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## Development of Differentiated Discovery Learning Worksheets Using Teaching at the Right Level for Chemical Bonding

Charine Vivinia Lado<sup>1</sup>, Sudirman<sup>2,\*</sup>, Daud Dakabesi<sup>3</sup>

<sup>1,2,3</sup>Chemistry Education Program, Faculty of Teacher Training and Education, Nusa Cendana University, Jalan Adisucipto, Penfui, Kupang Regency, NTT, Indonesia

Email: [sudirman\\_bandu@staf.undana.ac.id](mailto:sudirman_bandu@staf.undana.ac.id)\*

### Abstract

This study aims to determine the form of the developed product, the level of validity, and student responses to the Discovery Learning-based worksheets using the TaRL approach on the chemistry bonding material for 11th-grade MIPA students in the 2025/2026 academic year. Although previous studies have integrated TaRL and Discovery Learning as separate approaches, no research has produced a differentiated worksheet specifically targeting chemical bonding concepts for high school students. The method used research and development (R&D) using the ADDIE development model. The developed worksheets were validated by subject matter experts and media experts and tested on students through small-group and large-group trials at State Senior High School 3 Kupang in Grade 11. The research data using a Likert scale to determine the product's validity level. The research produced a worksheet featuring chemical bonding material presented through text and images. The worksheet is organized according to the Discovery Learning syntax and incorporates the Teaching at the Right Level approach. It is differentiated into three levels of student ability (low, medium, and high) to address different educational needs in chemical bonding concepts. The developed worksheets have a high level of validity, with an average validation percentage of 94.67% from subject matter experts, 87.88% from media experts, 98.52% from students in the small-group pilot test and 99.33% in the large-group pilot test. Based on the research results, the developed worksheets are suitable for use as teaching materials to support students' understanding according to their cognitive ability levels. The scope of this study is confined to the development, validation, and student response stages. Future research should include effectiveness testing to assess improvements in learning outcomes.

**Keywords:** Discovery Learning, Chemical Bonding, Worksheets, Teaching at the Right Level (TaRL)

### Introduction

Education is a conscious and planned effort to create a learning environment that enables students to actively develop their potential and foster high-quality, competitive human

resources (Ujud et al., 2023) . In the context of education in Indonesia, improving the quality of learning is a primary focus, particularly in fostering critical and creative thinking skills, as well as deep conceptual understanding among students. Chemistry instruction at the high school level often faces challenges due to the abstract nature of many concepts. Chemical bonding material, for example, involves concepts such as ionic, covalent, and metallic bonds that cannot be directly observed, thus requiring strong symbolic representation skills and conceptual understanding. Ristiyani (2016) notes that chemistry is among the subjects with lower student interest due to its abstract and complex nature.

Based on the results of a needs analysis at SMA Negeri 3 Kupang, it was found that students' learning outcomes in the topic of chemical bonding remain relatively low. This situation is influenced by the use of Student Worksheets (LKPD) that do not adequately accommodate differences in students' ability levels and do not sufficiently encourage critical thinking activities. The results of the analysis of student characteristics also indicate a diversity in learning abilities, necessitating a teaching approach capable of adapting the material to students' ability levels. One relevant approach is Teaching at the Right Level (TaRL), which groups students based on their initial ability levels to ensure more effective and targeted learning (Hidayatni & Fathani, 2023) . Previous research indicates that the implementation of the TaRL approach can improve students' learning outcomes in chemistry instruction (Natzir et al., 2023), as well as effectively enhance student engagement and understanding (Sau et al., 2024).

The discovery learning model is a teaching approach considered effective in helping students discover concepts independently through a structured inquiry process. This model encourages students to actively identify problems, collect data, process information, and draw conclusions (Surakarta, 2021). Discovery-based learning has been shown to enhance students' conceptual understanding and engagement in the learning process. Previous studies have revealed that the discovery learning model has a positive impact on students' understanding of high school chemistry material (Biya et al., 2023); the discovery learning model can lead to a significant improvement in student learning outcomes (Noormalina, 2023; Cahyaningtyas & Wijayanti, 2025). Furthermore, the discovery learning model is effective in enhancing communication and collaboration skills (Ekaputra, 2023; Cahyaningtyas & Wijayanti, 2025), as well as increasing students' active participation and understanding of chemistry material (Setiyarini, 2022). Based on these issues, there is a need for worksheet-based instructional materials that integrate the discovery learning model with the TaRL approach.

Among the available instructional media and approaches, worksheets (LKPD) represent the most suitable option for this context. As structured written instructional tools, worksheets guide students in actively exploring and discovering concepts through systematic activities, aligning closely with the Discovery Learning model (Anggraini & Susilowati, 2022). Empirical evidence demonstrates that Discovery Learning-based worksheets significantly enhance students' conceptual understanding, as indicated by notable pre-to-post gains in concept mastery (Anggraini & Susilowati, 2022). For chemical bonding, a topic characterized by abstract concepts, worksheets have also been shown to increase student motivation and improve learning outcomes when combined with structured discovery activities (Tanjung & Louise, 2024). Additionally, worksheets can be differentiated more readily than other media to accommodate diverse student ability levels, as each activity and question can be adapted to varying readiness levels without additional technological infrastructure. This flexibility is a considerable advantage compared to digital modules, instructional videos, or flipped classroom approaches, which require internet access and devices that are not consistently available in schools in eastern Indonesia (Pratiwi & Margunayasa, 2022). Although project-based learning and flipped classroom models have proven effective in certain settings, they typically require extended time, greater access to technology, and student autonomy, which

may not align with the characteristics and conditions of the target school (Septiani et al., 2025). Consequently, developing worksheets that integrate Discovery Learning and the Teaching at the Right Level approach is the most contextually relevant and feasible strategy for addressing ability diversity in chemical bonding instruction.

The Teaching at the Right Level (TaRL) approach is grounded in the comprehensive understanding that each student possesses varying levels of mastery of the learning material (Ahyar et al., 2022). Discovery learning-based worksheets with the TaRL approach are designed to facilitate active, contextual, and differentiated learning according to students' ability levels, thereby minimizing learning ability gaps and improving understanding of chemical bonding concepts. The discovery learning model with the Teaching at the Right Level (TaRL) approach can improve student learning outcomes (Fadhilah et al., 2025; Sholihi et al., 2025; Fakhrudin & Rezkita, 2025; Sari & Rezkita, 2025; Fitnanto et al., 2024), student engagement (Fadhilah et al., 2025), improved conceptual understanding of high school chemistry material (Tomasoa & Mustapa, 2025), and higher-order thinking skills (Hasanah et al., 2024).

This study aims to develop discovery learning-based worksheets using the TaRL approach on chemical bonding material for 11th-grade high school students and to determine the validity and student response to the developed product.

## **Method**

This study is a research and development (R&D) project aimed at producing new products or improving existing ones (Jami'ul Amil et al., 2021). The procedure for developing the worksheets in this study refers to the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation (Arda, 2020).

During the analysis phase, a needs analysis, curriculum analysis (Learning Outcomes, Learning Objectives, Learning Objective Sequence, and the Merdeka Curriculum), analysis of student characteristics, and analysis of chemical bonding material were conducted as the basis for product design. The design phase includes the formulation of learning objectives, the design of the structure and organization of the worksheets, the integration of discovery learning syntax, the grouping of activities based on the TaRL approach according to student ability levels (low, medium, and high), and the development of research instruments. Next, in the development stage, the product is validated by subject matter experts and media experts to assess aspects of content appropriateness, language, presentation, and graphics, and is then revised based on the suggestions provided. The implementation stage in this study was not carried out in full but was limited to small-group and large-group trials to obtain student responses to the developed product. The evaluation stage was conducted formatively during each product validation and revision process, so that improvements were made continuously until the LKPD was deemed suitable for use.

The research subjects included six validators, comprising three subject matter experts and three instructional media experts, who assessed the product's suitability. Additionally, 11th-grade students participated in the product trials. Purposive sampling was employed, with 9 students participating in the small-group trial and 30 students in the large-group trial. The small-group trial included 9 students, representing each ability level within the TaRL approach: three students from each of the low, medium, and high ability categories. This aligns with the principle that small-group trials in educational research and development typically involve 6 to 12 participants selected based on characteristics relevant to the product (Sugiyono, 2019). The large-group trial involved 30 students from a single intact class, consistent with standard practice in educational product development research, which uses a single unit analysis (Sugiyono, 2019). A limitation of this study is that the product was tested at only one

school; therefore, generalization of the findings should be approached with caution. Broader trials at multiple schools are recommended for future research.

Data collection in this study was conducted using non-test instruments in the form of validation sheets and student response questionnaires. The validation sheets were used to obtain data on the product's suitability from subject matter experts and instructional media experts, covering aspects of content quality, language, presentation, and graphics. Meanwhile, the student response questionnaire was used to determine the level of appeal, ease of use, and usefulness of the worksheets after they were implemented in the classroom.

During the validation process, evaluations used qualitative categories such as excellent, good, fair, poor, and very poor. Subsequently, this qualitative data was converted into quantitative form by assigning scores based on a five-point Likert scale, thereby enabling descriptive analysis in the form of suitability percentages.

The next step is to interpret the obtained scores into a validation assessment distribution table and determine the criteria.

**Table 1.** Validation Assessment Criteria

Percentage (%)	Validation Criteria
$80 < P \leq 100$	Highly valid
$60 < P \leq 80$	Valid
$40 < P \leq 60$	Fairly valid
$20 < P \leq 40$	Less valid
$0 < P \leq 20$	Invalid

(Darwis et al., 2019)

**Table 2.** Student Response Criteria

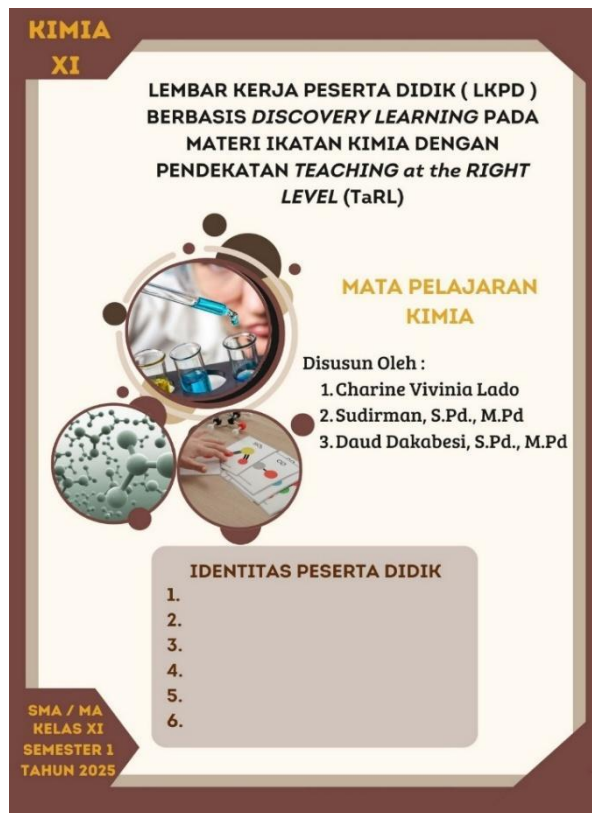
Percentage (%)	Validation criteria
$80 < P \leq 100$	Very Acceptable
$60 < P \leq 80$	Acceptable
$40 < P \leq 60$	Fair
$20 < P \leq 40$	Unacceptable
$0 < P \leq 20$	Very Unacceptable

(Darwis et al., 2019)

## Results and Discussion

This study produced a Student Worksheet (LKPD) based on discovery learning with the Teaching at the Right Level (TaRL) approach for the chemistry bonding material for 11th-grade high school/MA students. Development was carried out using the ADDIE model, which includes the analysis, design, development, limited implementation, and formative evaluation stages. During the analysis phase, it was found that chemical bonding instruction is still dominated by lecture-based methods and the use of instructional materials that do not adequately accommodate the diversity of students' abilities. Analysis of student characteristics revealed that students' learning abilities regarding chemical bonding vary significantly, while the existing LKPDs do not fully align with students' ability levels and do not incorporate differentiated instruction. Subsequently, the designed worksheets were developed into a preliminary product containing content, discovery activities, illustrations, and structured questions related to Grade 11 high school/MA chemistry bonding material in accordance with the discovery learning syntax. The worksheets were designed by integrating the discovery

learning syntax—comprising the stages of stimulation, problem statement, data collection, data processing, verification, and generalization along with the TaRL approach, which groups students into categories based on cognitive ability (low, moderate, and high), ensuring that activities and the difficulty level of questions are tailored to each student’s ability. The TaRL approach in this worksheet also adapts activities and exercises to students’ initial ability levels through grouping based on their level of conceptual mastery, so that each student can learn according to their needs and understand the material optimally.



**Figure 1.** Cover

LKPD Model Discovery Learning Pendekatan TaRL

**STIMULATION**

Amatilah gambar di bawah ini !



Garam Dapur



Air



Logam

Apa perbedaan wujud dari ketiga zat pada gambar di atas ? Menurutmu, apakah ketiga zat tersebut tersusun dari partikel dengan jenis ikatan yang sama ? Jelaskan alasanmu secara sederhana !

**J A W A B A N**

**PROBLEM STATEMENT**

Mengapa senyawa dengan jenis ikatan yang berbeda memiliki sifat fisik yang juga berbeda ? Jelaskan pendapatmu secara sederhana !

**J A W A B A N**

6

**Figure 2. Low-Level Worksheet**

LKPD Model Discovery Learning Pendekatan TaRL

**STIMULATION**

Amatilah gambar di bawah ini !



Garam Dapur



Air



Kawat Tembaga

Jenis ikatan apakah yang terbentuk dari zat pada ketiga gambar di atas ? Bagaimana sifat dan daya hantar listrik dari ketiganya ? Jelaskan hubungan antara jenis ikatan dan sifat tersebut secara sederhana !

**J A W A B A N**

**PROBLEM STATEMENT**

Diskusikan bersama temanmu, bagaimana susunan partikel dan jenis ikatan dalam zat seperti garam, air dan logam dapat memengaruhi sifatnya secara sederhana ?

**J A W A B A N**

6

**Figure 3. Medium-Level Worksheet**



**Figure 4.** High-Level Worksheets

The LKPD products based on discovery learning with the TaRL approach on chemical bonding material that had been created were tested by subject matter experts, media experts, and students using an expert validation sheet containing a number of questions related to the content quality, language, presentation, and graphics of the LKPD. In this study, the collected questionnaire data were analyzed and categorized qualitatively, then further analyzed and converted into quantitative data. The validity levels were categorized using the results of the validation questionnaires from subject matter experts and media experts, as well as student responses.

**Table 3.** Results of Subject Matter Expert Validation

No	Evaluation Aspect	V1	V2	V3	Average	Category
1	Content Quality	24	23	25	96.00%	Highly Valid
2	Presentation	30	26	28	93.33%	Highly Valid
3	Linguistic	19	18	20	95.00%	Highly Valid
Total					94.67%	Highly Valid

Based on the validation results from 2 lecturers and 1 chemistry teacher, an average score of 94.67% was obtained, which falls into the highly valid category. The assessment was conducted on three main aspects. The content quality aspect received an average score of 96.00%, categorized as highly valid, supported by learning objectives aligned with learning outcomes, as well as the use of the discovery learning model and the TaRL approach. The presentation aspect received an average percentage of 93.33%, falling into the highly valid category, presenting chemical bonding material consistent with test questions and feedback. Furthermore, the linguistic aspect received an average score of 95%, falling into the "highly valid" category, supported by clear and communicative language. These results reinforce that

the developed materials are not only appropriate in terms of content quality but also present information that is easy to understand.

**Table 4.** Media Expert Validation Results

No	Evaluation Aspect	V1	V2	V3	Average	Category
1	Graphics	48	47	50	87.88%	Highly Valid

Based on the validation results from 3 lecturers, an average score of 87.88% was obtained, which falls into the “highly valid” category. These results indicate that the developed product is not only feasible in terms of visual and technical aspects but also aligns with the differentiated learning approach through the TaRL framework.

**Table 5.** Student Validation Results

No	Assessment Aspect	Pilot Test	Number	Average	Category
1	Content Quality	Small Group	532	98.52%	Highly Valid
		Large Group	1788	93.33%	Highly Valid

Based on the validation results from students in the small-group pilot test (9 participants) and the large-group pilot test (30 participants), average percentages of 98.52% and 93.33% were obtained, which fall into the highly valid category. These results indicate that the developed product received a positive response from the students.

The validation results from experts and students indicate that the developed worksheets are engaging, easy to understand, and help students grasp the concept of chemical bonding. The high validation percentages from experts and student responses indicate that the worksheets have met the criteria for content, language, presentation, and graphic design, and are effective in accommodating differences in learning abilities. The integration of discovery learning allows students to actively construct concepts through the discovery process, while the TaRL approach helps reduce learning gaps by providing activities tailored to each student’s readiness level. Thus, the discovery learning-based worksheets with the TaRL approach are deemed suitable for use as an alternative teaching material for the chemistry bonding topic in 11th-grade high school/MA. This is also supported by previous research relevant to this study, namely the study from (Natzir et al., 2023), which reported that students experienced improved learning outcomes with the TaRL approach through peer-tutoring methods in chemistry instruction. Another relevant study was conducted by (Sau et al., 2024), which reported that students’ learning outcomes improved with the use of the discovery learning model employing the TaRL approach. Furthermore, the study conducted by (’Ulya et al., 2024) also reported that the TaRL approach proved effective in improving students’ learning outcomes through the use of differentiated worksheets in junior high school mathematics instruction.

Improvements in learning outcomes in each cycle occur because students gain learning experiences aligned with their individual ability levels; this fosters a sense of self-confidence and responsibility within the group, as there are no significant ability gaps among members, thereby making the group a conducive space for expression and experience that supports the development of students’ abilities (Norrizqa & Sugianoor, 2024). Other studies also indicate that there is an improvement in student learning outcomes through the implementation of TaRL-based learning; furthermore, the teacher’s approach during the implementation of the learning process significantly influences how students comprehend the presented material (Rosa et al., 2024).

The integration of the discovery learning method with the TaRL approach significantly enhances engagement and participation in learning by stimulating intrinsic motivation through

independent exploration while providing individualized support (Ismail et al., 2024). It is explained in detail that inquiry-based discovery learning activities encourage independent exploration and intrinsically motivate students, while the TaRL method provides personalized support and feedback tailored to students' current ability levels. Through the TaRL approach, the learning process can be tailored to students' capacities, needs, and interests; consequently, teachers need to conduct an initial assessment in the form of a diagnostic test to identify the characteristics, needs, and potential of each student, with the assessment results providing an overview of students' abilities and initial development as a foundation for designing and implementing modified instruction (Suharyani et al., 2023).

## Conclusion

This study produced a discovery learning-based worksheet using the TaRL approach on chemical bonding material designed according to students' ability levels. The resulting worksheet contains material in the form of text and images, as well as worksheet activities organized based on the stages of discovery learning, where students' abilities are grouped according to the TaRL approach. The developed product was deemed highly valid based on the results of validation by subject matter experts (94.67%) and media experts (87.88%), making it suitable for use in instruction. Furthermore, student responses in the small-group pilot test (98.52%) and large-group pilot test (99.33%) fell into the "very good" category, indicating that the worksheets are engaging, easy to understand, and support the understanding of chemical bonding concepts.

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