

Developing Laras Degung Vocal Etudes as ICT-Based Learning Media for Sundanese Kawih

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Article Info

Article history:

Received 2026-08-20

Revised 2026-09-03

Accepted 2026-09-10

Keywords:

Digital learning
Educational technology
Laras degung
Music education
Sundanese kawih
Virtual instrument

ABSTRACT

Learning Sundanese kawih requires accurate pitch reproduction, yet beginners often have limited access to consistent laras degung pitch references for independent practice. Existing digital learning resources for Sundanese music remain limited, particularly those that provide structured, repeatable pitch practice. This study aimed to develop and initially validate an ICT-based laras degung vocal etude as a digital learning resource for Sundanese kawih practice. This study used a Research and Development approach based on the ADDIE model. The implementation involved 30 senior high school students who were beginners in Sundanese karawitan. Data were collected through interviews, observations, documentation, student-response questionnaires, and expert validation. Qualitative data from interviews and observations were analyzed descriptively, while expert and student questionnaire data were analyzed quantitatively using feasibility and response percentages. Expert validation indicated high feasibility, with an overall score of 89.4%, comprising tuning accuracy (93.8%), audio quality (86.1%), and pedagogical feasibility (87.5%). The student-response score was 88.7%, categorized as very positive. The developed medium demonstrated high feasibility and positive initial usability for laras degung pitch practice, but its learning effectiveness was not experimentally established. The resource offers an accessible digital complement to teacher-guided practice and supports the digital preservation of Sundanese musical heritage.

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1. INTRODUCTION

Sundanese kawih is a form of vocal art that occupies an important position in the cultural life of the Sundanese people in West Java, Indonesia [1], [2], [3]. As part of the intangible cultural heritage, kawih serves not only as entertainment but also as a medium for transmitting values, language, and cultural identity across generations [4], [5]. Its continuity therefore depends not only on preserving the traditional repertoire but also on learning practices that enable younger generations to acquire the musical knowledge and skills

required to perform it. However, kawih transmission currently faces serious challenges due to changing lifestyles, the dominance of popular culture, and declining interest among younger generations in traditional arts. These conditions may reduce opportunities for sustained intergenerational transmission, particularly when traditional learning practices are less compatible with the learning habits and technological environments of contemporary learners. Conventional transmission, which has traditionally relied on oral instruction and face-to-face interaction, has become increasingly difficult to sustain in modern life. Accordingly, preservation efforts need to move beyond simply maintaining traditional materials and consider learning media that can connect the characteristics of Sundanese musical traditions with the accessibility, repetition, and independent learning opportunities expected in contemporary education.

Among the various aspects of kawih learning, mastering pitch accuracy, or intonation, in the laras degung tuning system is one of the most fundamental yet challenging competencies for beginners to acquire [6], [7]. Laras degung consists of five principal pitches (Da, Mi, Na, Ti, and La), with unequal intervals between pitches, as illustrated in Figure 1. Unlike the diatonic scale, in which intervals between pitches are relatively uniform, intervals in laras degung vary considerably, ranging from about 80 cents at the narrowest interval to 400 cents at the widest. This distinctive interval structure creates a specific perceptual and technical challenge for learners more familiar with the relatively regular interval organization of Western diatonic music. These unequal intervals can make it difficult for learners accustomed to the diatonic system to reproduce degung pitches accurately, particularly without a consistent pitch reference. For beginning learners, repeated exposure to an appropriate pitch reference is consequently important because accurate intonation requires not only understanding the pitch sequence but also developing the ability to recognize and reproduce the characteristic interval relationships of laras degung.

	T	-	-	S	-	-	G	-	-	P	-	-	L	-	-	T
Salendro	1	-	-	5	-	-	4	-	-	3	-	-	2	-	-	1
Degung	1	-	-	-	-	5	4	-	-	3	-	-	-	-	2	1
Interval	400 sen				80 sen		240 sen		400 sen				80 sen			

Figure 1. Pitch Arrangement and Intervals Laras Degung Compared with Laras Salendro

Laras degung, a distinctive pentatonic tuning system in Sundanese karawitan, has an interval structure that differs from the diatonic scale commonly familiar to learners. This difference often makes it difficult to reproduce pitches accurately, especially when learners lack consistent guidance. Conventional learning relies heavily on the teacher as a pitch reference, thereby limiting opportunities for independent practice. The central instructional problem is therefore not merely acquiring vocal technique, but providing a stable, repeatable auditory reference that learners can use while developing pitch accuracy. Consequently, a learning medium is needed to provide an accurate and consistent laras degung pitch reference that learners can access repeatedly and independently.

The development of information and communication technology (ICT) offers significant opportunities for innovation in music education and cultural preservation [8], [9], [10]. ICT can expand accessibility, improve learning quality, and provide more engaging learning experiences for digital-generation learners [11]. In music education, technology is not merely a neutral tool; it also shapes how learners think, listen, and interact with musical materials [12]. ICT enables more democratic creative processes, offers opportunities for sound exploration, and boosts learning motivation by presenting relevant, contextualized materials [13]. These findings indicate that the educational value of ICT lies not simply in digitizing existing instructional materials, but in creating learning experiences that support repeated listening, exploration, feedback, and independent practice. Therefore, ICT can serve as a strategic instrument for bridging the preservation of Sundanese musical traditions with the demands and characteristics of twenty-first-century learning.

One promising approach to developing pitch accuracy is using an etude, a composition designed to develop particular technical skills in a structured, gradual manner [14]. In the context of kawih vocal training, an etude can develop mastery of intervals and pitch accuracy in laras degung through systematic melodic patterns. Unlike general song materials, an etude allows specific technical components to be isolated, sequenced, and practiced progressively, making it relevant to the pitch-accuracy problem identified in laras degung vocal learning. When the etude is realized as an audio resource using Virtual Studio Technology (VST)- based virtual instruments, learners can obtain an accurate degung gamelan pitch reference that can be replayed repeatedly. This format also allows learners to practice without continuous dependence on a teacher to produce the reference pitch. The combination of a structured etude and accurate virtual instruments can provide an effective medium for independent practice while preserving the authentic sonic characteristics of Sundanese karawitan in an accessible digital format.

Several previous studies have attempted to develop digital-based learning media for Sundanese kawih. Previous research has developed kawih learning media in the form of animated instructional videos to develop Sundanese vocal techniques, including pitch accuracy through laras degung etudes [15], [16]. These studies demonstrate the feasibility of using digital media to support the teaching of Sundanese vocal techniques, particularly by presenting instructional content in forms that can be accessed visually and repeatedly. Other studies have examined the application of specific learning models to improve ngawih skills in musical expression and vocal technique [17], [18], [19]. This line of research emphasizes pedagogical strategies and learning implementation, suggesting that ngawih competence can be improved through structured instructional processes rather than performance practice alone. Research on the use of virtual instruments in gamelan composition has also demonstrated the potential of VST technology for traditional music [20], [21], [22], [23]. Taken together, these studies establish three relevant strands of previous research: digital media for Sundanese vocal learning, instructional approaches for developing ngawih competence, and virtual technology for representing traditional gamelan sounds. However, these strands have largely developed separately, leaving limited evidence of how to systematically integrate them into a specifically designed laras degung vocal etude.

The methodological orientation of the previous studies also reveals an important distinction relevant to the present research. Studies on digital kawih media have primarily emphasized the resulting instructional product, whereas studies employing learning models have focused more strongly on the learning process and students' musical competencies. Research involving VST technology, meanwhile, has demonstrated its usefulness for traditional music production and composition but does not directly address developing a structured vocal-learning medium for beginning learners. Consequently, the existing literature provides a foundation for using digital media, etudes, and virtual instruments, but offers limited explanation of how these components can be systematically designed, developed, and evaluated as an integrated learning medium.

This limitation constitutes the research gap addressed in the present study. Existing studies tend to present learning media as completed products without systematically explaining how they made technological decisions or how they designed and developed the media. In addition, ²⁰ expert validation of media feasibility has received limited attention, even though validation is an important stage in determining the quality and applicability of learning media. The gap is therefore both developmental and evaluative. Systematic documentation of the process through which an ICT-based laras degung etude is designed and produced remains limited, as does attention to the feasibility of the resulting medium based on expert evaluation. The absence of a comprehensive study that combines documentation of the ICT-based laras degung etude development process with an examination of its feasibility makes this area important for further investigation. Addressing this gap is particularly relevant because a learning medium for traditional music must satisfy both technological and musical requirements while remaining appropriate for its intended learners.

This study's novelty lies in integrating a laras degung vocal etude, VST-based virtual gamelan instrumentation, and an ICT-based learning medium within a systematic Research and Development process. Rather than treating the digital medium as a finished instructional product, this study documents the design and development decisions behind it and examines its feasibility through expert evaluation. The ¹⁸ study also positions Simon's decision-making framework as a supporting framework for the Design stage of the ADDIE model. Simon's framework is theoretically relevant to this stage because the design process involves identifying a problem, considering alternative solutions, evaluating options, and selecting design decisions appropriate to the instructional objectives and technological context. Thus, the framework provides a rationale for explaining how design alternatives are considered and transformed into concrete characteristics of the developed medium, while ADDIE provides the broader systematic structure for the development process.

Based on the identified problem, research gap, and proposed novelty, this study addresses the following research questions:

1. How is the laras degung vocal etude developed as an ICT-based learning medium using the ADDIE model?
 2. How feasible is the developed laras degung vocal etude medium based on expert evaluation?
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3. How do beginner learners respond to the developed ICT-based laras degung vocal etude medium?

To address this research gap, this study aims to develop a laras degung etude as an ICT-based digital learning medium for Sundanese kawih using a Research and Development approach. Specifically, the study aims to document the medium's systematic development using the ADDIE model, explain the design decisions made during the Design stage through Simon's decision-making framework, and determine the feasibility of the resulting medium through expert evaluation. The study also examines beginner learners' responses to the developed medium as an initial indication of its practical applicability in learning. More specifically, the study documents the media development process, beginning with needs analysis and the design of etude notation and continuing through audio production using music notation software and virtual instruments, while also examining the feasibility of the resulting medium through expert evaluation. By connecting instructional analysis, systematic design, digital production, and expert evaluation, the development process aims to ensure the resulting medium addresses the identified learning problem rather than functioning solely as a technological innovation. The design process is examined through a technology-based decision-making framework to explain the rationale underlying each design choice. With this focus, the study seeks to produce learning media that are not only technically functional but also pedagogically appropriate, musically relevant, and feasible for supporting independent laras degung pitch practice.

This study is expected to contribute to several areas. Practically, the resulting media can serve as an alternative learning resource for students and teachers to practice laras degung pitch accuracy independently and repeatedly. For teachers, the medium may provide a consistent auditory reference that complements classroom demonstrations, while for learners, it may offer opportunities for repeated practice beyond direct teacher supervision. Academically, the study enriches the limited body of research on technology-based learning media for traditional music, particularly in the context of Sundanese vocal arts. Methodologically, the study contributes a documented development procedure that integrates ADDIE with a decision-making perspective to explain the transition from identified learning needs to concrete technological and musical design decisions.

Furthermore, the study contributes to the preservation of intangible cultural heritage by demonstrating how ICT can be strategically utilized to support the continuity of Sundanese musical traditions. The study therefore positions digital technology not as a replacement for traditional musical knowledge, but as a complementary mechanism for extending access to culturally specific learning resources. Thus, this study connects arts education, instructional technology innovation, and cultural preservation within an integrated, mutually reinforcing framework.

9 2. METHOD

2.1. Research Design

This study employed a Research and Development (R&D) approach to produce a learning media product and evaluate its feasibility [24], [25]. The R&D approach was selected because this study focused on systematically developing an ICT-based learning

medium for Sundanese kawih and evaluating the feasibility of the resulting product. ² The development framework adopted was the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation [26], [27], [28]. ADDIE was selected for its systematic, iterative nature, which provides a clear framework for identifying learning needs, designing instructional solutions, developing the product, conducting an initial implementation, and evaluating the resulting medium.

In addition to ADDIE, Simon's decision-making framework was applied specifically during the Design stage. This framework explained the rationale for selecting learning materials, musical structures, software, and technological components from available alternatives. Thus, ADDIE served as the primary procedural framework for product development, while Simon's decision-making framework supported the analysis of design decisions within the Design stage. Figure 2 presents the five stages of the research process.

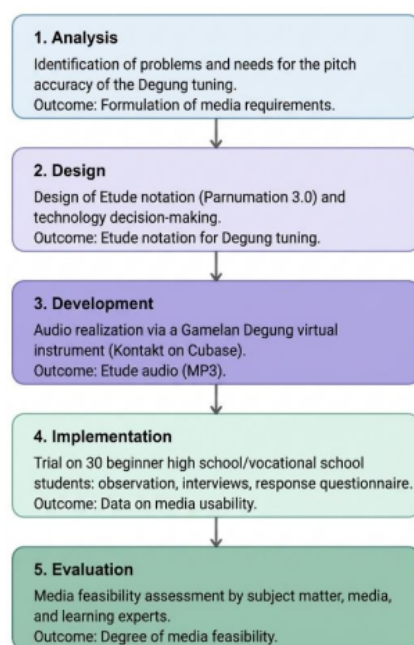


Figure 2. Flowchart of the ADDIE Model Research Stages

2.2. Development Procedures

The media development process consisted of five interconnected stages.

Analysis

In the Analysis stage, the researchers identified learning problems, particularly difficulties in mastering pitch accuracy in laras degung, and analyzed the need for learning media and the availability of supporting equipment. The analysis focused on learners' difficulties in reproducing laras degung pitches, the availability of consistent pitch references, existing learning practices, and the technological resources required to support repeated and independent practice. This information formed the basis for determining the learning medium's characteristics and requirements.

Design

In the Design stage, the researchers designed the Laras Degung etude notation using Parnumation 3.0 software and determined the technological components based on systematic considerations. The design process included determining melodic patterns, pitch sequences, the etude's structure, notation, and technical requirements for audio production. Simon's decision-making framework was applied at this stage to support the selection of appropriate musical and technological alternatives. The main output of this stage was the preliminary design of the laras degung etude and its digital production specifications.

Development

In the Development stage, the design was transformed into an audio product using a virtual degung gamelan instrument in Kontakt within Cubase. The researchers transferred the etude notation into the digital audio-production environment, selected and configured the virtual degung gamelan instrument, arranged the musical material, and produced the audio learning resource. The resulting prototype was subsequently prepared for implementation and expert evaluation.

Implementation

In the Implementation stage, the media were tested with 30 senior high school students who were beginners in Sundanese karawitan to examine their usability for practicing laras degung pitch accuracy. The participants were selected purposively because they represented the intended beginner-user group for the developed learning medium. The participants were senior high school students who were learning Sundanese kawih/karawitan and had limited prior experience with Sundanese karawitan. In this study, beginner learners referred to students who were still at an introductory level of Sundanese karawitan learning and therefore required structured guidance and pitch references when practicing laras degung.

Data at this stage were collected through observations of students during practice sessions, interviews, and participant response questionnaires. The implementation was conducted as an initial trial to examine the practicality of using the medium and learners' responses to the developed product rather than to test its effectiveness through an experimental design.

Evaluation

The Evaluation stage assessed the media's feasibility through expert evaluations. The evaluation considered the suitability of the musical material, tuning accuracy, audio quality, media characteristics, and pedagogical aspects of the developed product. Experts' feedback and implementation findings identified areas for refinement and determined the overall feasibility of the learning medium.

The five ADDIE stages were interconnected, allowing revisions when implementation and evaluation findings indicated the need for improvement. This procedure ensured that the developed medium remained aligned with the learning needs identified during the Analysis stage.

2.3. Research Participants

This study included needs-analysis informants and implementation-trial participants. The needs-analysis informants included a Sundanese kawih teacher, a lecturer specializing in Sundanese karawitan, and a student learning Sundanese kawih. These participants were selected because they represented practitioner, academic, and learner perspectives that were relevant to identifying the requirements of the developed medium. Table 1 presents the informants involved in the needs analysis stage.

Table 1. Needs Analysis Informants

No.	Informant	Expertise/Status	Role
1	Sundanese <i>Kawih</i> Teacher	Practitioner and instructor of Sundanese <i>kawih</i>	Learning needs interview
2	Lecturer of Sundanese <i>Karawitan</i>	Expert in Sundanese <i>karawitan</i> materials and <i>laras</i>	Interview and validation of material needs
3	Student	Learner studying Sundanese <i>kawih</i>	Interview on learning experiences

The implementation trial involved 30 senior high school students who were beginners in Sundanese karawitan. The students participated in the trial to provide initial information regarding their experiences and responses when using the developed *laras degung etude* medium for pitch practice.

Purposive sampling was used for the implementation participants because the study required learners at an introductory level of Sundanese karawitan who were appropriate users of the developed medium.

2.4. Data Sources and Data Collection Techniques

This study collected data from multiple sources to ensure the completeness and credibility of the information. Data collection involved a literature review, interviews, observations, and documentation studies related to the use of ICT and digital learning media for Sundanese kawih. Primary data were obtained from needs-analysis informants, implementation-trial participants, and expert evaluations, while secondary data came from relevant literature and documentation generated during the development process.

Interviews with needs-analysis informants identified learning problems, existing instructional practices, learner difficulties, and requirements for developing the medium. Observations were conducted during the implementation trial to document students' activities, interactions with the medium, and difficulties encountered during practice. The researchers used questionnaires to collect student responses and expert evaluations. Documentation included development artifacts such as etude notation files, digital audio files, and project files generated during production.

To assess the product's feasibility, the researchers used evaluation instruments administered to experts, including experts in Sundanese karawitan and vocal music, instructional media, and learning. Experts from these areas examined the product from complementary perspectives, including musical accuracy, media quality, and pedagogical suitability.

2.5. Research Instruments

The study used four types of instruments: interview guides, observation sheets, student-response questionnaires, and expert-validation instruments. The interview guide identified learning needs, difficulties in learning laras degung, existing learning practices, and expectations regarding ICT-based learning media. The observation sheet documented students' activities and interactions with the medium during the implementation trial.

The student-response questionnaire was used to obtain learners' perceptions of the developed medium after the implementation trial. The questionnaire addressed the medium's attractiveness, ease of use, clarity, usefulness, and ³⁰ potential to support independent practice.

The expert-validation instrument assessed the feasibility of the developed medium from musical, media, and pedagogical perspectives. The assessment included aspects of tuning accuracy, audio quality, suitability of the learning material, technical characteristics of the medium, and pedagogical feasibility.

Because the original study materials do not specify the exact number of items for each questionnaire dimension, this report does not include the number of items to avoid introducing unsupported information.

2.6. Expert Evaluation

Experts in Sundanese karawitan and vocal music, instructional media, ⁴ and learning/pedagogy assessed the feasibility of the developed product. The experts were selected based on their relevant academic and professional expertise in the respective field. ³⁴ Their evaluation focused on determining whether the developed medium was appropriate in terms of musical content, technical/media quality, and instructional suitability.

The expert evaluation was conducted after prototype development and was used to identify strengths and areas requiring revision before the product was considered feasible for use as an ICT-based learning medium.

2.7. Validity and Trustworthiness

¹⁰ The credibility of qualitative findings was strengthened through source and methodological triangulation. Source triangulation was achieved by comparing information obtained from the Sundanese kawih teacher, Sundanese karawitan lecturer, and student. Methodological triangulation was conducted by comparing findings from interviews, observations, and documentation.

²¹ Using multiple perspectives aimed to reduce dependence on a single source and provide a more comprehensive understanding of the learning problem and the requirements of the developed medium. Expert evaluation also provided an external assessment of the product's feasibility from musical, technological, and pedagogical perspectives.

2.8. Data Analysis

³⁷ Data analysis combined qualitative and basic quantitative techniques according to the types of data collected. Qualitative data from interviews, observations, and documentation were analyzed through data reduction, data presentation, and conclusion drawing to describe the media development process [29], [30], [31]. The qualitative analysis was organized

according to the five ADDIE stages to identify learning needs, design considerations, development activities, implementation findings, and evaluation results. We compared and synthesized information from interviews, observations, and documentation to describe the development process systematically.

Expert evaluation data were analyzed quantitatively by calculating feasibility scores for each aspect, including tuning accuracy, audio quality, and pedagogical feasibility, and then categorizing the results according to predetermined feasibility criteria. The expert-validation scores were summarized for each assessment aspect and converted into feasibility percentages. The resulting percentages were then interpreted using the predetermined feasibility categories.

The researchers analyzed student-response questionnaire data descriptively to determine learners' responses to the developed medium. The results served as supporting evidence of the medium's practicality and acceptability during the initial implementation trial.

To enhance the credibility of the findings, the researchers applied source and methodological triangulation by comparing data obtained from different sources and methods. Through this procedure, the research conclusions were based on mutually corroborating evidence and could therefore be justified methodologically.

2.9. Ethical Considerations

The implementation trial involved student participants and was conducted with attention to voluntary participation and confidentiality. Participants were informed about the study's purpose and procedures before data collection, and researchers used participant information solely for research purposes. Personal information was not reported in the presentation of the research findings.

¹⁴ 3. RESULTS AND DISCUSSION

This section presents the study findings according to the ADDIE development stages, including needs analysis, design, development, implementation trial, and expert evaluation. The results are presented together with their interpretation to explain how the identified learning needs informed the design and development of the laras degung etude and how the resulting

3.1. Needs Analysis of Sundanese Kawih Learning Media

The initial needs analysis indicated that mastering pitch accuracy, or intonation, in laras degung is one of the primary difficulties learners face in Sundanese kawih learning. Unlike general singing skills, ngawih requires sensitivity to the distinctive pentatonic pitch system, which many learners may not be familiar with. The interview and observation findings indicated that pitch difficulties were particularly apparent when learners moved between pitches with different interval sizes and when they practiced without a stable auditory reference. Pitch inaccuracies frequently occur, particularly during transitions between pitches and melodic leaps involving wide intervals. These findings indicate that pitch accuracy is not an isolated technical component but an important competency

underlying the quality of laras degung vocal performance. Therefore, mastering pitch accuracy in laras degung requires particular attention and appropriate practice media in the learning process.

The analysis stage identified learners' problems and needs in Sundanese kawih learning, particularly regarding mastery of pitch accuracy in laras degung. Data were obtained through interviews with a Sundanese kawih teacher, a Sundanese karawitan lecturer, and a music student. The three informants represented practitioner, academic, and learner perspectives, respectively. The findings were organized into several recurring needs related to pitch accuracy, interval recognition, access to pitch references, reliance on teacher demonstrations, and the need for repeatable digital practice resources. Table 2 summarizes the needs analysis.

Table 2. Needs Analysis of Sundanese Kawih Learning

No.	Identified Learning Need	Findings from Needs Analysis
1	Difficulty in determining accurate pitches	Learners had difficulty determining and maintaining accurate pitches when practicing Sundanese kawih.
2	Difficulty in recognizing pitch intervals	Learners had difficulties distinguishing and reproducing ascending and descending pitch movements, particularly when the intervals became wider.
3	Limited availability of pitch references	Learning activities relied heavily on teacher demonstrations, limiting learners' opportunities to access consistent pitch references during independent practice.
4	Need for structured and progressive exercises	Learners needed exercises arranged progressively from simple pitch movements to wider intervallic patterns.
5	Need for digital learning support	A digital medium with repeatable audio examples was needed to support individual and repeated practice of laras degung vocal patterns.

Table 2 shows that the three perspectives converged on several major learning needs, particularly difficulty determining accurate pitches in laras degung and limited access to pitch references for independent practice. These findings indicate that Sundanese kawih learning remains highly dependent on the teacher as the primary source of pitch reference. The findings also indicate that learners require opportunities to repeatedly hear and reproduce the characteristic pitch relationships of laras degung beyond direct classroom demonstrations. In addition, difficulties in distinguishing intervals in laras degung were identified as an important learning problem because the interval structure differs from the diatonic pitch system that may be more familiar to learners. This condition indicates the need for learning media that can provide an accurate, consistent, and independently accessible pitch reference.

The qualitative findings can therefore be synthesized into three main themes: (1) difficulty reproducing laras degung pitches, (2) dependence on teacher-provided pitch references, and (3) the need for repeatable digital practice. These themes establish a direct relationship between the learning problem and the requirements of the proposed medium. Rather than introducing technology as an end in itself, the needs analysis positioned technology as a potential response to a specific instructional problem.

One underlying cause of these difficulties is the difference in interval systems between *laras degung* and the diatonic scale with which learners are more familiar. As part of the pentatonic pitch system of Sundanese *karawitan*, *laras degung* has a specific arrangement of pitch intervals (*swantara*) that differs from the interval patterns of Western diatonic music. Learners accustomed to the diatonic scale often struggle to adjust their auditory perception and vocal production to the interval structure of *laras degung*. Consequently, they often produce pitches that deviate from the intended tuning, particularly when an accurate pitch reference is unavailable. This difference in interval systems demonstrates that learning pitch accuracy in *laras degung* requires an approach and learning medium that provide an accurate and consistent auditory reference.

These challenges are further intensified by the limited availability of pitch references in conventional learning, which relies heavily on the teacher's presence. In classroom practice, the teacher generally serves as the primary source of pitch reference by providing direct demonstrations. When learners practice independently outside the classroom, they lose access to this reference, making it difficult to verify the accuracy of the pitches they produce. Dependence on an oral reference that is not always available limits the intensity and independence of practice, even though mastery of intonation requires consistent repetition. The needs analysis consequently identified a mismatch between the requirement for repeated pitch practice and the limited availability of a stable reference outside direct teacher-led instruction.

Based on these findings, a need was identified for practice media that could provide an accurate *laras degung* pitch reference and support independent learning. Ideally, the media should provide consistent *laras degung* pitches that can be replayed repeatedly without requiring a teacher's direct presence. Such media would enable learners to continuously develop their pitch sensitivity and accuracy according to their individual needs. This requirement became the central design specification for the subsequent development stages. The needs analysis also confirms that media development is not merely a technological innovation but a response to real and specific learning problems identified in the field.

The need for an accurate, repeatedly accessible pitch reference aligns with the potential of technology-based learning media. In this context, digital media can complement conventional teacher demonstrations by providing a stable audio resource that learners can access repeatedly during individual practice. Technology-based media can provide consistent and precise audio references that are difficult to achieve through oral demonstrations alone. In the context of *kawih* learning, technology can provide a stable *laras degung* pitch reference while preserving the sonic characteristics of Sundanese *karawitan*. Thus, technology does not replace the teacher but complements the learning process by providing a practice resource learners can access flexibly and continuously.

Overall, the needs analysis established a clear design rationale: learners required a repeatable auditory reference, the medium needed to represent the characteristic sound of *laras degung*, and the resource needed to be accessible beyond teacher-led practice. These requirements directly informed the subsequent design decisions concerning notation, virtual instrumentation, audio production, and media accessibility.

3.2. Design of the Laras Degung Etude Notation and ICT Decision-Making

The design stage is a core component of the media development process because it establishes the technological decisions that determine the media's final form. Designing Sundanese kawih learning media cannot be done arbitrarily; it requires systematic consideration of the learning materials, instructional needs, and available supporting resources. To explain the rationale behind these decisions, this study examined the design process using Simon's decision-making framework, which consists of three phases: intelligence, design, and choice. This framework was selected because it shows how technological decisions develop progressively, from problem identification to solution selection. Its application in this study therefore provided an analytical structure for explaining why particular musical and technological alternatives were selected during the Design stage of ADDIE.

The first phase, intelligence, involves identifying and understanding the problem underlying the decision-making process. At this stage, the researchers identified the learning problems revealed during the needs analysis, namely learners' difficulties in mastering pitch accuracy in laras degung and the limited availability of pitch references in conventional learning. The researchers collected and examined this information to gain a comprehensive understanding of the underlying issues, including the characteristics of laras degung and learners' need for independent practice. At this stage, a comprehensive understanding of the problem is essential to ensure the proposed solution is genuinely relevant to the needs identified in the field. Thus, the intelligence phase ensured that the technological decision originated from an actual learning problem rather than merely from the availability of a particular technology.

The second phase, design, involves identifying, developing, and analyzing alternative solutions that could potentially be implemented. At this stage, the researchers considered several types of media and software that could provide an accurate Laras degung pitch reference. The alternatives were evaluated based on their suitability for representing the required musical notation, accessibility, ease of use, availability, and affordability. These considerations align with instructional technology selection principles that emphasize contextual appropriateness, usability, and cost-effectiveness. Through this analysis, the researchers identified the software best suited for writing the laras degung etude notation. The design phase therefore ensured that the final decision was based on a systematic comparison rather than on an isolated choice without adequate consideration.

The third phase, choice, involves selecting one of the alternatives analyzed during the preceding phase for subsequent implementation. Based on the considerations identified in the previous phase, the researchers selected Parnumation 3.0 to write the laras degung etude notation. Parnumation was selected because it is a numerical notation font that can represent the pentatonic pitch system of Sundanese karawitan, including octave markers using dot symbols. In addition, the notation can be used in common word-processing applications, making it accessible without specialized or complex equipment. This decision became a key factor guiding the overall notation design process. Thus, the choice phase completed the decision-making process by selecting the technology considered most appropriate for the needs and context of Sundanese kawih learning.

After selecting the software, the design process continued with notation for the laras degung etudes using the pentatonic pitch system Da–Mi–Na–Ti–La. The notation used numerical symbols with dot markers to distinguish high, natural, and low octaves, following Sundanese karawitan notation conventions. Parnumation enabled the notation to be presented in a clear, readable format, allowing it to function as an instructional resource for learners. The notation served as the foundation for constructing the melodic patterns practiced in the etudes. Therefore, the notation design functioned not merely as pitch documentation but also as a musical framework that structured laras degung pitch-accuracy training systematically and progressively.

The etudes used progressive interval patterns to develop pitch accuracy systematically, consistent with the principle of an etude as a structured technical exercise. The patterns progressed from simple melodic movements, such as sequential notes within one *gembyang*, to more complex patterns involving wider intervallic leaps. This progressive structure was intended to enable learners to develop pitch accuracy gradually, from basic patterns to more challenging ones. Each pattern had a specific training focus, allowing learners to develop sensitivity to laras degung intervals systematically. This design reflects both musical and pedagogical considerations, positioning the etude as a systematic training resource rather than merely a collection of notation without a clearly defined instructional purpose. Table 3 presents examples of the progressively structured laras degung etude notation.

Table 3. Musical Notation and Etude Patterns of Laras Degung

Etude	Musical Notation	Description
1	1 2 3 4 5 . . . 5 4 3 2 1 . . . da mi na ti la ... la ti na mi da ... 1 2 3 4 5 . . . 5 4 3 2 1 . . . da mi na ti la ... la ti na mi da ...	The melodic pattern in Etude 1 moves downward through five pitches, then upward through five pitches, repeatedly. This pattern aims to develop learners' understanding of, and reinforce, pitch accuracy within one <i>gembyang</i> (octave) of <i>laras degung</i>.
2	1 2 3 . 2 3 4 . 3 4 5 . 4 5 i 5 da mi na.. mi na ti.. na ti la.. ti la da la 5 4 3 . 4 3 2 . 3 2 1 . 2 1 5 1 la ti na ti na mi na mi da mi da la da	In each bar, the melodic pattern in Etude 2 moves downward through three pitches and then upward through three pitches. This pattern provides a variation designed to develop understanding and accuracy in reproducing three-pitch patterns.
3	1 . 3 . 2 . 4 . 3 . 5 . 4 . i . 5 . . . da.. na.. mi.. ti.. na.. la.. ti.. da.. la.... 5 . 3 . 4 . 2 . 3 . 1 . 2 . 5 . 1 . . . la.. na.. ti.. mi.. na.. da.. mi.. la.. da....	In each bar, the melodic pattern in Etude 3 involves downward and upward leaps of two pitches. This variation introduces wider pitch intervals than those presented in the previous etude to strengthen pitch accuracy.
4	1 . 4 . 2 . 5 . 3 . i . 5 . . . da ti mi la na da la 5 . 2 . 4 . 1 . 3 . 5 . 1 . . . la mi ti da na la da	The melodic pattern in Etude 4 involves downward and upward leaps of three pitches (<i>kempyung</i>). This pattern varies Etude 3 and is intended to develop accuracy when reproducing intervals of one <i>kempyung</i>.

Note: The four etudes can be accessed through the audiovisual learning media embedded in the following barcode.



Figure 3. QR code providing access to the audio files of etudes 1–4. The recordings can also be accessed at https://www.youtube.com/watch?v=5M_sUc1RODA.

The four etudes were arranged progressively according to the difficulty of their interval patterns. Etude 1 targets mastery of a one-gembyang range through sequential melodic movement, while Etude 2 focuses more specifically on accuracy in reproducing three-pitch patterns. Etudes 3 and 4 increase the level of difficulty by introducing wider intervallic leaps, culminating in the kempyung pattern in Etude 4. This progression provides a pedagogical sequence that lets learners move from relatively simple pitch relationships to more demanding intervallic movements.

Overall, the design stage demonstrates how technological decisions and musical considerations were integrated into the development of the media. Applying Simon's framework shows that selecting Parnumation was not an isolated decision but the outcome of a progressive process involving problem identification, analysis of alternatives, and selection of the most appropriate solution. At the same time, the design of the etude patterns ensured that the resulting media had a strong pedagogical foundation for developing pitch accuracy in laras degung. The design therefore translated the needs identified in the Analysis stage into concrete musical and technological specifications. Integrating these two dimensions provided a solid basis for realizing the design as digital audio.

3.3. Development of Etude Audio Using Virtual Instruments

The development stage involved transforming the designed etude notation into a usable learning media product, namely digital audio serving as a laras degung pitch reference. At this stage, the notation developed during the design stage was converted into sound using a virtual degung gamelan instrument. This audio realization was essential because an accurate and consistent pitch reference was the central need identified during the analysis stage. The development process utilized Kontakt as the virtual instrument within Cubase as the Digital Audio Workstation (DAW). By combining these two tools, the etude notation was transformed into degung gamelan sounds that could be heard, replayed repeatedly, and used by learners as a reference for independent pitch-accuracy practice.

The development process began with preparing the required hardware and software. The hardware included a computer, an external sound card, and speakers or headphones for

monitoring the quality of the generated sound. The software consisted of Cubase as the Digital Audio Workstation, Kontakt as the virtual instrument, and an appropriate degung gamelan sound library. The Digital Audio Workstation was used to record, edit, process, and produce digital audio, while Kontakt generated and manipulated sampled gamelan sounds. Hardware and software compatibility was essential to ensure a smooth audio production process and to produce sound with appropriate quality and pitch accuracy.

Once the equipment was prepared, the next step was to load the virtual degung gamelan instrument into Cubase through Kontakt. The researchers created an instrument track, selected Kontakt as the sound source, and loaded the degung gamelan sample using the saron instrument specification. The researchers selected the saron as the sound source because of its clear, distinctive pitch characteristics, making it suitable as a pitch reference for vocal practice. The virtual instrument received pitch data and simulated the corresponding acoustic instrument. Thus, learners could access a degung gamelan sound resembling the original instrument without requiring a physical gamelan ensemble during practice.

The next step involved entering the previously designed etude notation into the virtual saron instrument according to the predetermined rhythmic and melodic patterns. Each etude was entered on a separate track to facilitate audio editing and management. Separating the tracks allowed each etude pattern to be managed independently, so that any pitch or rhythmic errors could be corrected without affecting the other etudes. This systematic track arrangement also helped organize the overall practice structure. Through careful input and verification, the numerical notation of the etudes was transformed into musical data ready to be rendered as audio while maintaining pitch accuracy according to the laras degung tuning system.

After entering all notation and verifying its accuracy, the final stage involved rendering the musical data into an accessible audio file. The MIDI output from the virtual instrument was rendered as audio and exported as an MP3 to facilitate playback across various devices. This format was selected for its small file size and broad compatibility, allowing learners to access the media conveniently in different contexts. The exported files constituted the final laras degung etude audio product, which could function as a pitch reference for practice. The availability of these audio files marked the completion of the development stage, turning the initial design into a concrete, functional learning product. Figure 4 shows the digital realization of the etude in Kontakt.



Figure 4. Digital display of Sound Etude 1 in Cubase

The development results demonstrate the technical feasibility of converting the designed numerical notation into a digital audio resource. However, because no objective acoustic measurement of tuning frequency or cent deviation was conducted, the term “pitch accuracy” in this section refers to conformity with the intended musical design and the subsequent expert assessment rather than an independently verified acoustic measurement.

Virtual instruments enabled the presentation of degung gamelan sounds that were consistent and repeatedly accessible while retaining relevant acoustic characteristics. For learning, this consistency offers an advantage over a pitch reference that must be generated manually for every practice session. At the same time, using sampled gamelan sounds allows the media to retain the characteristic timbre of Sundanese karawitan, enabling learners to practice with sounds that resemble those of the actual instruments. The resulting medium therefore combines repeatable digital access with a sound representation associated with Sundanese karawitan.

Furthermore, successfully realizing the laras degung etudes through virtual instruments demonstrates the potential of VST technology to support the preservation of traditional music. Previous studies have shown that virtual instruments can reproduce gamelan sounds in digital music production without requiring physical instruments. In the present study, this technology does not replace the actual degung gamelan; rather, it expands access to its sounds for educational purposes. Thus, virtual instruments bridge tradition and technology, keeping the distinctive sonic heritage of Sundanese karawitan accessible to digital-generation learners. The contribution of the present development therefore lies in adapting virtual-instrument technology to a specific instructional need in Sundanese kawih learning.

3.4. Media Trial in the Learning Process

After developing the etude audio product, the media were tested with 30 students in a music-learning context to examine their practical use and learner responses in an actual

practice setting. During the trial, the media served as a pitch reference for laras degung pitch-accuracy practice, allowing the researchers to observe how students used the media directly during the learning process. This stage was important because it allowed the researchers to examine the needs identified during the analysis stage—namely, an accurate, consistent, and independently accessible pitch reference—in practice, as learners used the media in an authentic learning situation.

The findings from the trial are distinguished between observed behavior and self-reported responses. Observational data describe what students demonstrated during practice, whereas interview and questionnaire data describe students' perceptions of the medium. This distinction is important because positive learner responses do not, by themselves, demonstrate improvement in pitch accuracy.

Table 4. Observed Student Behavior During Media Trial (N = 30)

No.	Observation Indicator	n	Percentage (%)	Interpretation
1	Students were able to follow the etude patterns during practice	22	73.3	Most students were able to follow the practice patterns
2	Students were able to practice independently after repeated exposure	20	66.7	Most students demonstrated emerging independent practice
3	Students required assistance when practicing wider intervallic leaps	8	26.7	Some students still required teacher scaffolding

During the trial, the researchers observed students' activities while using the etude media as a practice reference. The observations focused on how students followed the laras degung sounds, matched their pitch production with the audio playback, and repeated the exercises independently without continuously relying on teacher guidance. Of the 30 students, 22 (73.3%) followed the etude patterns during practice, while 20 (66.7%) repeated the exercises independently after several repetitions. These observations indicate that the medium served as a usable practice reference for a substantial proportion of participants.

Nevertheless, 8 of the 30 students still required assistance when practicing etude patterns involving wider intervallic leaps, particularly during the initial stages of media use. This finding is pedagogically important because it indicates that repeated digital audio exposure does not necessarily eliminate the need for teacher scaffolding, especially when learners encounter more demanding intervallic patterns. The result suggests that the developed medium is better positioned as a complement to teacher guidance than as a complete replacement for teacher-led instruction.

The student-response data provided a complementary perspective. In addition to observation, the researchers collected students' responses through brief interviews and a response questionnaire after the practice session. Overall, the students reported that the degung gamelan sounds were clear, easy to follow, and helpful for understanding pitch accuracy in laras degung. Students also reported that they could replay the media as needed, making practice more flexible than relying solely on teacher demonstrations in the classroom. The questionnaire results showed an average response score of 88.7%, categorized as very positive, as presented in Table 5.

Table 5. Overall Student Response to the Developed Media (N = 30)

No.	Assessment Result	Percentage (%)	Interpretation
1	Overall student response to the developed media	88.7	Very Positive

Because the available results report only the overall questionnaire percentage and does not provide item-level or dimension-level scores, this report does not include separate percentages for attractiveness, ease of use, clarity, usefulness, or other indicators. Reporting fabricated indicator-level values would not be methodologically appropriate.

The combination of observational and self-reported findings suggests that the medium was well received and usable for initial practice. However, the results should not be interpreted as evidence that the medium improved students' pitch accuracy because no pre-test/post-test measurement or objective acoustic assessment of learner performance was conducted.

The trial results indicate that the laras degung etude media provided a usable practice resource and received positive responses from the student users. These findings suggest that the media were not only conceptually appropriate at the design stage but also demonstrated practical usability in an actual learning context. Nevertheless, the trial in this study was limited in scope and was intended to examine media usability rather than measure its effectiveness in improving learners' abilities through statistical analysis. The finding that eight students still required assistance with wider intervallic leaps further indicates that the medium should be integrated with appropriate teacher scaffolding, particularly for more difficult melodic patterns.

3.5. Media Feasibility Based on Expert Evaluation

The evaluation stage assessed the feasibility of the laras degung etude media before broader implementation in the learning process. The assessment involved experts with relevant competencies, including Sundanese karawitan and vocal music experts, instructional media experts, and learning experts. Each expert evaluated the media using an assessment instrument covering several aspects, namely tuning accuracy, audio quality, and pedagogical feasibility, based on a predetermined rating scale. The scores obtained were then calculated and categorized according to established feasibility criteria. This assessment procedure aimed to ensure that the developed media were not only technically functional but also met academic standards for musical content, audio quality, and pedagogical suitability.

The assessment used a four-point scale (1–4), with the feasibility percentage calculated by comparing the total score with the maximum possible score. The results were categorized as very feasible (81–100%), feasible (61–80%), moderately feasible (41–60%), less feasible (21–40%), and not feasible ($\leq 20\%$).

Table 6. Results of Expert Evaluation of Media Feasibility

Aspect	Total Score	Maximum Score	Percentage	Category
Tuning Accuracy	45	48	93.8%	Very Feasible
Audio Quality	31	36	86.1%	Very Feasible
Pedagogical Feasibility	42	48	87.5%	Very Feasible
Overall Average	118	132	89.4%	Very Feasible

The evaluation results show that the media achieved high feasibility in tuning accuracy and audio quality, as shown in Table 6. Regarding tuning accuracy, the media obtained a score of 93.8%, categorized as very feasible. This result indicates that the experts judged the notation and generated audio to be sufficiently consistent with the intended laras degung musical material for instructional use. Because the study did not conduct independent acoustic measurements, this result should be interpreted as an expert-based feasibility judgment rather than objective proof of tuning precision.

Regarding audio quality, the media obtained a score of 86.1%, also categorized as very feasible, with the degung gamelan sounds considered clear and stable, which is important for supporting learners' auditory sensitivity. The positive evaluation suggests that the audio presentation was suitable for repeated use as an auditory reference.

The media also received a positive evaluation for pedagogical feasibility, with a score of 87.5%, categorized as very feasible. The experts considered the progressively structured etude patterns consistent with the principles of systematic practice, progressing from simpler patterns to more complex ones. This structure supported learners' gradual, focused development of pitch accuracy. The results align with the observation that wider intervallic patterns were more challenging for some learners, indicating that progressive sequencing is pedagogically relevant to the characteristics of beginning learners.

In addition, the media were considered suitable for independent practice, thereby addressing the need for a pitch reference that does not depend entirely on the direct presence of a teacher. Overall, the media received an average feasibility score of 89.4%, categorized as very feasible, indicating strong expert-rated feasibility across musical, audio, and pedagogical dimensions.

These feasibility findings strengthen and complement previous research on digital-based learning media for Sundanese kawih. Previous studies have generally focused on media production without systematically examining their feasibility. By incorporating an expert validation stage, the present study addresses this gap and provides a stronger basis for evaluating media quality before broader implementation. The findings also align with studies showing the potential of virtual instruments to reproduce gamelan sounds for various musical purposes [32], [33]. This study extends this line of work by applying virtual-instrument technology to a structured vocal-training medium and documenting its feasibility through expert evaluation.

The findings also reveal an important pedagogical implication. Although the overall expert evaluation was very positive, the implementation trial showed that 8 of 30 students (26.7%) still required assistance when working with wider intervallic leaps. This finding suggests that digital media can provide a stable, repeatable pitch reference, but it should not be interpreted as eliminating the teacher's instructional role. Teacher scaffolding remains important when learners encounter more complex intervallic relationships or require individualized correction.

The combined results therefore show a coherent relationship across the development stages. The needs analysis identified the lack of an accessible and repeatable pitch reference; the Design stage translated this need into progressively structured etudes and a specific technological solution; the Development stage transformed the notation into digital audio

using virtual instruments; the implementation trial demonstrated positive practical use and learner responses; and expert evaluation indicated very high feasibility.

3.6. Summary of Key Findings and Implications

The principal findings can be summarized in four points. First, the needs analysis identified pitch accuracy, interval recognition, and limited access to independent pitch references as central problems in learning laras degung. Second, the Design stage produced four progressively structured etudes and selected Parnumation 3.0, using Simon's decision-making framework, to support the notation process. Third, the implementation trial showed that 22 of 30 students (73.3%) could follow the etude patterns and 20 of 30 students (66.7%) could practice independently after repeated exposure, while 8 students (26.7%) still required assistance with wider intervallic leaps. Fourth, expert evaluation produced an overall feasibility score of 89.4%, categorized as very feasible.

These findings have both practical and theoretical implications. Practically, the developed medium can complement teacher-led instruction by providing a repeatable auditory reference for individual practice. Theoretically and methodologically, the study demonstrates how the ADDIE framework can be combined with Simon's decision-making framework to document the transition from an identified instructional problem to concrete musical and technological design decisions. The findings also indicate that technology-based traditional-music learning should be understood as a complementary approach: digital resources can expand access and practice opportunities, while teacher guidance remains important for addressing individual difficulties and more complex musical patterns.

The study has several limitations. The implementation trial involved only 30 students and was designed as an initial media trial rather than an effectiveness experiment. Consequently, the positive learner responses and observed practice behaviors cannot be interpreted as evidence of improvement in pitch accuracy. In addition, experts evaluated tuning accuracy rather than independent acoustic measurement. Future research should therefore examine the medium's effectiveness using objective pitch-accuracy measures, compare learning outcomes before and after the intervention, and investigate how teacher scaffolding can be integrated with digital etude practice, particularly for wider intervallic patterns.

4. CONCLUSION

This study developed and initially validated an ICT-based laras degung vocal etude to support Sundanese kawih pitch practice. The developed resource demonstrated high feasibility based on expert evaluation and received very positive initial responses from beginner learners, indicating that it is accessible and suitable for supporting independent practice. However, these findings reflect feasibility and initial usability rather than proven educational effectiveness.

The study contributes a culturally relevant digital learning resource that integrates laras degung materials with virtual-instrument technology, supporting flexible practice while contributing to the digital preservation of Sundanese musical heritage. The findings are limited by the small implementation sample, limited expert validation, uncertain

generalizability, potential self-report bias, and the absence of objective pre-test/post-test pitch-deviation measurements. Future research should employ experimental or quasi-experimental pre-test/post-test designs with comparison groups and objective pitch-deviation measures, including comparisons between virtual-instrument practice, teacher-led instruction, and physical gamelan accompaniment. Validation across different schools, learner proficiency levels, and Sundanese tuning systems is also recommended to examine transferability.

This study's principal contribution is an accessible digital resource for independent laras degung pitch practice that supports both music learning and the digital preservation of Sundanese musical heritage.

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