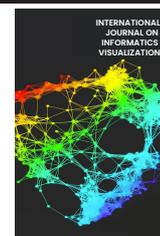




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## Design and Development of Sound and Rhythm Perception Assessment Application for Students with Hearing Impairment

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**Abstract**— Technology use is becoming increasingly popular in life, including in educational aspects. Some widely used applications in education include metaverse, blended learning, game learning, cloud-based learning, mobile applications, and social media learning. Apps are generally in the form of software applications or programs designed to run on smartphones. In this study, we propose using applications in assessing children with hearing impairments at school. Design and Development of the Sound and Rhythm Perception Assessment Application uses the ADDIE development model of Analysis, Design, Development, Implementation, and Evaluation. The test subjects in this study were validation test subjects consisting of 3 experts to test the feasibility of the application. Data was collected through a questionnaire in the form of a tool tested for validity and reliability with a score of 90.1% for learning design, 88.9% for layout, and 94.7% for software. Validation was carried out through focus group discussions. The application was tested on four teachers who teach students with hearing impairments. The results of the main field experiment show that teachers can use the application to help them assess students with hearing loss. With availability, the accuracy of the Design and Development of the Sound and Rhythm Perception Assessment Application can be further improved by conducting training with more teachers who teach children with hearing impairments at school.

**Keywords**— Sound; rhythm; assessment; hearing impairments; application.

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### I. INTRODUCTION

Nowadays, all areas of life are expected to advance and develop. This development is also accompanied by technological advances that continue to advance, sometimes too rapidly. Almost everyone has used and utilized technology in life, including in educational aspects. Some widely used applications in education include metaverse, blended learning, game learning, cloud-based learning, mobile applications, and social media learning. Apps are generally software applications or programs designed to run on smartphones. App examples always offer various specialized platforms that can be downloaded: Apple App Store, Google Play (Android Market Place), Nokia Ovi Store, Windows Phone Marketplace, and Amazon App Store [1]. Technology has penetrated through education and is used in students' learning. Education is one of the most important aspects of national development. History shows that the key to the successful development of developed countries is the educated population in a sufficient number of types and levels [2]. Mobile devices and applications often help solve work-

related challenges and tasks that assist users in being more productive and efficient [3]. Based on this, the trend of learning to use electronics is also increasingly being developed. One of the technologies used in education is mobile phones. Mobile phones can support various learning processes as media and learning resources. Until now, schools have used numerous applications, including the Zoom application [4], which helps online meetings between teachers and students. WhatsApp is commonly used to conduct meetings or discussions by creating groups, e-learning, helping teachers and students with subject matter at school [5], and also Android games that help broaden students' vocabulary [6].

Many people utilize communication media to express their emotions and ideas and deliver information [7]. Other apps, such as Instagram, also work similarly to WhatsApp and other apps teachers use to aid the learning process in specialized classrooms for deaf students. Hearing loss is a health condition that results in hearing deficits. This condition impacts daily activities and physical functioning [8], [9]. More than 5% of the world's population has hearing

impairments. To overcome the obstacles that hearing-impaired people face, various sign languages have been developed as easy and efficient means of communication [10], [11]. People with hearing loss can also not distinguish frequencies, which could impair speech perception [12], [13]. Hearing loss is a common childhood disorder and is one of the most common disabling congenital disabilities [14], [15]. Less than 10% of those with hearing loss worldwide use hearing aids. Hearing should be stimulated in both ears as much as possible for the brain to function as a functional development of the auditory pathway [16], [17].

A special needs school for hearing-impaired students requires a type of assessment to determine the range of the students' ability so that the teacher can help the student by providing topics and activities that suit the student's needs and maximize the remaining hearing that the child has. Students with hearing loss can also have access to education in inclusive schools [18]. In Indonesia, inclusivity development has been keeping track of advancements from around the world, starting with Scandinavian countries, which implemented inclusive education, followed by the United States and then the United Kingdom. In 2004, Indonesia held a national convention, which resulted in the 2004 Bandung Declaration, which established Indonesia's inclusivity towards education [19]. Loss of hearing will lead to insufficient development of vocabulary, grammar, world knowledge, pragmatic skills, and age-appropriate social interaction [20], [21]. Students with hearing loss show a decline in learning and social skills due to difficulties speaking and acquiring sound-based information, especially in challenging auditory situations, such as noisy environments or in tracking sound-based clues and information [22]. Lack of or limited access to spoken language, especially at a young age, actively affects language and communication skills and has implications for educational success in children with hearing loss [23], [24]. Communication with people who are deaf or hard of hearing and hearing-impaired is typically through (i) Manualism and Oralism. Manualism is a finger spelling technique to represent words and concepts, and (ii) Oralism is an auditory training with a high-pitched voice and lip reading [25]. Total hearing loss usually results in a delay or lack of speech and language acquisition, depending on the situation at each home, and often causes a delay in the development of sign language, which is a visual-spatial language that does not correspond to the native spoken language [3], [26]. The subject material that most affects a student's hearing level is literacy, such as understanding the mastery of the principles of the alphabet, i.e., the intuition that graphemes (letters or groups of letters) correspond to "letter sounds" or, more precisely, to phonemes [2], [27].

Any student who often experiences problems in perceiving sound and rhythm is a student with hearing impairment. Hearing-impaired students experience obstacles in hearing because they cannot hear sounds perfectly. WHO defines normal hearing when the Pure Tone-Average (PTA) is less than 25 dB HL [28]. Rhythm incorporates more than just time differences [29]. Audiogram sound power or intensity, measured in decibels (dB), is the physical dimension of sound that primarily corresponds to the perceptual dimension of noise [30]. Teachers use music therapy to improve students' hearing ability [31]. Recently, sign language translation

systems based on image processing, or sensor-embedded hand signals, have been developed to aid communication between the deaf and non-hearing impaired [32]. Hearing is a very sensitive alert system, meaning that irrelevant sounds can interrupt activities. It gets difficult for hearing-impaired individuals to concentrate, and if the warning system is not sensitive enough, it could be threatening when important alert sounds are not noticed. Another important task of the auditory system is communication [33].

A person can develop hearing loss before, during, or after birth. The restrictions of hearing loss are not only limited to very severe but include all levels of hearing loss, from mild to moderate to severe [34]. One study evaluated the impact of literacy on phoneme perception. This study involved 47 adults as samples. The results showed that the literacy level significantly affects one's ability to detect phonemic categories accurately [35]. Learning by listening to rhythms has also assisted athletic movements in the body [36], [37]. Reduced rhythm perception may be related to difficulties synchronizing movements with rhythm and may determine how much students benefit from rhythm training [38].

The lack of rhythmic movements in students with hearing loss in BKPBI learning leads to a lack of deep rhythmic movements; highly rhythmic movements are essential in BKPBI learning to maximize hearing and control rhythmic movements [39]. Children with rhythm hearing loss rely mostly on visual information or tactile stimulation; rhythm and coordination training experiences with children with hearing loss can be enhanced by using digital games or applications developed to entertain and achieve additional training goals [40], [41]. In addition, we also found that the results of another study showed a relationship between paced motor tapping, auditory rhythmic processing, and written language development. This study was conducted on 40 ten-year-old students. Twenty-five students had been diagnosed with a literacy disability issued by a qualified psychologist [42]. Of the existing studies, none discussed the application of the Communication Development Perception of Sound and Rhythm (PKPBI) assessment in deaf students. PKPBI assessment can be done manually by writing on paper. However, a PKPBI assessment application can assist assessors in carrying out PKPBI assessments. In this study, we have utilized four teachers in different special schools, all teaching children with hearing loss.

## II. MATERIALS AND METHOD

A sound and rhythm perception assessment application were developed to assess the ability of students with hearing loss. This research aims to design an application that can assist teachers in assessing students with activities related to sound and rhythm perception. This study uses the research and development method as a tool to collect data with the ADDIE Model. The ADDIE model consists of a five-phase approach: analysis, design, development, implementation, and evaluation. Fig.1 shows the steps to develop this application using the ADDIE model.

The suitability of sound and rhythm perception assessment applications in this study was measured using assessments from professionals such as material and media experts. This process aims to determine the strengths and weaknesses of the application. The results obtained by the expert assessment are

used as a reference in revising the developed application. The application trial was conducted by four special schoolteachers who teach hearing-impaired students. Teachers with hearing-impaired students will benefit from this application more than teachers who teach non-hearing-impaired students. The content contained in the app leans more toward testing students' abilities, including sound and rhythm perception.

The data that has been obtained is then analyzed qualitatively and quantitatively - qualitative data analysis in the form of data interpretation and processing suggestions from validators for product revision. Quantitative analysis processes data in numbers contained in the validation sheet, practicality questionnaire, and pretest and post-test results (Wilcoxon test). Table 1 shows the measurement of product feasibility through the validation sheet using a rating scale.

TABLE I  
RATING SCALE FOR VALIDATION SHEET

Quality	Score
Very Good	5
Good	4
Not Good	3
Poor	2
Very Poor	1

### III. RESULTS AND DISCUSSION

#### A. Analysis Stage

This stage of analysis is carried out to find out the problems and requirements in the assessment. Table II shows the steps of the analysis conducted.

TABLE II  
PRODUCT REQUIREMENT ANALYSIS

Identification	Needs	Solution
Teacher's needs	Based on the interview results, it is visible that teachers assess hearing-impaired children's perception of sound and rhythm through manual instruments (sheets) by providing a manual checklist.	Developing a Sound and Rhythm Perception Assessment App for Students with Hearing Loss
Teacher's characteristics	Based on the results of interviews conducted with principals, the demand for teachers to teach and fulfill administrative duties makes it difficult for teachers to conduct assessments quickly and accurately.	Developing an application that can speed up the assessment process.
Purpose of assessing sound perception	Teachers can assess deaf students' abilities in sound and rhythm perception.	Developing an application that has a better assessment process than manual assessment.

Based on the analysis stage, it is necessary to develop a Sound and Rhythm Perception Assessment Application for

deaf students that can conduct the assessment process quickly and accurately.

#### B. Design Stage

Based on the results of the analysis that has been conducted, an alternative solution to assist teachers in conducting communication and rhythm assessments has been designed using Android Studio Artic Fox. The design of the application begins with a material review, media design, and assessment instrument design.

1) *Material review*: The materials used for deaf children concern competencies in BKPBI, including phoneme pronunciation, word pronunciation, sounds, and language.

2) *Media design*: Media design begins with creating a storyboard containing an application design outline. This application is equipped to run on a smartphone, with the main page containing several menus according to the material used. These include competency tests that contain instruments used by teachers in assessing deaf students, sound tests that can be used to measure students' hearing skills, achievement charts in the form of assessment scores, and personal data that shows student profiles.

3) *Assessment instrument design*: The last stage is instrument preparation; the instruments are divided into two, namely, product assessment instruments and knowledge assessment instruments. The product assessment instrument was in the form of a validation questionnaire for media experts and material experts. The student knowledge assessment instrument was prepared as a pretest and posttest to measure the teacher's abilities at the start and after the assessment was carried out using the BKPBI application.

#### C. Development Stage

The application development process begins with analyzing the challenges found in special education schools. Assessments are the main tool used by teachers in special schools. Each assessment result requires a process to conclude that it suits the student's ability. The many instrumental items that must be used in the assessment will require a longer time in the process. System performance can be improved by using a more diverse training data set. A significant development would also be implementing and testing the system in a standalone platform or as an application for mobile phones [43]. This application will give teachers more time that can be used for other learning activities at school. It may be used as a solution for teachers to save time when processing assessment results and carry out the task faster than before [44]. Each app designer has a different way of thinking, background, and approach, so the resulting display design is unique [45]. The creation of the sound and rhythm perception assessment application consists of several components. In Fig. 1, we can observe the initial presentation of the application's main menu. As envisioned in our pre-designed storyboard, this main menu features multiple options. Specifically, users can access menus such as Competency Test, Voice Test, Achievement Diagram, and Personal Data.



Fig. 1 The Main Menu of the Perception of Voice and Rhythm Assessment Application

Fig. 2 depicts the competency test menu, encompassing phoneme pronunciation, word pronunciation, voice, and language assessments.



Fig. 2 Competency Test - Voice and Rhythm Perception Application

Furthermore, Fig. 3 displays the sound test menu, designed to gauge ambient sound levels for teacher assessments. This test employs decibels (dB) as its unit of measurement.



Fig. 3 Sound Test - Sound and Rhythm Perception Assessment

Fig. 4 presents the menu within the achievement diagram. The achievement chart showcases the results of administered tests and serves as the foundation for crafting interventions for students with hearing impairments.

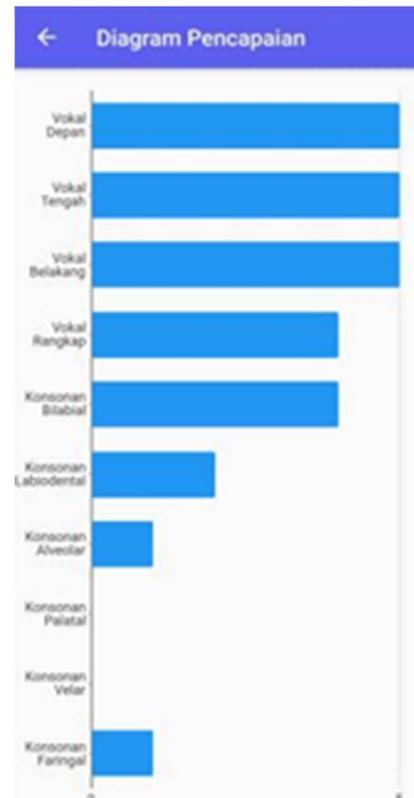


Fig. 4 Achievement Chart

Fig. 5 exhibits the child's identity menu, comprising name, class, and school information. This identity streamlines the process for teachers to group children by class and school, facilitating the classification of their abilities. The viability of implementing the sound and rhythm application can be assessed by engaging various experts in the field of materials and media. This evaluation aims to ensure that the resultant application is well-suited for integration into the assessment process. The validation phase involves the utilization of assessment tools and rating scales. According to the feedback provided by experts specializing in materials and media, the sound and rhythm application received a favorable evaluation score. Nevertheless, some enhancements are still required, including adding a primary menu and a seamless transition menu from the assessment instrument to the main display menu.



Fig. 5 Child Identity

Table III exhibits the expert assessments, with individual scores provided for reference.

TABLE III  
EXPERT ASSESSMENT SCORES

Material Aspects	Components	Percentage (%)	Average
Learning design	Material relevance	96	90.1
	Objective relevance	84.1	
Layout	Text	92.7	88.9
	Graphics	91.4	
	Audio	82.7	
Software	Compatibility	98	94.7
	Effectiveness	91.4	

#### D. Implementation

The creation and development of an application geared towards evaluating sound and rhythm perception in students with hearing impairments encompass the following components:

1) *Hardware Configuration*: The hardware setup comprises an Intel Core i3-6006U CPU operating at a speed of 2.0 GHz, 8.00 GB of RAM, a 64-bit operating system, a 1024 GB hard drive, and a 120 GB SATA SSD.

2) *Software Environment*: The software ecosystem includes the Windows 10 Operating System (64-bit), the use of Android Studio Arctic Fox for application development (version 2020.3.1), and the adoption of Dart as the programming language within the Flutter framework.

The development of this assessment application for sound and rhythm perception, integrated into digital learning [46], revolves around assessing students' proficiency in comprehending sound and rhythm. Its primary objective is to aid educators in evaluating the aptitude of students with hearing impairments. After an evaluation by a panel of experts, the next phase entails incorporating improvements based on

their feedback. An effective application offers user-friendliness and tangible advantages. To gauge sound and rhythm perception among students with hearing impairments, the educator conducted a trial run of the application in four specialized schools, subjecting it to testing by a group of four hearing-impaired students. The outcomes stemming from the evaluation of hearing-impaired students reveal a discernible disparity in their sound and rhythm perception capabilities before and after utilizing the application as shown in Fig. 6 below.

#### Wilcoxon Signed Ranks Test

		Ranks		
		N	Mean Rank	Sum of Ranks
Post Test - Pre Test	Negative Ranks	0 <sup>a</sup>	.00	.00
	Positive Ranks	4 <sup>b</sup>	2.50	10.00
	Ties	0 <sup>c</sup>		
	Total	4		

- a. Post Test < Pre Test  
b. Post Test > Pre Test  
c. Post Test = Pre Test

#### Test Statistics<sup>a</sup>

		Post Test - Pre Test
Z		-1.841 <sup>b</sup>
Asymp. Sig. (2-tailed)		.066

- a. Wilcoxon Signed Ranks Test  
b. Based on negative ranks.

Fig. 6 Sound and rhythm perception capabilities

#### E. Evaluation

The evaluation entails a thorough examination of the merits and demerits of media usage. One drawback of the developed application is the potential for enhancing sound test measurements. The presence of background noise can significantly impact the accuracy of sound test results. Typically, sound detection measurements are conducted within a controlled environment, such as a specialized room, to minimize external noises that might interfere with the testing outcomes. Researchers often rely on this evaluation as a reference point for future application enhancements aimed at achieving superior functionality compared to the current version.

#### IV. CONCLUSION

This instrument application was crafted to evaluate sound and rhythm perception in individuals with hearing impairments. The research adopts the ADDIE methodology, encompassing stages of analysis, design, development, implementation, and evaluation. In the analysis phase, various aspects are considered, including the assessment of educators' requirements, an evaluation of materials related to sound and rhythm perception among those with hearing loss, and scrutiny of assessment objectives. The design phase entails preparations for materials, media design, and instrument development. The application undergoes creation, validation, and revision during the development phase. The implementation phase encompasses a trial involving four educators as research participants. Lastly, the evaluation phase encompasses an all-encompassing appraisal of the

product, accompanied by an elucidation of its strengths and weaknesses.

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