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DEVELOPMENT OF DISCOVERY LEARNING-BASED SCIENCE INSTRUCTIONAL MATERIALS TO ENHANCE JUNIOR HIGH SCHOOL STUDENTS' NUMERACY SKILLS

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Abstract

Science learning packages that explicitly integrate numeracy skills remain limited in development for junior high school level, particularly on the topic of Vibration and Waves. This study aimed to develop and examine the feasibility of a *Discovery Learning*-based science learning package oriented toward strengthening the numeracy skills of eighth-grade junior high school students. The study employed the Dick & Carey development model, with the reporting focus limited to the expert validation stage as part of formative evaluation. The developed products consisted of a teaching module, instructional materials, student worksheets (LKPD), and assessment instruments on the topic of Vibration and Waves. Validation was conducted by three experts: a content expert, an instructional design expert, and a media expert. The validation instrument used a five-point Likert scale, with feasibility percentages analyzed based on Sugiyono's (2013) criteria. The validation results showed that the learning package obtained feasibility percentages of 89.3% (content expert), 97.24% (instructional design expert), and 82.9% (media expert), all of which fell into the *Very Feasible* category. The developed *Discovery Learning*-based science learning package was declared valid and feasible for use in the learning trial stage.

Keywords: science learning package, discovery learning, numeracy skills

INTRODUCTION

Numeracy is one of the fundamental competencies required in 21st-century education, defined as the ability to reason mathematically and to use and interpret mathematics to solve problems in real-world contexts, including in science (IPA) learning (Geiger, 2016; Oktafiani et al., 2020). However, the numeracy achievement of Indonesian students remains a serious concern. Education report data from SMP Negeri 230 Jakarta show that students' literacy ability reached 97.78% (good category), while numeracy ability reached only 75.56% — far below the literacy achievement. This gap is reinforced by a needs analysis showing that 74.3% of students experienced difficulty solving science problems requiring more than one calculation step. These findings indicate that existing science learning has not yet effectively supported the development of students' numeracy skills. *Discovery Learning* is one of the most relevant learning models to address this need, as it emphasizes students' active engagement in discovering concepts through observation, data processing, and drawing conclusions (Ozdem-yilmaz & Bilican, 2016). Various studies have confirmed the effectiveness of *Discovery Learning* in science learning, including in improving learning outcomes (Gede et al., 2020; Hidayat et al., 2026) maupun keterampilan berpikir kritis (Setyawan & Kristanti, 2021), including at the junior high school level (Muqoffi et al., 2024). On the other hand, efforts to integrate numeracy into science learning are also growing through various approaches, such as STEM (Kamal et al., 2024), pembelajaran terpadu (Ismail, 2025), dan *Project Based Learning* (Pramesti et al., 2022). Nevertheless, two gaps remain unaddressed by existing research. First, research on *Discovery Learning* in junior high school science remains limited compared to the elementary level, particularly on science topics such as Vibration and Waves. Second, the integration of numeracy into science learning has generally been conducted at the level of learning models (STEM or PjBL), not at the level of an integrated learning package, meaning there is currently no *Discovery Learning*-based science learning package that explicitly positions numeracy as an embedded outcome within the teaching module, LKPD, and assessment instruments. This study was conducted to fill that gap by developing a *Discovery Learning*-based science learning package that explicitly integrates numeracy activities across all stages of instruction, from stimulation through generalization. This approach distinguishes the present study from prior research that integrated numeracy only at the model level, not at the level of a ready-to-use package for classroom implementation. Before the learning package is trialed with students, expert validation must be conducted as part of formative evaluation to ensure the product's validity in terms of content, instructional design, and media (Dick & Carey, 2015). Therefore, this article aims to describe the development process and the results of expert validation of a *Discovery Learning*-based science learning package oriented toward numeracy on the topic of Vibration and Waves for eighth-grade junior high school students.

METHOD

This study is a (*Research and Development*) study using the Dick & Carey model. This model was selected for its systematic nature and comprehensive needs-based approach, making it well-suited for developing learning packages whose feasibility can be tested in a staged manner. The Dick & Carey model consists of ten sequentially implemented stages: (1) assessing needs to identify goals; (2) conducting instructional analysis; (3) analyzing learners and contexts; (4) writing performance objectives; (5) developing assessment instruments; (6) developing instructional strategy; (7) developing and selecting instructional materials; (8) formative evaluation; (9) revising instruction; and (10) summative evaluation (Dick & Carey, 2015). This article specifically reports the results of the eighth stage, namely formative evaluation at the sub-stage of expert validation (*expert review*), which serves as the basis for refining the product before it is trialed with students (Dick & Carey, 2015). The product developed was a science learning package on the topic of Vibration and Waves for eighth-grade junior high school students in Semester II of the Merdeka Curriculum. The package consists of a teaching module, instructional materials, a Student Worksheet (LKPD), and assessment instruments. The package was designed based on the *Discovery Learning* syntax comprising six stages: stimulation (*stimulation*), problem identification (*problem statement*), data collection (*data collection*), data processing (*data processing*), verification (*verification*), and generalization (*generalization*) (Astuti et al., 2015), which has been formalized as a learning model in the Merdeka Curriculum (Hanim et al., 2022). These six stages are integrated with numeracy activities such as reading data or graphs, completing observation tables, interpreting graphs, calculating scientific quantities, and drawing data-based conclusions, consistent with the concept of numeracy as the ability to reason mathematically in real-world contexts (Geiger, 2016).

Validation was conducted by three experts selected based on their respective fields of expertise in relation to the components being assessed. The content expert is a Physics Education lecturer at Universitas Negeri Jakarta with expertise in science content and the development of science instructional materials. The instructional design expert is an Educational Technology lecturer at Universitas Negeri Jakarta with expertise in instructional design and curriculum development. The media expert is an Educational Technology lecturer at Universitas Negeri Jakarta with expertise in visual design and learning media development. Each expert conducted the assessment through two sessions: the first session for providing initial feedback, and the second session for confirmation after revisions were made. The validation instrument consisted of a rating sheet using a five-point Likert scale (1 = very poor to 5 = very good). The content expert rating sheet comprised 19 items covering three aspects: accuracy of physics concepts, numeracy integration, and language & communication, plus four dichotomous "Yes/No" items as basic feasibility confirmation. The instructional design expert rating sheet comprised 29 items covering five aspects: instructional characteristics & design, instructional strategy, language & communication, practicality & formative evaluation, and feasibility & effectiveness of the LKPD. The media expert rating sheet covered six aspects of visual appearance and consistency. In addition to quantitative ratings, each expert also provided qualitative feedback in the form of notes and suggestions for revision. Validation data were analyzed using a feasibility percentage technique with the formula:

$$Percentage(\%) = \frac{Total\ Score\ Obtained}{Maximum\ Score} \times 100\%$$

The resulting percentages were interpreted using feasibility criteria (Sugiyono, 2013) as presented in Table 1.

Table. Feasibility Criteria for Instructional Materials

Percentage	Category
81% - 100%	Very Feasible
61% - 80%	Feasible
41% - 60%	Fairly Feasible
21% - 40%	Not Feasible
>20%	Very Not Feasible

The learning package is declared valid and suitable to proceed to the trial stage if it achieves a minimum percentage in the Feasible category (≥61%).

RESULTS AND DISCUSSION

Results

The product developed was a science learning package on the topic of Vibration and Waves for eighth-grade junior high school students in Semester II of the Merdeka Curriculum, consisting of a teaching module, instructional materials, a Student Worksheet (LKPD), and assessment instruments. The package was designed based on the *Discovery Learning* syntax integrated with numeracy activities at each stage. Before trialing, the package was validated by three experts to assess its validity in terms of content, instructional design, and media.

Subject Matter Expert Validation

Content validation was conducted by a Physics Education lecturer at Universitas Negeri Jakarta using an instrument covering three assessment aspects: accuracy of physics concepts, integration of numeracy skills, and language and communication. The content validation results are presented in Table 2.

Tabel 2. Content Expert Validation Results

Aspect	Mean
Accuracy of Physics Concepts	4,50
Numeracy Integration	4,40
Language & Communication	4,50
Mean	**4,47**

Based on Table 2, the content expert feasibility percentage is as follows

$$Percentage(\%) = \frac{67}{75} \times 100\% = 89{,}3\%$$

Instructional Design Expert Validation

Instructional design validation was conducted by an Educational Technology lecturer at Universitas Negeri Jakarta using an instrument covering five assessment aspects: instructional characteristics and design, instructional strategy, language and communication, practicality and evaluation, and feasibility and effectiveness of the LKPD. The instructional design validation results are presented in Table 3.

Table 3. Instructional Design Validation Results

Aspect	Mean
Instructional Characteristics & Design	4,85
Instructional Strategy (*Discovery Learning)*	4,57
Language & Communication	5,00
Practicality & Formative Evaluation	5,00
Feasibility & Effectiveness of LKPD	5,00
Mean	**4,88**

Based on Table 3, the instructional design expert feasibility percentage is as follows

$$Percentage(\%) = \frac{141}{145} \times 100\% = 97{,}24\%$$

Media Expert Validation

Media validation was conducted by an Educational Technology lecturer at Universitas Negeri Jakarta using an instrument covering six assessment aspects. The media validation results are presented in Table 4

Table 4. Media Expert Validation Results

Aspect	Mean
Visual & Layout of Printed LKPD	4,12
Visual & Layout of PPT Media	4,28
Visual & Layout of Printed Instructional Materials	4,71
Visual & Layout of Differentiated Numeracy Questions	4,25
Visual & Layout of Graphs, Tables, and Data	4,00
Visual Consistency & Harmony	4,00
Mean	**4,22**

Based on Table 4, the feasibility percentage of the media expert is as follows

$$Percentage(\%) = \frac{141}{170} \times 100\% = 82{,}9\%$$

Summary of Expert Validation Results

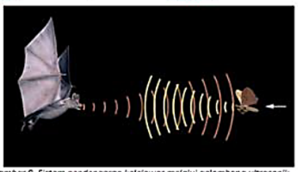
Tabel 5. Summary of Expert Validation

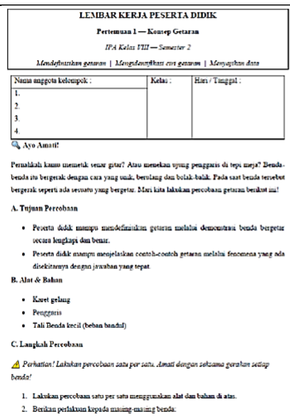
Validator	Percentage	Category
Content Expert	89,3%	Very Feasible
Instructional Design Expert	97,24%	Very Feasible
Media Expert	82,9%	Very Feasible
Mean	**89,81%**	**Very Feasible**

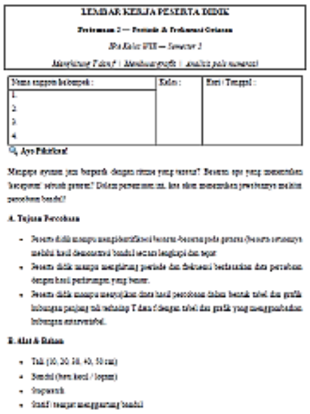
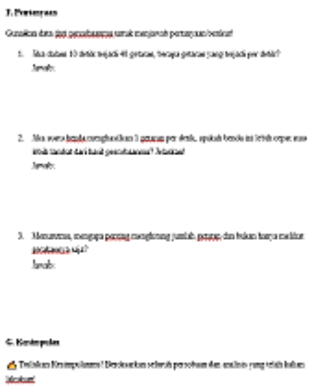
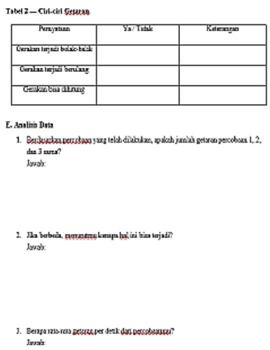
Based on Table 5, all three validators assigned a Very Feasible rating, with an overall average of 89.81%. The highest percentage was obtained from the instructional design expert (97.24%) and the lowest from the media expert (82.9%), though both remain in the Very Feasible category. In addition to quantitative ratings, all three experts also provided qualitative feedback that served as the basis for product revision. The feedback and revision follow-up are presented in Table 6.

Tabel 6. Expert Suggestions and Feedback

Content Expert

Suggestion / Feedback	Revision Follow-up
The word "Concept" in the vibration sub-topic should be changed to "definition". '	**GETARAN** Definisi, Besaran, dan Penerapan
Include image sources.	Kelelawar adalah hewan yang menggunakan gelombang ultrasonik untuk bernavigasi dan berburu mangsa dalam kegelapan total. Kemampuan ini disebut ekolokasi.  *Gambar 9. Sistem pendengaran kelelawar melalui gelombang ultrasonik* *Sumber: https://bimbelsmartgenius.com/pengertian-bunyi-audiosonik-infrasonik-dan-ultrasonik-detail-420531*
Include university textbooks as reference sources for the development of instructional materials.	**DAFTAR PUSTAKA** ◆ Tri Maryana, O.F., dkk. (2021). Ilmu Pengetahuan Alam untuk SMP Kelas VIII. Jakarta: Pusat Kurikulum dan Perbukuan, Kemendikbudristek. ◆ Kemendikbudristek. (2022). Panduan Pembelajaran dan Asesmen Kurikulum Merdeka. Jakarta: Kemendikbudristek. ◆ Serway, R. A., & Jewett, J. W. (2018). Physics for Scientists and Engineers (10th ed.). Cengage Learning.

Adjust the LKPD layout to black and white for greater efficiency.	 LEMBAR KERJA PESERTA DIDIK Pertemuan 1 — Konsep Getaran *IPA Kelas VIII — Semester 2* *Mendefinisikan getaran | Mengidentifikasi ciri getaran | Menyajikan data* Nama anggota kelompok : 1. 2. 3. 4. | Kelas : | Hari / Tanggal : Ayo Amati! Pernahkah kamu memetik senar gitar? Atau menekan ujung penggaris di tepi meja? Benda-benda itu bergerak dengan cara yang unik, berulang dan bolak-balik. Pada saat benda tersebut bergerak seperti ada sesuatu yang bergetar. Mari kita lakukan percobaan getaran berikut ini! A. Tujuan Percobaan • Peserta didik mampu mendefinisikan getaran melalui demonstrasi benda bergetar secara lengkap dan benar. • Peserta didik mampu menjelaskan contoh-contoh getaran melalui fenomena yang ada disekitarnya dengan jawaban yang tepat. B. Alat & Bahan • Karet gelang • Penggaris • Tali Benda kecil (beban bandul) C. Langkah Percobaan *Perhatian! Lakukan percobaan satu per satu. Amati dengan seksama gerakan setiap benda!* 1. Lakukan percobaan satu per satu menggunakan alat dan bahan di atas. 2. Berikan perlakuan kepada masing-masing benda:
Instructional Design Expert	
Suggestion / Feedback	**Revision Follow-up**
Remove the word "understand" from the instructional objective statements as it does not align with the operational verb taxonomy (KKO).	The word "understand" has been removed from all instructional objectives and replaced with appropriate operational verbs. Example: Students are able to define vibration through a demonstration of a vibrating object completely and correctly.
The assessment indicator listed course management information as one of the instructional package components. If not applicable, it should be removed. *course management information.* If not applicable, it should be removed.	Not included, as there is no system serving as a platform for this learning package.
Numbers should not be written in bold. *bold* .	Bold formatting has been removed from all numbers.
Media Expert	
Suggestion / Feedback	**Revision Follow-up**
Learning objectives are not yet consistent across all learning package components.	Learning objectives have been standardized across all package components, including the PPT, lesson plan, and LKPD.
The writing of learning objectives is not yet structured.	Learning objectives have been written following the ABCD principle *(Audience, Behaviour, Condition, Degree).* The same example was also revised for session 2 as: *Students are able to identify the quantities of vibration along with their units through the results of a pendulum demonstration completely and correctly.* All learning objectives for each session have been revised using the ABCD principle.
Use images that support the topic of Vibration and Waves.	Supporting images have been added to the PPT. 

<table>
<tr><td>The experimental procedure section of the LKPD needs to include images so that students have a visual reference for the practical activities.</td><td>Images for the experimental procedure steps have been added for each session.
Penggaris : Letakkan di tepi meja lalu tekan ke bawah atau tarik ke atas
</td></tr>
<tr><td>Colors should only be used if they carry specific meaning.</td><td>The LKPD has been produced in black and white for greater efficiency when printed and used by teachers in the classroom.

</td></tr>
<tr><td>Reduce unnecessary text boxes as they may feel restrictive to students.</td><td>Unnecessary text boxes have been removed.
</td></tr>
<tr><td>The spacing in the LKPD should be adjusted to accommodate student answers.</td><td>The spacing in the LKPD has been adjusted to provide adequate room for student answers.

</td></tr>
</table>

The developer's and lecturer's identities should be included in the science instructional materials.	The developer's and lecturer's identities have been added to the science instructional materials.  IDENTITAS PENGEMBANG BAHAN AJAR ILMU PENGETAHUAN ALAM Judul : Bahan Ajar Getaran dan Gelombang dengan Fokus Pengembangan Kemampuan Numerasi Penulis : Hanna Rohana, S.Pd (Mahasiswi Magister Teknologi Pendidikan Universitas Negeri Jakarta) Dosen Pembimbing : 1) Dr. RA. Murti Kusuma W, S.IP, M.Si 2) Prof. Dr. Maria Paristiowati, M.Si Institusi : Universitas Negeri Jakarta | Jalan Rawamangun Muka Raya No. 11, Rawamangun, Pulo Gadung, Jakarta Timur, 13220 Tahun & Kurikulum : 2026 | Kurikulum Merdeka | Kelas VIII SMP Semester II | *Discovery Learning*

Discussion

The content expert validation obtained a feasibility percentage of 89.3% in the Very Feasible category. The highest scores were recorded for the accuracy of physics concepts and language & communication aspects (4.50 each), while the numeracy integration aspect scored slightly lower (4.40). The high score on the physics concept aspect indicates that the Vibration and Waves material presented in the package aligns with the learning objectives and scientific principles of science education. The slightly lower score on the numeracy integration aspect, while still in the Very Feasible category, confirms that embedding numeracy into science content requires precision in designing activities that are both conceptually sound and quantitatively relevant. This finding aligns with the view that numeracy in a science context is not merely computational ability, but rather the capacity for mathematical reasoning to solve real-world problems that require the simultaneous integration of scientific concepts and quantitative thinking (Geiger, 2016). This result is also consistent with the findings of (Kamal et al., 2024), who showed that developing numeracy-based learning packages in science requires careful attention to the alignment between numeracy activities and the underlying scientific concepts, so that numeracy does not appear as an element detached from the learning content.

The instructional design aspect obtained the highest feasibility percentage among the three validators, at 97.24% in the Very Feasible category. Perfect scores (5.00) were achieved for three aspects simultaneously: language and communication, practicality and formative evaluation, and feasibility and effectiveness of the LKPD. The high score on the instructional strategy aspect (4.57) indicates that the *Discovery Learning* syntax has been systematically integrated throughout the instructional design, from the stimulation to the generalization stage. This is consistent with the principle that the effectiveness of *Discovery Learning* syntax has been systematically integrated throughout the instructional design, from stimulation through generalization. This is consistent with the principle that the effectiveness of Discovery Learning is largely determined by the quality of instructional design, particularly in the strategic presentation of content and the use of guiding questions that lead students to discover concepts independently (Honomichl & Chen, 2012). Expert validation at this stage also aligns with the position of formative evaluation in the Dick & Carey (2015) model, which places expert review as a critical step for ensuring the soundness of the instructional design before proceeding to field trials. This finding is consistent with research by (Muqoffi et al., 2024), who found that the quality of instructional design is a key determinant of the effectiveness of *Discovery Learning* in junior high school, and that packages designed with a clear and structured syntax tend to be more readily implemented by teachers in the classroom.

The media aspect obtained the lowest feasibility percentage among the three validators at 82.9%, though still in the Very Feasible category. The highest score was recorded for the visual appearance of the printed instructional materials (4.71), while the lowest scores were on the visualization of graphs, tables, and data and the overall visual consistency and harmony (both 4.00). This pattern indicates that while the general appearance of the package is satisfactory, the presentation of visual elements directly related to numeracy activities, such as graphs and data tables still requires greater attention in terms of clarity and design consistency. This finding is relevant to the research of (Kristiyajati & Wijaya, 2019), who demonstrated that the quality of data visualization in discovery-based learning significantly contributes to students' ability to understand relationships between variables. In the context of numeracy, visual clarity in graphs and tables is not merely an aesthetic consideration but a functional prerequisite, since numeracy requires students to read, interpret, and draw conclusions from data representations accurately (Geiger, 2016). Therefore, the revisions made based on media expert feedback represent an appropriate and necessary step toward improving the visual quality of the package in support of students' numeracy activities.

Overall, the average feasibility percentage across the three expert validations reached 89.81% in the Very Feasible category. The variation in scores across aspects shows a consistent pattern: aspects directly related to the presentation of numeracy in both content and media validation tend to score relatively lower than other aspects, although all remain in the Very Feasible category. This pattern suggests that integrating numeracy into a science learning package, as an embedded competency within the content rather than a standalone one, demands extra precision in both content design and visual presentation. These findings reinforce the position of this study in addressing the gap identified in the introduction, namely that numeracy integration has thus far been implemented predominantly at the level of instructional models (STEM, PjBL) rather than at the level of ready-to-use learning packages. With Very Feasible ratings across all three validation aspects, the package can be declared valid conceptually, instructionally, and visually, and is ready to proceed to the classroom trial stage. This study has several limitations that warrant acknowledgment. First, this article reports only the expert validation stage as part of formative evaluation, and therefore cannot yet provide empirical evidence regarding the practicality and effectiveness of the learning package under real school conditions. Second, the package development was focused on a single science topic (Vibration and Waves) and a single grade level (Grade VIII junior high school), so generalization of the findings to other topics or grade levels should be made with caution. Based on these limitations, future research is recommended to test the practicality of the learning package through *one-to-one* and small-group trials, and to examine its effectiveness through field testing using an experimental or quasi-experimental design, in order to obtain empirical evidence of the package's impact on students' numeracy skills.

CONCLUSION

This study produced a *Discovery Learning*-based science learning package oriented toward numeracy on the topic of Vibration and Waves for eighth-grade junior high school students, comprising a teaching module, instructional materials, LKPD, and assessment instruments, developed using the Dick & Carey model. The expert validation results showed that the learning package was rated Very Feasible across all three aspects assessed, with feasibility percentages of 89.3% for content, 97.24% for instructional design, and 82.9% for media. Overall, these expert validation results demonstrate that the *Discovery Learning*-based science learning package oriented toward numeracy is valid conceptually, instructionally, and visually, and is therefore feasible for use in the learning trial stage. For junior high school science teachers, this package offers an alternative instructional design that explicitly integrates numeracy through the *Discovery Learning* syntax without treating numeracy as a competency separate from science content. Future research is recommended to examine the practicality and effectiveness of this package through field trials in order to obtain empirical evidence of its impact on students' numeracy skills.

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