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Development Of High School Physics Practical Guidelines In Sound Resonance Instrument Using Model Learning Discovery Learning

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Abstract

This research is motivated by the availability of new laboratory equipment assistance in the form of a Sound Resonance tool in 2024 at SMA Negeri 2 Kotamobagu which has not been optimally used due to the unavailability of specific practicum guidelines. This has an impact on the lack of direct experimental activities and low achievement of students' science process skills. This study aims to develop a product in the form of a high school Physics practicum guide on the Sound Resonance tool by integrating a valid and feasible Discovery Learning learning model. This type of research is Research and Development (R&D) by applying the 4-D development model (Define, Design, Develop, Disseminate). The trial subjects in this study were Grade XII students in the second semester of SMA Negeri 2 Kotamobagu in the 2025/2026 academic year. Data collection instruments include validator/material and media expert assessment sheets, student response sheets, and practicum performance observation sheets. The validation results by the expert team showed that the general design and completeness of the practicum guide were in the feasible category after going through several revisions to strengthen the concept. In the Develop stage through small group trials (10 students), the percentage of positive student responses reached an accumulation of 97.5%, with an average achievement of 83.75% of the practical task performance which is in the valid and feasible qualification. In the Disseminate stage through large-scale trials (20 students), the positive student responses increased to reach an accumulation of 100% in the very useful and beneficial category. Based on these results, it can be concluded that the Discovery Learning-based Physics practical guide on the Sound Resonance tool is declared valid, feasible, and effective to be used to optimize laboratory activities and meet the criteria for student completion in the cognitive, affective, and psychomotor aspects.

1. INTRODUCTION

Physics is a branch of Natural Sciences (IPA) that studies the basic components of the universe and their interactions. This characteristic indicates that learning physics is not simply limited to reading or listening to theoretical explanations. Furthermore, students need to be directly involved in observing natural phenomena to collect empirical data as part of the concept discovery process. Therefore, the application of appropriate learning methods such as lab work or experiments is crucial. Through these direct experiences, students can apply scientific methods, practice motor skills in using laboratory equipment, and hone scientific thinking skills that connect concepts to real contexts. This aligns with Edgar Dale's Cone of Experience theory (in Trianto, 2010:126), which states that learning through direct experience provides concrete understanding and can retain students' memory of up to 70% of what is said and done. Thus, lab work is effective in developing students' understanding of the phenomena, concepts, and principles of physics.The results of Amalia's research (2013) showed that 72% of students were unable to carry out physics experiments, 68% of students were unable to carry out the observation and data processing process, and 91% of students found it difficult to understand physics concepts.

Laboratory practical activities play a crucial role as a center for developing thought patterns and data acquisition activities through observation. This characteristic aligns with the essence of physics as a set of basic skills that reflect the process of achieving scientific goals. Furthermore, practical activities contribute significantly to building conceptual understanding, effectively developing process skills in students, increasing learning motivation, and training psychomotor abilities (Sutrisno, 2006:36).Specifically, at State Senior High School 2 Kotamobagu, the science laboratory is a key facility for the school. The learning process involves more than just reading and writing various physics theories. Students also need to understand the concepts and context of physics through existing phenomena and direct experience in the real world. In the laboratory, students can conduct various experiments to discover the concepts and contexts they learn in theory and discover in practical work.

Practical activities require a practical guide to guide them throughout the process. In 2024, the school will add additional laboratory equipment, including a Sound Resonance instrument. Generally, the only equipment available for new laboratories is a manual. The developed practical guide will be adapted to the learning model described in the research related to the equipment's use.Meanwhile, the results of the basic physics practicum assessment showed a score of 55%, which is categorized as poor (Arikunto, 2010). One effort to overcome this obstacle is to optimize the use of practicum guides. The practicum guide itself is an implementation guideline containing procedures for preparation, implementation, data analysis, and reporting, compiled by the responsible teaching staff. The function and purpose of this guide is as an independent teaching material that minimizes direct intervention from the teaching staff, so that students can carry out laboratory activities independently, in a structured, and orderly manner. Through systematic guidance, students are also stimulated to develop creative thinking and psychomotor skills (hand skills), which in turn makes it easier for lecturers to manage learning in the laboratory. In addition to the availability of these learning methods and guides, students' higher-order thinking skills are also essential to fulfill the essence of physics as a whole, namely as a product, process, and attitude.

The Discovery Learning model is oriented towards a scientific process approach that facilitates students' self-construction and discovery of new knowledge. Through this model, the knowledge gained will be in-depth conceptual understanding (meaningful learning), not merely momentary memorization that is easily forgotten. In its implementation, students are required to be more active and organized into study groups to encourage the exchange of information. This collaborative activity not only hones critical thinking skills in problem-solving but also fosters self-confidence, independence, and teamwork skills in solving shared challenges.

Based on Lavenia's (2017) research, the application of the Discovery Learning model in practical activities showed that students adapted well and achieved an achievement score of 80%. These results placed the developed practical guide within the criteria of being quite appropriate or valid, with a good category. Furthermore, an assessment of the learning process, which encompassed affective, cognitive, and psychomotor aspects, showed that the majority of students achieved positive results in the 60%–80% range. These findings further reinforce the practical guide's good level of appropriateness.

Based on these facts, developing a lab manual that integrates the Discovery Learning model is a strategic step to improve the quality of the learning process in the laboratory. This manual development is based on the characteristics of the Discovery Learning model, which confronts students with a problem, encouraging them to actively work and solve it through scientific activities, one of which is through investigation in labs.

2. LITERATURE REVIEW

The Essence of Research and Development

Research and development (R&D) is a method used to produce a specific product and test its effectiveness. This research is generally longitudinal, so the implementation process is carried out in stages and continuously (Sugiyono, 2015).According to Borg & Gall, research and development is a process used to develop and validate educational products.

According to Sugiyono, 2015 research and development is a "bridge" between basic research, where basic research aims to "drive new knowledge about fundamental phenomena" and applied research which aims to find knowledge that can be practically applied.

Real Laboratory

A laboratory is a place where experiments and investigations are conducted (Hadidat et al., 2000: 7). A laboratory can be a closed space, a room, or an open garden, for example, where experiments and research are conducted. In the laboratory, students obtain data/information through experiments or findings.

A real laboratory is a special place equipped with tools and materials for conducting experiments/practical work. Terminologically, a practicum can be defined as a series of activities that allow a student to apply skills or practice something (Subiantoro, 2009). In practicum activities, students will experience, among other things, an introduction to equipment, measurements, observations, and experiments.

Practicum

Practicum is a learning process where students conduct experiments by experiencing something they are learning for themselves. Practicum has its own advantages over other learning methods, namely: students directly gain experience and skills in conducting practicums, increase student participation both individually and in groups, students learn to think through the principles of the scientific method or learn to practice work procedures based on the scientific method (Djamarah, 2010).

Learning through practical work is very effective in achieving all domains of knowledge simultaneously, including training so that theory can be applied to real problems (cognitive), training independent activity planning (affective), and training the use of certain instruments (psychomotor) (Rahayuningsih, 2005). One of the advantages of practical (laboratory) learning is that students can practice through trial and error, can repeat the same activity or action until they are truly skilled (Sumiatun, 2013).

Discovery Learning Model

Discovery is a learning model developed based on constructivism. According to Kurniasih & Sani (2014: 64), discovery learning is defined as a learning process that occurs when learning material is not presented in its final form, but is expected to organize students themselves. Furthermore, Sani (2014: 97) states that discovery is finding concepts through a series of data or information obtained through observation or experimentation. A further statement is put forward by Hosnan (2014: 282) that discovery learning is a model for developing active learning methods by self-discovery, self-investigation, so that the results obtained will be loyal and long-lasting in memory.

Through discovery learning, students can also learn to think analytically and try to solve the problems they face themselves. Wilcox (Hosnan, 2014: 281) states that in discovery learning, students are encouraged to learn largely through their own active involvement with concepts and principles and teachers encourage students to have experiences and conduct experiments that allow them to discover principles for themselves.

Bruner (Ministry of Education and Culture, 2013b: 4) stated that the learning process will run well and creatively if teachers provide opportunities for students to discover a concept, theory, rule, or understanding through examples encountered in their lives. Sardiman (Ministry of Education and Culture, 2013b: 4) revealed that in applying the discovery learning model, teachers act as guides by providing opportunities for students to learn actively, teachers must be able to guide and direct student learning activities in accordance with the objectives.

Four-D Device Development Model

The Four-D Model of software development was suggested by Sivasailam Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel (1974). This model consists of 4 stages of development, namely Define, Design, Develop, and Disseminate or adapted into a 4-D model, namely defining, designing, developing, and disseminating.

Characteristics of Material

Physics is a branch of natural science that essentially aims to study and provide quantitative understanding of various natural phenomena or processes, the properties of matter and their applications in Tanti (2013). Therefore, according to Wospakrik (1993) in Tanti (2013) the approach used to develop and understand physics is to combine experimental results and mathematical analysis. The concepts of physics are very abstract, however, the abstractness of these physics concepts is not the main factor causing difficulties for students because many concepts in everyday life are also abstract.

Relevant Research

1. **Development of a Discovery Learning-Based Physics Lab Guide to Improve High School Students' Science Process Skills. Rani et al. (2022)**

   "The comparative relationship between this research and previous research can be explained through the following aspects:

- **Equality:**Both studies focused on product development in the form of a high school physics practical guide based on the Discovery Learning model.
- **Difference:**Previous research has focused on general physics materials and has not focused on optimizing specific laboratory equipment. Meanwhile, this study is specifically designed to optimize the use of the Sound Resonance Instrument in wave mechanics.
- **Contribution:**Previous research provides a real contribution for researchers as a primary reference in compiling and aligning each Discovery Learning syntax (such as stimulation, problem identification, and data collection) into work procedures in the practicum guide."

2. **Development of Practical Equipment Design and Student Worksheets for Sound Waves Using Sound Analysis Software. Wahyuni & Setiawan (2024)**

"The comparison of characteristics between this study and previous research can be reviewed from the following three aspects:

- **Equality:**Both studies used the same Research and Development (R&D) method and focused on the same material limitations, namely Sound Wave material for high school students.
- **Difference:**Previous research combined practical tools with digital technology or virtual/hybrid sound analysis software and did not employ a specific learning model. Meanwhile, this study emphasizes the use of real-world laboratory equipment packaged using the syntax of the Discovery Learning model.
- **Contribution:**Previous research provides scientific contributions as a methodological reference for researchers, especially in designing expert validation procedures (media and materials), managing small group trials, and developing product effectiveness testing instruments."

3. RESEARCH METHODS

This research was conducted at the Laboratory of SMA Negeri 2 Kotamobagu in February-May 2026.The object of this research is a guide to practical physics tools. *Sound Resonance*Discovery Learning model, while the research subjects were Class XII students, semester II, class A, 2025/2026 academic year.

The model in this study is a type of research and development (R&D), with reference to the research model suggested by Thiagarajan et al., 1974 (in Marcela Tamatompol 2016) with the 4-D model (four D models).

The procedures or steps taken are:

1) Define Stage
   a) Front-end analysis
   b) Student Analysis
   c) Concept Analysis
   d) Task analysis
   e) Formulating Learning Objectives (Specifying Instructional Objectives)
2) Design Stage
3) Development Stage
   a) Pre-Writing
   b) Initial Product Creation
   c) Validation
   d) Revision
   e) Limited trial
   f) Revision
   g) Field trials
   h) Revision of field trial results
4) Dissemination Stage (Disseminate)

The research instruments used were reviewer assessment sheets, small-group student response sheets, and observation assessment sheets. The reviewer assessment sheets were used to refine the design and content of the practicum guide to align with the learning model used. The small-group student response sheets were used to determine the usefulness of the practicum guide. The observation assessment sheets were used to measure achievement indicators of the learning process, including assessment of product, process, psychomotor, behavioral, and social skills.

The development of the Practical Guide is carried out by:

1) Data analysis techniques regarding quantitative descriptive processes in the form of percentages according to the process variable/indicator categories
2) Data analysis on capabilities, achievements and obstacles is described in narrative form about general trends and emerging variations.
3) Data analysis regarding student perceptions is described in narrative form regarding general trends and variations that emerge.

This Practical Guide is considered suitable for use and meets the criteria standards if the responses obtained are in the range of 76% ≤ score ≤ 100% and 51% ≤ score ≤ 75% or in the criteria of "Very Good" and "Good". The practical guide was tested in practicals for students, both small group tests and large group tests.

4. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Definition Stage

Researchers found an important problem, especially in the science laboratory, namely the lack of a practical guide for the new tool, namely Sound Resonance. In determining and establishing problems, it begins with an analysis of the objectives of the practical needs in the science laboratory. Therefore, at this stage, researchers really need to create a practical guide so that it can be used to support practical activities in the science laboratory at SMA Negeri 2 Kotamobagu. The result of the definition stage is the determination of the device to be developed.

3.1.2 Design Stage

This design began by considering existing physics laboratory experiment guidelines, then developed them to include materials and equipment specifications not listed (names and functions of equipment parts), and adapted them to a Discovery Learning-based learning model. First, the researchers conducted a trial run of the Resonance apparatus.*Sound.*

The next stage is an assessment carried out by a team of experts in the field of physics experiments. The assessment is carried out by2 Material and Media Experts,who assessed the design and content of the researcher's practicum guide. The expert team conducted two assessments to determine whether the general design and completeness of the practicum guide could be recommended for practicum implementation.

3.1.3 Development Stage of the Physics Experiment Guide "Sound Resonance"

The experimental guide will be used to test the functionality of the Sound Resonance experimental apparatus. The experimental guide has been created based on materials adapted to experiments using the apparatus for physics experiments. The testing stage of this Sound Resonance guide is a Small Group Test.

Table 1. General student response data to the Sound Resonance experiment guide for small group limited trials.

No	Response	Frequency				
		SB	B	KB	TB	TOTAL
		4	3	2	1	
1	I am interested in using the Wave Resonance experiment guide with the Discoveri Learning based learning model.	9	1			10
2	I feel challenged to make thorough preparations before conducting experiments with guides who use a learning model based on Discoveri Learning like this.	7	3			
3	I understand well what to do according to the instructions listed in the Sound Resonance experiment guide with a learning model based on Discovery Learning like this.	6	3	1		
4	By focusing on this experimental activity and working well with my fellow group members, I was able to carry out the Wave Resonance experiment with this kind of guidance well.	6	3	1		
5	Using an experimental guide with a Discovery Learning model like this encouraged me to practice developing a guide like this for use in physics learning in high schools.	7	3			
6	Carrying out experiments with the Discovery Learning learning model like this has provided me with practical experience as a physics teacher in developing the ability to use a scientific approach (scientific attitude).	7	3			
7	The use of experimental guides for the Discovery Learning model like this challenges me to develop my creativity as a physics teacher.	8	2			
8	Carrying out experiments with models like this, if done seriously, is very useful in developing professional competence as a physics teacher.	7	3			10
Total Frequency		57	21	2		80
Presentation		**71.25%**	**26.25%**	**2.5%**		**100%**

The percentage analysis results showed a very positive assessment indicator, where 71.25% of students rated it "Very Useful" (SB) and 26.25% rated it "Useful" (B), with a total accumulation of 97.5%. In contrast, only 2.5% of students chose the "Less Useful" (KB) category, and no responses were found in the "Not Useful" (TB) category.

3.1.4 Dissemination Stage (Disseminate)

Dissemination is carried out to disseminate the product so it can be adopted by users. This dissemination process can be applied to other classes to test the effectiveness of the developed physics lab tools and guides.

Table 2. General student response data to the Sound Resonance experiment guide for the dissemination stage trial (Disseminate)

No	Response	Frequency				
		SB	B	KB	TB	TOTAL
		4	3	2	1	
1	I am interested in using the Sound Resonance Practicum guide with a learning model based on Discoveri Learning.	18	2			20
2	I feel challenged to make thorough preparations before conducting experiments with guides who use a learning model based on Discoveri Learning like this.	15	5			20
3	I understand well what to do according to the instructions listed in the Sound Resonance experiment guide with a learning model based on Discovery Learning like this.	14	6			20
4	By focusing on this experimental activity and working well with my fellow group members, I was able to carry out the Sound Resonance experiment with this kind of guidance well.	15	5			20
5	Using an experimental guide with a Discovery Learning model like this encouraged me to practice developing a guide like this for use in physics learning in high schools.	16	4			20
6	Carrying out experiments with the Discovery Learning learning model like this has provided me with practical experience as a physics teacher in developing the ability to use a scientific approach (scientific attitude).	17	3			20
7	The use of experimental guides for the Discovery Learning model like this challenges me to develop my creativity as a physics teacher.	17	3			20
8	Carrying out experiments with models like this, if done seriously, is very useful in developing professional competence as a physics teacher.	18	2			20
Total Frequency		130	30			160
Presentation		**81.25 %**	**18.75 %**			**100%**

The percentage calculation results show that the accumulation of positive student assessments reached 100%, divided into two categories: "Very Useful" (SB) at 81.25% and "Useful" (B) at 18.75%. In line with these results, no students responded in the "Less Useful" (KB) or "Not Useful" (TB) categories.

3.2 Discussion

The research results show that the main obstacle in practical activities is generally rooted in the lack of proper guidance, especially for new laboratory equipment. Responding to this problem, researchers developed a Physics practical guide for Sound Waves specifically for the Sound Resonance apparatus. This product was developed with the hope of helping optimize student experimental activities and supporting the effective use of the Science Laboratory at SMA Negeri 2 Kotamobagu.

In designing this practical guide, the researchers went through a design guidance and validation process with a team of experts (reviewers) competent in the field of Physics experiments. This validation aims to ensure the developed product meets the eligibility requirements before being tested in the field. General aspects assessed include the degree of innovativeness, creativity, originality, functionality, efficiency, aesthetics, and its usefulness for schools. In terms of completeness of substance, this guide is systematically structured including the stages of orientation, problem formulation, hypothesis formulation, variable determination, experimental design, data collection, hypothesis testing, and drawing conclusions.

In accordance with the initial design, this practicum guide was developed based on the Discovery Learning model. Through this model, students are directed to actively solve problems and discover concepts independently through stimuli provided in experiments. The characteristics of discovery learning require active student participation in constructing scientific principles based on direct experience. In line with Dahar's view (in Ratumanan, 2002: 49), discovery-based learning has several advantages, including: the knowledge gained is more durable (strong retention), has a better transfer effect, and is able to improve students' reasoning and free-thinking abilities. Specifically, this model trains students' cognitive skills in solving problems independently.

The high feasibility of the Discovery Learning-based practical guide product on the Sound Resonance tool is strongly supported by several relevant previous research results from the UNIMA Postgraduate Science Education group.

FirstThe integration of this independent discovery step aligns with the findings of Cosmas and Roring (2022) who developed a Problem-Based Learning-based science learning tool to improve students' Higher Order Thinking Skills (HOTS). Their research confirmed that structuring laboratory instructions that require active problem-solving is directly proportional to improvements in students' cognitive performance, reasoning, and in-depth understanding. In this study, the formulation of discovery syntax within the practicum guide was proven to be successful in triggering students' scientific competence, as demonstrated by the average achievement of students' practicum performance tasks in small groups that fell within a logical and satisfactory range.

Second, the active involvement of students in carrying out real experiments in the laboratory is able to boost their affective aspects and interest in learning. This phenomenon of increased motivation and learning independence is in line with research conducted by Tuwo and Palilingan (2023) regarding the implementation of Project-Based Learning (PjBL) in Physics and Science learning to improve the scientific creativity of postgraduate students. In a limited trial of small groups in the Science Laboratory of SMA Negeri 2 Kotamobagu, the accumulated percentage of positive student responses reached 97.5%, and soared to an absolute figure of 100% in the dissemination testing stage. This high number of benefits proves that the packaging of student-centered practical instructions (student-centered approach), whether using discovery-based or project-based models, actually provides space for students to explore physical variables, practice group cooperation, and build a positive emotional closeness to physics.

Third, related to the substance of wave material as well as mitigating technical constraints and visualizing abstract concepts in resonance phenomena, this research is strengthened by the results of Wahyuni and Setiawan's (2024) research on the development of the design of practical tools and student worksheets for Sound Wave material. If Wahyuni and Setiawan's (2024) research emphasizes the use of sound analysis software, this development research takes a complementary position by optimizing the functionality of the Sound Resonance mechanical laboratory equipment provided in 2024 at the school. The presence of a draft practical guide that has been harmonized based on reviewer input—which requires a strong reinforcement of Physics concepts—is effectively able to guide students to observe resonance points, measure the length of air columns, and find the inverse relationship between tuning fork frequency and wavelength in a concrete manner without giving rise to new misconceptions.

The field trial was conducted in a small group of 10 students. At the first meeting, students were able to follow the experimental procedures well and began to adapt positively to the applied learning syntax (this aspect can be seen in Table 4.1.5.1). The evaluation of student performance covered three main domains: affective, cognitive, and psychomotor. The analysis results showed the highest score was 88.46% (Student 1) and the lowest score was 69.23% (Student 10 — rounded to the lower limit of 70%). All score variations were logical and fell within the target range (Appendix II and III). These results placed the practicum guide in the feasible category.

As part of the final stage of the 4D model, namely the dissemination stage, response measurements were carried out and showed that more than 90% of students gave positive responses. Students felt interested in using the Sound Resonance tool in the Science Laboratory of SMA Negeri 2 Kotamobagu because the guide provided really helped them find Physics concepts concretely while increasing their interest in practicums. Based on the accumulation of expert team assessments, small group trial results, and student response analysis, it can be concluded that the Discovery Learning-based practicum guide on this Sound Resonance tool is valid and suitable for use. For further improvements, researchers still expect constructive input from lecturers and practitioners before this product is disseminated on a wider scale.

5. CONCLUSION AND SUGGESTIONS

4.1 Conclusion

Based on the theoretical review and discussion, it can be concluded that the Discovery Learning-based Sound Resonance Practical Guide is suitable for use. This product has gone through all stages of the development procedure and has proven effective in meeting student completion criteria in the cognitive, affective, and psychomotor aspects.

4.2 Suggestion

This lab guide is expected to encourage teachers to develop independent experiment modules, especially for new laboratory equipment that doesn't yet have a manual. Furthermore, the Discovery Learning model implemented in this guide is designed to enable students to actively investigate and deeply understand physics concepts through this learning model.

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