solving, convergent thinking occurs when students select the most suitable solution step (Levine & Moreland, 2004), engage in symbolic thinking (Wießner et al., 2022), identify problems that require exploration, compare and sequence potential solutions, and draw conclusions (Puccio et al., 2004).

Essentially, individuals who exhibit tendencies towards divergent or convergent thinking each possess their own advantages (de Vink et al., 2022). The superiority of divergent students over convergent students is not universally applicable, as it depends on the nature of the problems presented, which can vary in their degree of divergence or convergence (Danili & Reid, 2006; Runco et al., 2016). Differences in performance between divergent and convergent students can be observed in terms of their understanding of concepts and ability to visualize problem-solving steps (Alamolhodaei, 2001). Thinking tendencies (cognitive) can impact students' personalities and influence their attention, interactions, and responses to the learning environment and the problems they encounter (Danili & Reid, 2006). In order to effectively accommodate and leverage the strengths of divergent thinkers, it is crucial to identify students' thinking tendencies at an early stage, thereby enabling teachers to optimize their potential. The use of supplementary instruments becomes imperative in discerning whether students lean towards divergent or convergent thinking. Researchers also evaluated the performance of students with different thinking tendencies in completing learning projects

Method

Construction Assessment of Questionnaire

This research endeavors to develop questionnaires capable of categorizing respondents based on their thinking tendencies, specifically divergent or convergent thinking. The questionnaires, which were prepared by the researchers, underwent examination by educational and learning psychologists affiliated with the State University of Malang, possessing a minimum of 15 years of experience in psychology and science education research. The primary objective of this stage was to assess the alignment of the questionnaire items with the theoretical foundation (content validity), as well as the thinking aspects and behavioral indicators (construct validity), while ensuring adherence to item writing guidelines (Arikunto, 2016; Azwar, 2012). The expert evaluations' scores were processed using Equation 1.

$$score = \frac{score\ of\ items}{maximum\ score} \quad (1)$$

The obtained score is subject to interpretation and can be further assessed in the field to determine the instrument's suitability. If the instrument falls below the minimum threshold for high feasibility, it must be refined and enhanced until it meets the prescribed criteria (Azwar, 2012). Instrument feasibility is categorized based on the score range as follows: 0 – 0.19 (poor), 0.20 – 0.39 (fair), 0.40 – 0.59 (moderate), 0.60 – 0.79 (high), and 0.80 – 1 (excellent) (Arikunto, 2016).

Validity and Reliability Assessment of Questionnaire

This stage was conducted utilizing the survey method through purposive random sampling. During the validity and reliability testing phase, a total of 300 questionnaires assessing divergent and convergent thinking tendencies, which had been compiled beforehand, were evenly distributed among students in 15 junior high schools (SMP) located in the West Lombok district, West Nusa Tenggara province, Indonesia. Out of these, 149 questionnaires were duly completed by the respondents.

Validity serves as an indicator of the extent to which an instrument is valid, reflecting the degree of correlation between the scores obtained by the subjects in each item and their overall scores. The validation of questionnaires and tests can be accomplished through item validation or the question item validation method (Arikunto, 2016; Sugiyono, 2010). In this study, validity testing was applied to all items using the Pearson product moment correlation equation, expressed as follows (Formula 2).

$$r_{xy} = \frac{N\sum X_{Div}Y_{Div} - (\sum X_{Div})(\sum Y_{Div})}{\sqrt{\{N\sum X_{Div}^2 - (\sum X_{Div})^2\}\{N\sum Y_{Div}^2 - (\sum Y_{Div})^2\}}} \quad (2)$$

The correlation coefficient (r) represents the degree of correlation between the score of an item assessing divergent thinking (X_{Div}) and the total score of divergent thinking obtained by the subject (Y_{Div}), where N denotes the number of subjects. The obtained correlation coefficient value is compared with the critical value from the product moment table at a significance level of 5%. If the correlation coefficient (r) for the tested items exceeds the critical value (r_{table}), the items are deemed valid. Subsequently, the instrument containing the valid items undergoes reliability testing.

Reliability testing is conducted to assess the consistency or reliability of the measurement results, reflecting the accuracy of measurements obtained using the tested instruments. Various techniques exist for determining the reliability of questionnaires, one of which is the split-half technique. The reliability coefficient is calculated based on the scores obtained from a group of subjects. If, following the determination of validity, it is established that the questionnaire items can be divided into two or three parts, the alpha reliability coefficient can be utilized. The items should be divided into equal halves, both in terms of the number of items and the indicators they measure. The alpha reliability coefficient is calculated using the following equation (Arikunto, 2016; Azwar, 2012; Sugiyono, 2010).

$$\alpha = \frac{n}{(n-1)}\left[1 - \frac{s_1^2 + s_2^2 + s_n^2}{s_x^2}\right] \quad (3)$$

The α (Alpha) reliability coefficient represents the measure of reliability, and n refers to the number of divisions in the instrument. The s_1^2; s_2^2; & s_n^2 indicate the variance scores of the first, second, and n^{th} divisions, respectively, while sx2 represents the variance score of the questionnaire items. If the number of valid instrument items does not permit division into two or three parts, alternative reliability testing can be conducted using the analysis of variance (ANOVA) technique. One such ANOVA technique that can be employed is the Hoyt ANOVA, which is calculated using the following equation (Azwar, 2012).

$$r_{xx'} = 1 - \frac{MK_{ixs}}{MK_s} \quad (4)$$

While

$$MK_{ixs} = \frac{\sum i - \frac{(\sum X^2)}{k} - \frac{(\sum Y^2)}{n} + \frac{(\sum i)^2}{nk}}{(n-1)(k-1)},$$

$$MK_s = \frac{\frac{(\sum X^2)}{k} - \frac{(\sum i)^2}{nk}}{(n-1)}$$

The MKixs represents the mean square of the interaction between item x subject, while MKs signifies the mean squared between subjects. I denotes the score of a subject on a particular item, X refers to the sum of scores of a subject across all items, Y represents the sum of scores of a subject on a single item, k indicates the number of items, and n denotes the number of subjects. The obtained reliability coefficient is categorized based on the following score ranges: 0 – 0.19 (poor), 0.20 – 0.39 (low), 0.40 – 0.59 (fair), 0.60 – 0.79 (high), and 0.80 – 1 (excellent).

Subject Categorization Trial

In the subject categorization trial, a total of 100 questionnaires were distributed, which had previously undergone validity and reliability testing. Out of these, 84 questionnaires were properly completed by the respondents of 8^{th} grade junior high school student. The divergent/convergent thinking character questionnaires were employed to classify the subjects into divergent thinking character groups and convergent thinking character groups. The scores obtained from the subjects were processed to facilitate the grouping of research subjects based on their thinking character. The categorization of subjects into thinking character categories was performed using the nominal method rather than levels, employing the following steps (Azwar, 2012). Calculates individual scores on each thinking tendency.

Divergent : $X_{Div} = \frac{(\sum x_{Div})}{i_{Div}}$ (5)

Convergent: $X_{Con} = \frac{(\sum x_{Con})}{i_{Con}}$ (6)

Here, X_{Div} and X_{Con} denote the divergent and convergent scores, respectively, while x_{Div} and x_{Con} represent the scores of each divergent and convergent item, and i_{Div} and i_{Con} indicate the number of divergent and convergent items, respectively. To convert an individual score into a z score, the following equation was utilized.

Divergent: $z_{Div} = \frac{(X_{Div} - M_{Div})}{s_{Div}}$ (7)

Convergent: $z_{Con} = \frac{(X_{Con} - M_{Con})}{s_{Con}}$ (8)

In this equation, z_{Div} & z_{Con} represent the z scores for divergent and convergent thinking, respectively, while M_{Div} & M_{Con} indicate the mean scores for divergent and convergent thinking, and s_{Div} & s_{Con} denote the standard deviations of the z scores for divergent and convergent thinking, respectively. The categorization of thinking characters is based on the following criteria: $z_{Div} \geq 0{,}50$ dan $z_{Con} < 0$ (divergent); dan $z_{Con} \geq 0{,}50$ dan $z_{Div} < 0$ (convergent).

Pre-experimental Design

The pre-experimental design is used because of the view that there are still other independent variables that can affect the dependent variable. Thus, experimental results that are dependent variables are not solely influenced by independent variables due to the absence of a control class. In this study, the *One-Shot Case Study* design was used, namely there was a group that was given treatment and then observed the results. The design of *the One-Shot Case Study* can be seen in Table 1.

Table 1. Pre-Experimental Design Scheme *One-Shot Case Study*

Group	Treatment	Posttest
Divergent	X	P
Convregent	X	P

X = Project Based Learning, P = Project completion performance

The pre-experimental design was used to determine the difference in performance between students with divergent and convergent thinking propensity who were taught with Project Learning strategies in science learning.

Assessing Divergent and Convergent Student Performance on Execute Project

The research activities transpired in 8th grade students of junior high school of SMPN 4 Gunungsari (58 students) and SMP Islam Al-Azhar NW Kayangan (26 students) during the months of January to March in the year 2024. The categorization test resulted in 16 students convincingly with divergent thinking propensity and 17 students with convergent thinking propensity. So the study encompassed a cohort of 33 of that categorized as divergent or convergent thinker actively participating in the science project learning, even though PjBL is applied to all class participants.

The pedagogical endeavors undertaken were structured around Local Natural Pesticide project. These encompassed the phases Observation (O1), Record Data (O2), Understand/Following Instructions (O3), Measure (O4), Apply Procedure (O5), Predict (O6), Selection Procedure (O7), Designing Investigation (O8), Implement Investigation (O9), Report Investigation Results (O10), Project Completion Performance (O11). The specific components evaluated are comprehensively detailed in Table 2, with each indicator warranting a multiple scoring system of 1 (poor), 2 (fair), 3 (good), and 4 (excellent).

Table 2. Student's performance assessment indicators in executing project

Indicator	Activities assessed	
	Observation during lab-work activities	Portfolio
Students gather information from a variety of sources.		O2
Students make a summary		O10, O11
Students set investigative / research variables		O6, O8
Students raise the background of the importance of conducting an investigation / research		O6, O8
Students formulate investigation/research objectives	O6, O8	O6, O8
Students make hypotheses.	O6, O8	O6, O8
Students select appropriate variables, collect relevant data, and select a form of presentation of results appropriate for a chosen investigative procedure	O6, O7	O6, O7
Students document pictures of observation objects.	O1	O1
Students present observations in a chart, graph, or histogram.		O10, O11
Students compile and complete an investigative procedure.	O5, O9	O5, O9
Students prepare units/measuring devices to take measurements.	O1, O3, O4, O5, O9	O1, O3, O4, O5, O9
Students take measurements according to the measurement scale	O1, O3, O4, O5, O9	O1, O3, O4, O5, O9
Students use the appropriate measuring instruments correctly.	O1, O3, O4, O5, O9	O1, O3, O4, O5, O9
Students make observations and collect data with measuring instruments	O1, O3, O4, O5, O9	O1, O3, O4, O5, O9
Students choose laboratory equipment that is in accordance with the task at hand.	O1, O3, O4, O5, O9	
Students adopt laboratory procedures by minimizing risk.	O3, O5, O7, O8, O9	O3, O5, O7, O8, O9

Indicator	Activities assessed	
	Observation during lab-work activities	Portfolio
Students move materials/materials/equipment using the right way/container	O3, O5, O7, O8, O9	
Students separate substances based on their form.	O3, O5, O7, O8, O9	
Students do sample preparation.	O3, O5, O7, O8, O9	O3, O5, O7, O8, O9
Students make/mix materials according to certain standards/concentrations.	O3, O5, O7, O8, O9	O3, O5, O7, O8, O9
Students maintain work safety using glassware and hazardous chemicals	O3, O5, O7, O8, O9	O3, O5, O7, O8, O9
Students make observations and collect data using the five senses	O1, O2, O4	O1, O2, O4
Students convert units from a legible measure into another quantity.		O2, O3, O4, O5
Students recognize objects based on their characteristics.	O1, O2	O1, O2
Students identify objects to match with specific references/reading sources.	O1, O3	O1, O3, O10
Students identify similarities/differences between objects	O1, O3, O6	O1, O3, O10
Students match an object with a variety of visible characteristics.	O1, O3, O6	O1, O3, O10
Students make reasonable generalizations/conclusions based on observations.		O1, O3, O6, O10, O11
Students use observations to confirm or prove errors/refute existing hypotheses.		O1, O2, O3, O4, O6, O10, O11
Students distinguish between observations and references/literature sources.		O1, O2, O6, O10, O11
Students generating idea and conduct investigations related to everyday life.		O1, O2, O6, O10, O11
Students formulate the benefits of investigation for the environment and social and promote innovation		O1, O2, O6, O10, O11
Students present observations in group discussions		O1, O2, O6, O10, O11
Students demonstrate the excellence of their product/investigation results and deliver idea to conduct new product		O1, O2, O6, O10, O11

Student performance is analyzed using percentage, average, and N-gain techniques. The score are interpreted consecutively by category as presented in Table 3.

Table 3. Student performance category

Score	Category
80.00-100	Excellence
60-79.99	Good
40-59.99	Poor
20-39.99	Fail

Statistical Analysis of Inference

To be able to test the data well, it is necessary to determine in advance whether the data should be tested with parametric tests or nonparametric tests. Parametric and nonparametric test requirements are presented in Table 4.

Table 4. Parametric and Nonparametric Test Requirements

Variance	Parametric	Nonparametric
Distribution	Normal	Abnormal
Measurement scale	Interval or rasio	Nominal and ordinal
Number of samples	N ≥ 30	N < 30

Comparative test

If the requirement for the number of data is not met each group is smaller than 30, then the comparative hypothesis test is carried out with the Mann-Whitney nonparametric statistical test technique. The statistical test was performed with the help of *SPSS 15 for Windows*. Guidelines in decision making are as follows.

- If *Sig.* > 0.05 then H0 is accepted which means there is no difference between the two groups.
- If *Sig.*< 0.05 then H0 is rejected which means that there is a difference between the two groups.

Free data is data that comes from two different groups of subjects. For example, performance data on completing projects between students with divergent thinking propensity and students with convergent thinking talents.

Result and Discussion

Questionnaire Construction

The indicators, descriptors, and items for the divergent/convergent thinking character questionnaires were developed based on the references (Danili & Reid, 2006; Guilford, 1959; Pavelich, 1982) as outlined in Table 5 and Table 6. The measurement scale is the Likert scale. To establish construct validity, the questionnaires underwent expert validation, which ensures that the items within the instrument accurately capture the desired aspect of thinking or behavioral indicators (Arikunto, 2016). These indicators serve as a basis for organizing the statement items in the questionnaire.

Table 5. Fundamental indicators and descriptors in constructing the questionnaires

Propensity of thinking	Indicator	Descriptor	Number of Item
Divergent	discover something new, explore and expand ideas (Danili & Reid, 2006; Guilford, 1959; Pavellch, 1982).	Generative, developing a major, accepting all possibilities.	1, 12, 22, 30, 31, 33, 35, 39
		Provocative, making leaps, not having to be precise at every step, Non-knowing negative rules.	2, 4, 7, 9, 14, 15, 17, 21, 25, 27, 28, 38
Convergent	Focus on a correct answer in solving problems and demand the right reasons (Danili & Reid, 2006; Guilford, 1959; Pavellch, 1982).	Selective, closing certain paths, ruling out irrelevant ones	8, 10, 16, 20, 24, 26, 32, 34, 36, 40
		Analytical, purposeful, sequential moves, must be precise at each step	3, 5, 6, 11, 13, 18, 19, 23, 29, 37

Table 6. Items of the questionnaire (D: Divergent; C: Convergent)

Item	Propensity of thinking
I sometimes find it hard to stay focused on one thing	D
I don't enjoy long projects that prevent me from doing other activities	D
I like to concentrate on a specific topic or task	C
I consider myself a forward thinker and prefer looking at the big picture	D
I enjoy working on long-term projects without getting distracted	C
I believe that even small tasks can bring benefits	C
I often feel the urge to try new hobbies	D
I prioritize sticking with one activity until I achieve something	C
I'm not afraid to share unpopular opinions	D
I avoid discussing things that are unclear	C
I'm organized and like to plan things out	C
I believe that experience is the best teacher	D
I prefer to make sure I do things correctly before starting	C
I find comfort in doodling or daydreaming	D
I'm always eager to learn new things	D
If something seems impossible, I choose to let it go	C
I have so many thoughts that it sometimes keeps me awake at night	D
I like to do tasks in a step-by-step manner	C
I pay attention to instructions and follow them carefully	C
I focus on what's relevant and ignore unnecessary details	C
Sometimes my mind wanders during lectures	D
I rely more on intuition than pure intellect	D
I enjoy critically analyzing subjects until I find the right answer	C
Rules don't greatly affect my decision-making	C
Being different from others gives me satisfaction	D
Sometimes I question if it's better to follow the norm rather than stand out	C
I get annoyed by trivial rules	D
I often do things in my own way, not necessarily in a specific order	D
I tend to follow instructions from others, especially teachers	C
I like to explore things without relying too much on guidebooks	D
I enjoy expressing my ideas and thoughts	D
I prefer to do things that are proven to be correct rather than coming up with new ideas that I haven't tried	C
I like taking different routes to reach my destination	D
I prefer sticking to familiar paths	C
I enjoy solving math problems in different ways	D
When faced with math or science challenges, I focus on one solution that makes sense to me	C
I believe in following instructions to get the right outcome	C
I'm open to the idea that there may be different ways to achieve the desired result	D
The term "zebra cross" evokes various images in my mind	D
To me, a "zebra cross" refers specifically to a pedestrian crosswalk on a highway	C

Construct Validity

The validity of the questionnaire construction was determined through expert evaluation conducted by professionals in the field of educational psychology. The evaluation encompassed various aspects, including the alignment of questionnaire items with the intended indicators, the clarity of item formulation, the use of appropriate and effective language, the suitability of language variety, and the prevention of ambiguity. The outcomes of the expert assessment pertaining to the developed divergent/convergent thinking character questionnaire instrument are presented in Table 7.

Table 7. Assess expert validators

	Score	
	Validator 1 (Dr. Imanuel Hitipeuw, M.A)	Validator 2 (Dr. Triyono M.Pd)
Score of items	866	924
Maximum score	1000	1000
Score	0,76	0,92
average	0,92	0,86
		Overall average : 0,89
Eligibility criteria		excellent

The first and second validators assigned feasibility ratings of 86.60 and 92.40, respectively, resulting in an average rating of 89.50 for the instrument. Based on these findings, it can be concluded that the divergent/convergent thinking character questionnaire instrument, in terms of its construction (construct validity) and language usage, demonstrates high merit and can be considered an excellent research tool. However, minor adjustments in the language domain for certain items are recommended prior to testing the instrument for validity and reliability.

Validity and Reliability of Questionnaire

The purpose of the validity test is to establish confidence in the ability of each statement item included in the instrument to yield consistent and dependable results (Sugiyono, 2010).

Table 8. Overview of the items validity compare the divergent and convergent categorization questionnaire

Stat.	Divergent item	Convergent item	rtable (149, 0.05)	Validity
N	149	149		
max	0.491	0.532		
min	0.176	0.179	0.16	Valid
Number of items	20	20		

The validity and reliability test data were gathered from a sample of 149 participants. The validity test results of the divergent/convergent thinking character questionnaire, as presented in Table 8, demonstrate the validity of all the carefully constructed items. Conversely, the objective of the reliability tests is to demonstrate that instruments comprised of valid items yield consistent and stable results, irrespective of any inconsequential variations that may occur. The findings of the reliability test are outlined in Table 9.

Table 9. Reliability of the questionnaire

Variable	N	Alpha (α) correlation	Pearson correlation	$r_{table(0,05)}$	Conclusion
Divergent item	149	0.64	0.47	0.160	highly reliable
Convergent item	149	0.72	0.57	0.160	highly reliable
Overall item	298	0.55	0.39	0.114	fairly reliable

The reliability assessment of this instrument was conducted using the halving technique, involving the calculation of the alpha reliability coefficient (α) and the Pearson Product Moment correlation. The test outcomes reveal that this questionnaire generates measurements with a high degree of reliability, as evidenced by the strong alpha correlation and $r_{calculated}$ exceeding r_{table}. Based on these favorable results, the questionnaires can be confidently employed for a larger population.

Subject Categorization

The categorization of subjects is predicated upon the scores derived from the completion of the divergent/convergent thinking character questionnaires by 84 junior high school students (58 of SMPN 4 Gunungsari and 26 of SMP Islam Al-Azhar NW Kayangan). The outcomes of the subject categorization are presented in Table 10.

Table 10. Subject categorization by the divergent and convergent categorization questionnaire

Thinking tend		Z Score		N	%
		Zdiv	Zcon		
Divergent	max.	1.919	-0.094	16	19.1
	min.	0.576	-1.981		
	average	0.79975	-0.60531		
Convergent	max.	-0.021	1.95	17	20.2
	min.	-1.812	0.535		
	average	-0.63541	0.895412		
Uncategorized				51	60.7

By employing the nominal subject categorization formula and stipulating a Z value criterion of > 0.5 for each category, it was found that 16 students fell into the divergent category, 17 students were categorized as convergent, while the remaining 51 individuals could not be assigned to a specific category. Hence, the questionnaire demonstrates a robust capability to effectively categorize subjects, accounting for up to 20% of the total population for each divergent and convergent thinking group. For greater flexibility, the questionnaire user may adjust the precision level (by employing a smaller Z value) to achieve a larger percentage or cater to specific requirements. Thus, within the framework of independent curriculum implementation, collaborative student groups can be formed, comprising individuals with divergent, convergent, or uncategorized thinking tendencies, thereby enabling students to support one another by leveraging their diverse thinking potentials. Furthermore, there is no discernible influence of gender on this propensity for divergent or convergent thinking (Runco, 1991).

Once the initial aptitude of students has been ascertained, teachers can facilitate their learning accordingly. Students who exhibit a propensity for divergent thinking can be engaged in open-ended learning tasks to foster their creativity (Kwon et al., 2006). Divergent thinkers contribute ideas as part of the creative process, which encompasses problem discovery and idea evaluation (Guilford, 1959; Reiter-Palmon et al., 2019; Runco, 1993). Consequently, training in creative processes, such as generating ideas, is essential for divergent thinkers and can be achieved through supportive instructional approaches (Runco, 1991). Given that idea generation significantly impacts creative achievement (Reiter-Palmon et al., 2019; Runco & Okuda, 1988) it becomes imperative to emphasize the importance of creativity in learning contexts.

During the process of problem-solving, divergent thinking manifests when students generate ideas and engage in problem-solving activities that necessitate multiple solutions (de Vink et al., 2022; Levine & Moreland, 2004). They analyze the requisite information sources for problem resolution, explore and refine ideas (Puccio et al., 2004), and explore alternatives and diverse approaches to finding solutions. Divergent thinkers excel at filtering out distractions and employing varied problem-solving strategies (Horne, 1988; Runco, 1993). As such, divergent thinking is often considered a pivotal component of creativity (Mölle et al., 1999). Educational environments must accommodate the strengths of divergent thinkers, as research has shown that they stimulate the generation of alternative concepts during learning and facilitate the design of novel products (Goldschmidt, 2016; Runco, 1993; Runco et al., 2016). However, divergent thinkers may struggle with evaluating the outcomes of their work (Grohman et al., 2006). Supportive learning contexts, including positive moods, can enhance students' divergent thinking abilities (Chamorro-Premuzic & Reichenbacher, 2008; Yamada & Nagai, 2015).

In contrast, convergent thinkers not only possess factual knowledge but also organize it effectively, drawing upon diverse sources of information, applying formulas, and arriving at solutions (Pavelich, 1982). In problem-solving scenarios, convergent thinking emerges as students select the most appropriate solution steps (Levine & Moreland, 2004; Webb et al., 2017), engage in symbolic reasoning (Wießner et al., 2022), choose problems to explore, compare and sequence potential solutions, and draw conclusions (Puccio et al., 2004). Convergent thinkers are adept at discerning the optimal solution based on acquired information, and they recognize the inherent relationship between the chosen solution and the correct/incorrect interpretation of the problem. Convergent thinking represents a component that can foster critical thinking abilities (Mölle et al., 1999). The advantage of convergent thinkers lies in their ability to enhance critical thinking skills within the realm of science education. Convergent thinkers strive to achieve their best performance and draw well-founded conclusions based on the investigative data they gather (Alamolhodaei, 2001).

Analysis of Student Performance in Executing Project

This data is obtained from measuring the performance of completing projects as long as students are taught with the Project Based Learning strategy.

Performance Measurement Completing student projects taught with conventional lecture strategies is not possible. The performance of completing a project consists of 3 aspects of skills that break down into 11 sub-aspects. Data descriptions of students' abilities with divergent and convergent thinking propensity across sub-aspects of project completion performance are presented in Table 11. The data description includes minimum scores, maximum scores, average values and standard deviations of data on the ability of students with divergent and convergent thinking propensity in each sub-aspect of Project completion performance.

Table 11. Divergent and Convergent Student Performance

	Minimum		Maximum		Mean		Std. Dev.	
	D	C	D	C	D	C	D	C
Observation	72.22	50.00	94.44	72.22	82.64	60.62	4.70	7.49
Record Data	67.86	46.43	96.43	71.43	81.03	59.25	7.57	8.29
Understand/ Following Instructions	75.00	58.33	100.00	83.33	91.15	74.51	8.32	8.57
Measure	66.67	54.17	95.83	83.33	82.55	64.71	8.77	7.38
Apply Procedure	85.71	58.93	94.64	83.93	91.41	68.80	2.63	9.60
Predict	25.00	50.00	100.00	75.00	75.78	55.88	23.48	7.80
Selection Procedure	68.75	37.50	93.75	62.50	80.08	50.74	7.98	7.30
Designing investigation	71.43	42.86	87.50	73.21	81.36	56.41	6.12	12.10
Implement Investigation	50.00	40.00	100.00	70.00	66.25	53.53	17.56	10.86
Report Investigation Results	78.57	46.43	96.43	89.29	89.27	65.34	5.05	16.31
Project completion performance	69.65	51.71	90.87	70.75	80.82	59.88	7.42	6.68

While D: Divergent; C: Convergent

It appears that there is a difference in project completion performance between students with divergent and convergent thinking talents. The significance of the difference was tested by the Mann-Whitney test technique using SPSS 15 for Windows as presented in Table 12.

Table 12. Comparison of Divergent and Convergent Students Performance on Executing Projects

Variants	Sig.	Conclusion
Observation	0.00	Significantly different
Record Data	0.00	Significantly different
Understand/ Following Instructions	0.00	Significantly different
Measure	0.00	Significantly different
Apply Procedure	0.00	Significantly different
Predict	0.00	Significantly different
Selection Procedure	0.00	Significantly different
Designing investigation	0.00	Significantly different
Implement Investigation	0.00	Significantly different
Report Investigation Results	0.00	Significantly different
Project completion performance	0.00	Significantly different

The percentage of students who successfully achieved the completion criteria Performance of completing the project is at least presented in Figure 1.

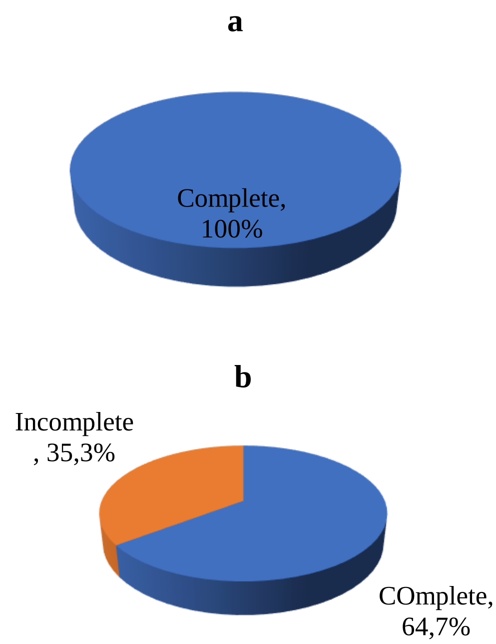

Figure 1. Performance Completeness of completing Divergent (a) and Convergent (b) Student projects in Project Based Learning

In general, the group of students with divergent thinking propensity performed very well completing projects (80.82) with 100% graduation. The group of students with divergent thinking propensity were able to apply the science process very well in aspects of observing skills (82.64), recording data (81.03), understanding and following instructions (91.15), measuring (82.55), applying procedures (91.41), selecting procedures (80.08), designing investigations (81.36), and reporting investigation results (89.27). While in other aspects of project completion performance, namely predicting skills (75.78), concluding (77.34), and carrying out investigations (66.25), the divergent group has done well.

In contrast to the quality of the science process students with convergent thinking talent. They were able to apply the science process quite well (59.88). Students with convergent thinking propensity are able to apply the science process well to aspects of observing skills (60.62), understanding and following instructions (74.51), measuring (64.71), applying procedures (68.80), selecting procedures (50.74), concluding (60.29), and reporting investigation results (65.34). While in other aspects of completing project completion, namely data recording skills (59.25), predicting (55.88), designing investigations (56.41), and carrying out investigations (53.53), the convergent group has done quite well with a pass percentage of 64.7%.

The difference in project completion performance scores between students with divergent and convergent thinking propensity can be caused by several things. *First*, there is a metacognitive activity peculiar to each thinking talent (divergent). It has been explained upfront that although there was no difference in metacognitive skill scores, during Project Based Learning problem solving, both groups of students were able to apply typical metacognitive processes mentally. This difference then has an impact on the difference in the performance of completing student projects in the two groups of thinking talents.

However, this group of students with divergent thinking propensity modified the procedure. Students with a talent for divergent thinking during the science process in Project really without hesitation bring out their generative way of thinking, develop a major, explore, and explore possibilities. The tendency of their generative way of thinking and developing a department gives an advantage to their skills in designing an investigative procedure.

In the other group, students with divergent thinking propensity performed provocative actions, did not recognize negative rules, and explored to the most inappropriate. The divergent students here show that they can provide alternatives to various sample conditions to answer the problems that are the focus of their investigation. Every variation and formulation of natural pesticides, every possibility, is tested onto a variety of crops and varies. They can explore more data that way. The group of students with divergent thinking talent is very open to performing various alternative procedures. They don't limit themselves to what can't be done and take advantage of the resources available in the laboratory.

Some of these notes explain why students with divergent thinking propensity can better carry out the science process in their investigative activities. Metacognitive models of investigative processes in students with divergent thinking aptitude can be seen in Figure 2.

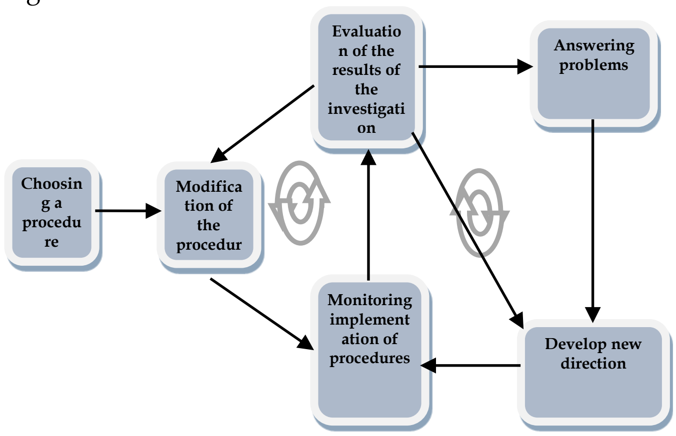

Figure 2. Thinking patterns of students with divergent thinking propensity in solving problems during projects

Something different happened to the group of students with convergent thinking propensity while going through the science process. From them comes a talent for thinking that only moves when there is a direction to move, must be precise at every step, and tends to undergo a limited process. Such a way of thinking is a weakness for them because it makes them not use various existing alternatives. The following text recordings show the thinking of convergent thinkers who prefer not to act when not according to procedure.

Students with convergent thinking propensity want to carry out investigative work in accordance with an optional procedure to which they are referred, namely the identification procedure. Students with convergent thinking talent insist on being able to use reagents according to the procedures in textbooks. Students with convergent thinking aptitude design and conduct almost completely similar investigative work with guidance from their reference references. It is only when Dragendroff reagents have been completely impossible to exist, that they use Hager reagents as an alternative. This is basically an advantage of students with convergent thinking talent because they can make more efforts to be able to apply procedures that they believe are correct. They strive to be able to carry out the procedure of their choice thoroughly. However, the learning applied in this study gives more assessment of the ability to modify/develop actions according to existing needs/resources.

Encouraged by the results of their evaluation that analytes gave negative to most reagents, their curiosity arose and they began planning modifications to the procedure. With a series of planning and evaluation (metacognitive) carried out during the implementation of the science process (investigation), students with convergent thinking propensity begin to be able to open new directions. After judging that what they obtained was unsatisfactory, students with convergent thinking propensity finally took the initiative to modify the procedure (change the solvent) and dig up to the opposite direction (negative).

The modification of the procedure is carried out only in order to overcome the problems encountered in the investigation activities so that it can answer the problems that are the focus of the investigation without being accompanied by a desire from the beginning to develop the direction of the investigation. Such a way of thinking can inhibit students with convergent thinking propensity from succeeding brilliantly in learning that requires the ability to solve problems openly (*open-ended*) such as Project Based Learning. A metacognitive model of the investigative process in students with convergent thinking aptitude can be seen in Figure 3.

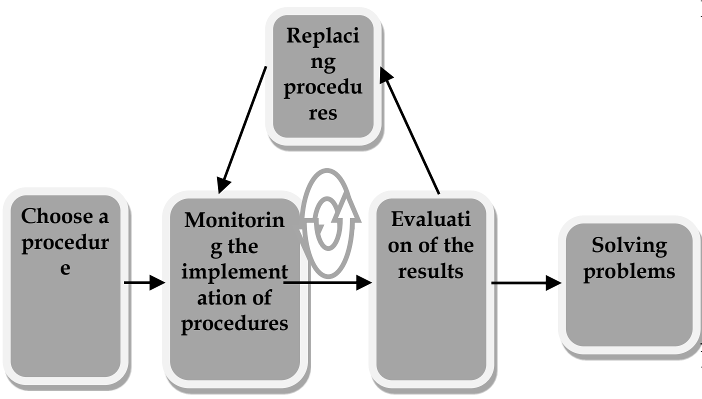

Figure 3. Thinking patterns of students with convergent thinking propensity in solving problems during projects

Convergent students cannot make a good work plan from the beginning because they cannot visualize the work plan. A good work plan in the sense of a work plan that has been modified according to certain needs and reasons. However, his repeated series of metacognitive activities (planning and evaluation) seems to lead them to continue to explore more investigative activities. They need more time to arrive at what students with divergent thinking propensity can do.

It is in this position that metacognitive skills become beneficial to them. Students with converging thinking propensity learn and can seek direction for their investigative development through a series of metacognitive activities (planning and evaluation) that they carry out repeatedly and continuously during the science process. According to Guilford (1959: 455-456) a person with a talent for convergent thinking can improve his thinking on the most difficult questions, choose a method of solving and follow up thoroughly.

Based on the explanation above, in the application of Project Based Learning strategies, although not as good as students with divergent thinking talent, in sufficient time, students with convergent thinking propensity can also bring up divergent thinking activities. This fact shows that Project Based Learning strategies can stimulate an increase in divergent thinking skills for even highly convergent students. Comparison of metacognitive processes between students with divergent and convergent thinking propensity during investigations in order to answer problems is presented in Table 13.

Table 13. Divergent and Convergent Student Processes in Executing Project

Process	Divergent	Convergent
Planning	- Choose some appropriate procedures and modify them.	- Choosing the right procedure.
Monitoring	- Modification of procedures to overcome obstacles or adapt to conditions and resources. - Modification of procedures to develop new directions in investigations.	- Make serious efforts to make the investigation in accordance with the chosen procedure. - Modification of procedures to re-fission and overcome obstacles.
Evaluation	- Determine whether or not it has answered the problem. - Looking at the possibility of developing the direction of the investigation	- to determine whether it has answered the problem or not. -

Second, the type of performance assessment technique used in this study. When one looks for a relationship between a student's abilities and their cognitive style, each type of assessment technique may support one type of cognitive style. With the type of assessment used in this study, divergent thinking propensity emerged from these students and became an advantage when they carried out their science process. While in students with convergent thinking talent, their thinking propensity appears and becomes a weakness. From this, it is clear that the performance of completing projects of students with divergent thinking propensity in Project Based Learning classes is better than convergent, even in all aspects of project completion performance. Students with divergent thinking propensity have higher scores than students with convergent thinking propensity in small science projects.

Conclusion

In conclusion, the findings of this study demonstrate that the divergent and convergent thinking categorization questionnaire comprised a total of 40 items, with 20 items dedicated to describing divergent thinking and another 20 items representing convergent thinking. The expert ratings for the questionnaire exhibited an average score of 89.50, indicating a very high level of validity. Additionally, the product moment test confirmed that all 40 items possessed validity, with product moment correlation values surpassing the critical value of r_{table} (149, 0.05) = 0.16.

Furthermore, the reliability analysis revealed that the questionnaire exhibited high reliability for both the divergent and convergent item groups, as well as sufficient reliability for all individual items, as evidenced by the alpha reliability coefficients of 0.64, 0.72, and 0.55, respectively. These results indicate that the questionnaire consistently produces stable and consistent measurements within each category.

The trials conducted using the questionnaire demonstrated its effectiveness in accurately categorizing subjects, encompassing up to 20% of the total population for each thinking group, whether divergent or convergent. Moreover, by adjusting the categorization criteria, a larger percentage of subjects can be accommodated. Consequently, this questionnaire serves as a valuable tool for diagnostic assessments and initial evaluations in educational settings.

Moving forward, future research may explore the practical implications of utilizing this questionnaire for instructional purposes, providing insights into how it can enhance learning outcomes and inform personalized teaching approaches. Additionally, further investigation into the relationships between thinking styles, student characteristics, and academic achievement would contribute to a more comprehensive understanding of cognitive processes and their impact on educational practices.

There are significant differences in divergent and convergent student performance during axecuting project. This study recommends that in the implementation of project learning, students with divergent and convergent propensity should be combined in a compound group in order to successfully complete the project well together.

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Author Contributions

Conceptualization, Ika Nurani Dewi and Yusran Khery; methodology, Ika Nurani Dewi and Yusran Khery; software, Habibi; validation, Baiq Asma Nufida and Habibi; formal analysis, Ardiana Sholehah; investigation, Ardiana Sholehah; resources, Ika Nurani Dewi and Yusran Khery; data curation, Ardiana Sholehah; writing—original draft preparation, Yusran Khery and Ardiana Sholehah; writing—review and editing, Yusran Khery; visualization, Yusran Khery; supervision, Ika Nurani Dewi and Habibi; project administration, Baiq Asma Nufida; funding acquisition, Ika Nurani Dewi. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

There is no conflict of interest in the implementation of this research.

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