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**Jurnal Inovasi Pendidikan IPA, 12 (1), 2026, 580-590**

# Students' Conceptual Understanding of the DSI Model within the TaRL Approach

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*Received: 10 January 2025; Revised: 24 July 2025; Accepted: 17 December 2025*

**Abstract**: The Merdeka curriculum uses differentiation in content, process, and product, with DSI process differentiation through tiered activities and varied guidance to accommodate diverse student learning styles. The research aimed to determine the level of concept understanding among students at the inquiry level, both before and after being taught using the DSI learning model based on the TaRL approach in class VIII. The subjects were 34 students from a junior high school in Makassar. This research was a pre-experimental with a one-group pretest-posttest design, involving an experimental group and a control group. Data collection used initial ability and concept understanding tests on light and optical devices through pre-tests and post-tests. Research findings showed that the student significantly improved their conceptual understanding, with average scores increasing from 6.31 on the pre-test to 16.12 on the post-test. Then, the DSI Model within the TaRL approach was effective in strengthening the students' conceptual understanding of science subjects
**Keywords**: DSI model, TaRL approach, concept understanding, light and optical devices.

**How to Cite**: Ramlawati., Sari, N.I., & Yunus, S.R. (2026). Students' Conceptual Understanding of the DSI Model within the TaRL Approach. *Jurnal Inovasi Pendidikan IPA, 12*(1), 71-81. doi:https://doi.org/10.21831/jipi.v12i1.82342

## INTRODUCTION

In the rapidly evolving landscape of science education, the need for innovative instructional approaches has become increasingly evident (Rosario & Chua, 2023; Astalini et al., 2023). The evolution in science and technology forces science education to develop and reorganize itself in terms of perception and method of approach, which leads pedagogy experts to think about the concept of knowledge and how it should be conducted (Leonor, 2015). The science teaching and learning process is a dynamic process, where the movement from one teaching approach to another occurs and does not always occur in an orderly sequence (Rauf et al., 2013; Fuad et al., 2017). Hence, the use of various teaching approaches in a single lesson create more opportunities for the inculcation and acquisition of science process skills in the classroom (Rauf et al., 2013; Utami et al., 2024). Amid this backdrop, the concept of differentiated science inquiry has emerged as a promising strategy to cater to the greater diversity of needs observed in today's increasingly diverse classrooms (Leonor, 2015).

The Differentiated Science Inquiry-Based Model tailors science learning to individual needs through differentiated instruction and guided inquiry, allowing them to explore and understand scientific concepts at a pace and level that is appropriate for their capabilities (Leonor, 2015; Restiana & Djukri, 2021; Windschitl & Buttemer, 2000; Ahmad & Sari, 2019). Guided inquiry provides a structured framework that allows students to develop critical thinking, problem-solving, and science process skills through scientific investigations (Asiri, 2018; Kazempour & Amirshokoohi, 2014). The theoretical foundation of this model is based on the premise that students learn best when they are actively engaged in the learning process. Also, it occurs when the instructional strategies and materials are aligned with their readiness, interests, and learning profiles (Utami et al., 2021; Hattie & Donoghue, 2016; Wang, 2019; Withers, 2016; Michelene & Wylie, 2014). By incorporating differentiated instruction, the model



https://doi.org/10.21831/jipi.v12i1.82342

aims to create a learning environment that cater to the diverse needs of students, allowing them to explore and understand scientific concepts at a pace and level that is appropriate for their capabilities (Fianti & Neratania, 2024). This DSI model allows educators to adjust the level of inquiry based on their respective strengths and weaknesses so that students can optimize learning (Zubaidah et al., 2017). Moreover, this model follows the call to differentiate learning activities to suit individual needs (Geel et al., 2019).

Teaching at the Right Level (TaRL) has gained significant traction in the field of science education, as educators strive to create learning environments that cater to the diverse needs and abilities of their students. One of the key principles underlying this approach is the recognition that students enter the classroom with varying levels of prior knowledge, learning styles, and readiness to learn, and that a one-size-fits-all approach to instruction is often insufficient (Goldman & Pellegrino, 2015; Rock et al., 2008). This understanding has led to a growing emphasis on differentiated instruction, where teachers adapt their teaching methods, content, and pacing to match the individual needs. By tailoring the learning experience to the unique strengths and challenges of their students, educators can better facilitate deep conceptual understanding and the development of critical thinking and problem-solving skills. The TaRL approach has emerged as a complementary approach to differentiated instruction, focusing on the importance of tailoring instruction to the specific learning levels of students, rather than relying on a one-size-fits-all approach (Smale-Jacobse et al., 2019; Iqbal et al., 2020; Kamarulzaman et al., 2019). This approach emphasizes the need to identify and address the individual learning needs of students, ensuring that they are provided with the appropriate level of challenge and support to facilitate their academic growth.

In the dynamic landscape of modern education, the integration of the DSI model and the TaRL approach has emerged as a critical area of study. Integrating differentiated instruction with science inquiry and Teaching at the Right Level offers a promising approach to personalize learning experiences for students with diverse cognitive and developmental needs (Jong et al., 2023; Kaldaras & Wieman, 2023; Kaldaras & Wieman, 2022; Schunn et al., 2018). The notion of the DSI model is rooted in the recognition that students possess unique learning preferences, strengths, and challenges and that a one-size-fits-all approach to science education is no longer sufficient (Foote et al., 2014). The TaRL approach is also provided in the Merdeka curriculum. This approach strongly supports the Merdeka Belajar program by providing freedom to carry out differentiated learning according to the abilities of students. On the other hand, the TaRL approach helps teachers design learning according to the achievement stage of each learner, especially in improving numeracy and literacy skills that support learning experiences. By using this approach, each learner will be allowed to fulfill their learning needs and get appropriate challenges to train their mind and improve their cognitive skills. Thus, learners do not feel bored in class (Yuli et al., 2023).

The effective teaching and learning of science has long been a persistent challenge in the education system, as highlighted by numerous studies (Musulin & Strahonja, 2023; Boulouta & Stavroulakis, 2015; Schwarz et al., 2021). One potential solution to this challenge is the development of science learning materials that can effectively foster students' science process skills and learning outcomes (Brown et al., 2021; Iwuanyanwu, 2019; Widyaningsih., 2020; Rosario & Chua, 2023; Ramlawati et al., 2025). Science process skills are needed by participants to face a world dominated by science and technology (Jaya et al., 2022; Yalçınkaya-Önder et al., 2022). In line with research by Gasila, Fadillah & Wahyudi (2019), by training in science, it hopes that students can participate actively and efficiently in learning and presenting the results. This target can be achieved through the development of students' potential during the science learning process (Puspitasari et al, 2020).

Conceptual understanding, which goes beyond memorization to encompass an integrated grasp of concepts and their applications (Smith et al., 2022), is determined by students' scores on a multiple-choice test designed to assess the following indicators: 1) Restating a concept; 2) Classifying objects according to specific properties or concepts; 3) Providing examples and non-examples of a concept; 4) Presenting a concept in various scientific representations; 5) Developing necessary or sufficient conditions for a concept; 6) Using, applying, and selecting specific procedures or operations; and 7) Applying the concept to solve the problem (Taslidere & Yildirim, 2023; Pan et al., 2021). Understanding concepts allows students to see beyond single facts and approaches. They understand why scientific issues are vital and how they can be applied in various contexts. This aligns with the fourth point of the Sustainable Development Goals, SDGs-4: quality education. To achieve the goal of quality education,


ISSN 2406-9205 (print), ISSN 2477-4820 (online)

conceptual understanding is needed to facilitate learners to analyze information, solve problems, and make the right decisions. This enables learners to become lifelong learners and contribute effectively to society (French & Kotzé, 2018; Hamidah et al., 2024). Several previous studies have discussed the importance of conceptual understanding in education and their relation to the SDGs, including, (Franco-Mariscal et al., 2024) who state that conceptual understandings are important in supporting the progress of a dynamic society; and the results of research by Rico et al. (2021), which reveal the integration of STEM in SDGs learning to improve the thinking skills of pre-service primary teachers. Thus, the TaRL-based DSI model that focuses on teaching according to students' ability levels can improve conceptual understanding of science subjects.

This research aims to determine the level of concept understanding among students at the inquiry level, both before and after being taught using the DSI learning model based on the TaRL approach in class VIII. The differentiation concepts that can be applied to the Merdeka curriculum are content, process, and product differentiation (Fianti & Neratania, 2024). The application of DSI is based on the principle of process differentiation, namely, how students will interpret the material studied independently or in groups, by providing tiered activities. So, students are divided into four levels according to their initial ability, namely, in the category of very high (Level 4), high (Level 3), medium (Level 2), and low (Level 1). The learning steps are the same provided for all levels. However, the guidance or assistance provided at each learning step is different.

## METHOD

The research used a One Group Pretest-Posttest Design (Abuhamda et al., 2021; Creswell, 2017) to describe students' conceptual understanding of science subjects using the Differentiated Science Inquiry (DSI) model based on the Teaching at the Right Level (TaRL) approach. Table 1 illustrates the research design.

**Table 1.** One Group Pre-test-Post-test Design

| Pre-test | Treatment | Post-test |
|---|---|---|
| $\mathbf{O_1}$ | X | $\mathbf{O_2}$ |

(Wiersma & Jurs, 2009)

$O_1$ : Pre-test;
X : DSI Model-based TaRL approach;
$O_2$ : Post-test

The research was conducted over three weeks at the SMPN 24 (Senior High School) Makassar. It aimed to analyze students' understanding of the concept of light and optical devices. The population consisted of 316 students of all eighth-grade in the 2023/2024 academic year. Purposive sampling was employed, mapping the diverse initial cognitive abilities of the students, which led to the selection of class VIII.1, consisting of 26 students. Data was collected using a concept understanding test with 20 multiple-choice questions on light and optical devices. Multiple-choice tests used to test for their objectivity, breadth of coverage, and ease of scoring (Towns, 2014). To ensure a comprehensive evaluation of conceptual understanding, the questions were designed to assess different levels of cognitive skills, such as the ability to restate a concept, classify objects, provide examples, and apply concepts to problem-solving (Oc & Hassen, 2025). The distribution of concept understanding question guideline is presented in Table 2.

**Table 2.** Distribution of Concept on Understanding of the Question Guideline

| No | Indicators of concept understanding | Number of questions | Question number |
|---|---|---|---|
| 1. | The ability to restate a concept | 3 | 2, 3, 9 |
| 2. | Classifying objects according to certain properties | 3 | 6, 7, 15 |
| 3. | The ability to give examples and non-examples of concepts | 3 | 1, 4, 12 |


ISSN 2406-9205 (print), ISSN 2477-4820 (online)

| No | Indicators of concept understanding | Number of questions | Question number |
|---|---|---|---|
| 4. | Presenting concepts in various forms of science representations | 2 | 10, 11 |
| 5. | Develop necessary or special conditions for a concept | 2 | 8, 16 |
| 6. | Use, utilize, and select specific procedures or operations | 4 | 5, 18, 19, 20 |
| 7. | The ability to apply concepts or problem-solving | 3 | 13, 14, 17 |

## DISCUSSION

### 1. Descriptive analysis

The results of the statistical analysis of the concept understanding of students in class VIII.1 SMP Negeri 24 Makassar, before and after being taught using the DSI model based on the TaRL approach, obtained pre-test and post-test scores on light and optical devices, which is presented in Table 3.

**Table 3.** Descriptive Statistical Data on the Understanding of Concepts

| No. | Statistics | Pre-test | Post-test |
|---|---|---|---|
| 1. | **Total Sample** | 26 | 26 |
| 2. | **Highest Score** | 9 | 19 |
| 3. | **Lowest Score** | 4 | 11 |
| 4. | **Mean** | 6,31 | 16,12 |
| 5. | **Variance** | 1,50 | 5,54 |
| 6. | **Deviation standard** | 1,22 | 2,35 |

Based on Table 3, with the number of 26 students, the pretest of concept understanding obtained the highest score, which is 9, while the lowest score is 4, and the average score is 6.31. This wider range in the post-test might indicate greater variability in learning after the intervention. The average score increased substantially from 6.31 to 16.12. This suggests a positive impact of your intervention. Also, the variance increased from 1.50 to 5.54. This means the spread or dispersion of scores is wider in the post-test, indicating some participants improved more dramatically than others. Similar to variance, the higher standard deviation (2.35 vs. 1.22) confirms greater variability in post-test scores.

This score aligns with the findings of Rais et al (2021), which showed a significant difference in student learning outcomes before and after the implementation of the DSI model. The average category of concept understanding scores is presented in Table 4**.**

**Table 4.** Category of Average Concept Understanding Score

| Indicator | ***Pre-test*** | | ***Post-test*** | |
|---|---|---|---|---|
| | **average score** | **category** | **average score** | **category** |
| **understanding concepts** | 6,31 | low | 16,12 | high |

Table 4 shows a significant improvement in the average concept understanding score from the pre-test to the post-test. The average score of 6.31 falls into the "low" category. This suggests that, before the intervention (e.g., a lesson, training, or program), students had a limited understanding of the concept. After the post-test, the average score increased substantially to 16.12, moving into the "high" category. This indicates a significant positive impact of the intervention on students' understanding of the concept. Supported by the findings of Dalila et al., (2022), that differentiated instruction has an impact on students' cognitive learning outcomes. Furthermore, conceptual understanding is influenced by the implementation of differentiated instruction, where students can absorb and comprehend the material, leading to positive learning outcomes (Astiti et al., 2021).


ISSN 2406-9205 (print), ISSN 2477-4820 (online)

The average score of the concept understanding before and after applying the DSI model based on the TaRL approach at each level of inquiry is presented in Table 5.

**Table 5.** Description of Average Concept Understanding Score Based on Groups

| Group | *Pre-test* average | Category | *Post-test* average | Category |
|---|---|---|---|---|
| **Group 1 (*Demonstrated Inquiry*)** | 6 | low | 14,50 | high |
| **Group 2 (*Structured Inquiry*)** | 6,43 | low | 14,43 | high |
| **Group 3 (*Guided Inquiry*)** | 6,25 | low | 17,75 | very high |
| **Group 4 (*Self-directed Inquiry*)** | 6,60 | low | 17,80 | very high |

Table 5 provides a detailed description of concept understanding, breaking down the results into four groups, each group is treated using a different inquiry-based learning approach. The pre-test results indicate that all four groups started with a *low* average conceptual understanding score, suggesting similar baseline knowledge. The post-test results show that all groups demonstrated substantial improvement, moving to either *high* or *very high* average scores. Analysis of the pre-test and post-test results shows that the TaRL-based DSI model positively affects students' understanding. The average post-test score of the experimental group was higher than that of the control. This shows that the TaRL-based DSI model maximize students' understanding (Puspitasari et al., 2020). Students were divided into four groups with a heterogeneous division that only applied one level of Inquiry without paying attention to the basic abilities of students, so students found it challenging to improve their outcomes (Gaitas et al., 2024). A learning model that accommodates this diversity is very much needed. Differentiated learning, developed by Llwellyn (2011), overcome the diversity of students in the group. Therefore, the TaRL-based DSI model was introduced, which applies several types of inquiries according to the needs of students (Zubaidah et al., 2017). Figure 1 illustrates the percentage comparison of pre-test (a) and post-test (b) scores across concept understanding categories at each inquiry level.

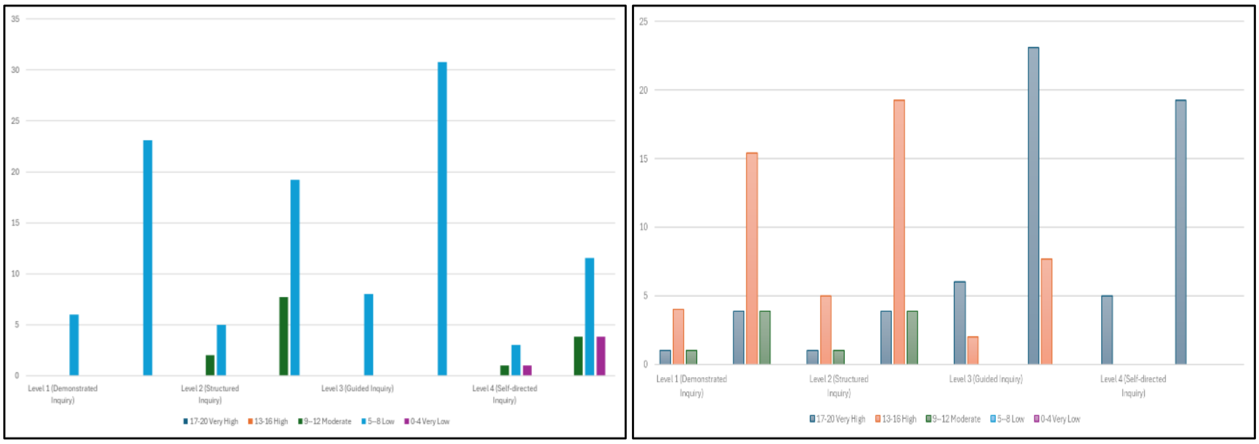

**Figure 1.** *Comparison of Pre-test (a) and Post-test (b) Scores Across Concept Understanding Categories at each Inquiry Level.*

Based on Figure 1, group comparisons (1) Demonstrated & Structured Inquiry (level 1 & 2): These groups achieved *high* average scores, showing significant but slightly less pronounced improvement compared to the other two groups; showing significant improvement, but slightly less pronounced than the other two groups. In Demonstrated Inquiry at level 1, students receive full assistance from educators throughout the learning process, with educators guiding, giving directions, and demonstrating each step. In Structured Inquiry at level 2, students receive assistance starting from the orientation stage, including formulating problems and hypotheses, designing, and conducting experiments. This approach can effectively guide students to gain understanding and abilities; (2)


ISSN 2406-9205 (print), ISSN 2477-4820 (online)

Guided & Self-Directed Inquiry (Groups 3 & 4): These groups reached *very high* average scores, indicating the most substantial learning gains. This suggests that providing more learner autonomy and exploration within the inquiry process might lead to a deeper understanding. Furthermore, students are asked to collect data and draw conclusions. This step guide or direct students to gain their understanding and abilities (Damhuri, Idrus, & Jumiarni, 2020). Then, it needs a learning model that accommodates this diversity. Differentiated learning, as developed by Llwellyn, can address the diversity of students in the group. Therefore, the TaRL-based DSI model was introduced, which applies several types of inquiries according to the needs of students.

The results of post-test level 3 (Guided Inquiry) show a very high category. Learners receive assistance only up to the hypothesis formulation stage. Furthermore, they are allowed to design and conduct experiments, collect data, and draw conclusions independently. The existence of cooperation in groups allows students to exchange ideas (Lovisia, 2018). At level 4 (Self-Direct Inquiry), the post-test results showed a very high category due to the learning model requires students to think independently, starting from the stage of providing problems, formulating hypotheses, and testing hypotheses. In line with Prayunisa & Rasyidi's research (2020), Self-Directed Inquiry has an impact on students with high initial abilities. The different assistance is based on the characteristics of the DSI learning model, as shown in Table 6.

**Table 6.** Characteristics of students and teachers at each level of inquiry.

| Inquiry syntax | *Demonstrated Inquiry* (1st level) | *Structured Inquiry* (2nd level) | *Guided Inquiry* (3th level) | *Self-Directed Inquiry* (4th) |
|---|---|---|---|---|
| **Asking questions** | teacher | teacher | teacher | student |
| **Formulating a hypothesis** | teacher | teacher | teacher | student |
| **Planning the step of problem-solving** | teacher | teacher | student | student |
| **Data analysis** | teacher | student | student | student |
| **Summarizing data** | student | student | student | student |

(Llewellyn, 2010)

Based on Table 6, the characteristics of the DSI model are based on the different treatments to learners according to their inquiry level groups, illustrating the shifting roles of students and teachers across different levels of inquiry-based learning. At the initial levels, Demonstrated and Structured Inquiry, the teacher takes the lead in asking questions, formulating hypotheses, and planning problem-solving steps. Students primarily engage in summarizing data, with some analysis at the Structured Inquiry level. This approach provides a strong scaffolding for students, introducing them to the inquiry process in a controlled environment. The teacher acts as the primary facilitator, modelling the necessary skills, and guiding students through the initial stages of inquiry (Dobber et al., 2017; Voet & De Wever, 2019).

As students' progress to Guided and Self-Directed Inquiry, the responsibility for driving the inquiry process gradually shifts. In Guided Inquiry, teachers still pose the initial questions and hypotheses, but students take ownership of planning and executing the problem-solving steps, and analysing and summarizing the data. Finally, at the Self-Directed Inquiry level, students assume full responsibility for all aspects of the inquiry process, from formulating questions to concluding. This progression fosters critical thinking, problem-solving skills, and independent learning, which empowers students to become active learners and knowledge constructors.

### 2. Inferential analysis

Inferential statistical analysis was used for hypothesis testing. Before conducting the hypothesis tests, the fundamental analysis assumptions were tested, specifically the normality assumption. The normality test was performed to determine whether the sample data came from a normally distributed


ISSN 2406-9205 (print), ISSN 2477-4820 (online)

population. The normality test was conducted using SPSS 29.0. The Shapiro-Wilk test was used to test for normality. The results of the normality test for students' conceptual understanding is presented in Table 7.

**Table 7.** Normality Test Results of Class VIII Students' Concept Understanding

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | **Statistic** | **df** | **Sig.** | **Statistic** | **Df** | **Sig.** |
| *Pre-test* | 0,214 | 26 | 0,003 | 0,929 | 26 | 0,074 |
| *Post-test* | 0,146 | 26 | 0,159 | 0,930 | 26 | 0,079 |

Based on the SPSS Shapiro-Wilk output in Table 7, the significance value for the pre-test is 0.074, and the significance value for the post-test is 0.079. Since both the pre-test and post-test significance values are greater than 0.05, it concluded that the data are normally distributed. Subsequently, a t-test, or hypothesis test, is performed. The test statistic used is the t-test with a Paired Sample T-test. The results of the analysis are presented in Table 8.

**Table 8.** Paired Sample T-Test Hypothesis Test Results

| | Paired Differences | | | | | T | Df | Sig. (1- tailed ) |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Deviation standard** | **Std. Error Mean** | **95% Confidence Interval of the Difference** | | | | |
| | | | | Lower | Upper | | | |
| Concept understanding | -9,80769 | 2,07883 | 0,40769 | -10,64735 | -8,96803 | -24,057 | 25 | <.001 |

Table 8 shows the results of the *Paired Sample T-test*. The absolute value of $t_{count}$ is obtained. The data analysis results on the student concept understanding show that $t_{count}$ = 24,057 > $t_{table}$ = 1,70814. This means that H0 is rejected and H1 is accepted. Therefore, it concluded that there is an increase in the concept understanding of class VIII students at SMPN (Junior high school) 24 Makassar. This is consistent with the research by Ulfah *et.al.*, (2023), that a differentiation learning model based on TaRL has a positive impact on the understanding of concepts and the implementation of learning. These findings suggest that the intervention or teaching method employed had a significant positive effect on the students' grasp of the material. The consistency with prior research strengthens the validity of the conclusion, indicating that the observed improvement is likely due to the implemented strategy.

Following the research of Salempa, et.al (2021); Rahmawati et al (2020); Ramlawati et al (2025), the application of the DSI learning model with different quantities of teacher intervention for each level of inquiry provides equal opportunities for all students to explore learning materials and improve their science process skills and learning outcomes according to their initial ability level. In addition, another supporting factor that causes the percentage of achievement of the self-directed inquiry level to be higher than the other levels are that students in that group have good initial abilities, so it is easier to understand the material provided. Based on the analysis and discussion, the DSI learning model based on the TaRL approach has been proven to improve students' conceptual understanding positively. This is indicated by the increase in students' conceptual understanding after going through the stages in the DSI model

## CONCLUSION

Based on the research and discussion, it concluded that the Differentiated Science Instruction (DSI) model based on the Teaching at the Right Level (TaRL) approach affects eighth-grade junior high school students’ conceptual understanding from 6.31 on pre-test to 16.12 on post-test. It is shown that the DSI Model within the TaRL approach is effective in strengthening the students’ conceptual understanding of science subjects. The research has the potential to inform pedagogical practices, encouraging educators to adopt learning models that cater to individual student needs. This research is limited by its implementation of the Teaching at the Right Level approach, which focuses on students' cognitive levels but does not accommodate for diverse learning styles or other individual student characteristics. Future research should explore these factors to optimize students' concept understanding.

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