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An Analysis of University Students' Understanding of Phonological Sound Change in Digital Media–Based Phonology Learning

Anin Asnidar[1], Junaid[2]

[1]Prodi Pendidikan Bahasa dan Sastra Indonesia, Universitas Muhammadiyah Makassar, Indonesia
[2]Prodi Pendidikan Bahasa Inggris, Universitas Muhammadiyah Makassar, Indonesia

*email Correspondence: aninasnidar@unismuh.ac.id

Abstracts

Phonological sound change is a crucial aspect of phonological studies that must be mastered by students of linguistics and language education. Along with technological advancements, digital media are considered to contribute significantly to the mastery of phonological materials due to their interactive and multimodal characteristics. This study aims to describe students' levels of understanding of phonological sound changes after participating in digital media–based phonology learning. The study employed a descriptive quantitative research design involving 30 students from the Indonesian Language and Literature Education Program. Data were collected through an objective test that had been examined for validity and reliability. Data analysis was conducted using descriptive statistics by calculating mean scores, percentages of understanding levels, and categories of comprehension. The results indicate that the majority of students achieved a high level of understanding of phonological sound changes, with a mean score of 83.5 on the comprehension test. These findings suggest that digital media are effective in enhancing students' understanding of phonological sound change concepts. Pedagogically, the results highlight the importance of integrating digital media into phonology instruction to improve students' linguistic competencies.

Keywords: Phonology; Sound Change; Digital Learning Media; Language Education

1. Introduction

Phonology is a branch of linguistics that examines the sound system and structural organization of sounds in language. One of the central concepts in phonological studies is phonological sound change, which includes processes such as assimilation, dissimilation, epenthesis, sound deletion, and neutralization. These processes illustrate how speech sounds dynamically interact and transform within actual spoken contexts, influenced by phonetic environments, articulatory constraints, and linguistic patterns (Khan & Jafree, 2022). Through the analysis of sound change, phonology provides a systematic framework for understanding how abstract sound units operate in real language use. A solid understanding of phonological sound change constitutes a fundamental competency for students of language and linguistics. This knowledge plays a crucial role in linguistic analysis, supports the development of advanced phonological studies, and contributes to effective language teaching practices (Mensah et al., 2023) (Gala & Kulkarni, 2023) (Fatahillah & Faradillah, 2023). In educational contexts, mastery of sound change processes enables future language

educators to explain pronunciation patterns more accurately, address learners' phonological difficulties, and design instructional strategies grounded in linguistic theory. Therefore, phonological competence, particularly in understanding sound change phenomena, is essential for both academic inquiry and practical language instruction (Yoorubsuk & Maneewan, 2022).

Previous studies have examined phonological sound change processes within the context of Indonesian grammatical reduction as part of phonological analysis; however, these studies have not emphasized the integration of digital media in the learning process (Fathira et al., 2024). In fact, the rapid development of digital technology has created innovative opportunities in language learning, including the field of phonology. Digital media such as interactive videos, learning applications, and online platforms enable phonological materials to be presented through both visual and auditory modes, thereby assisting students in understanding sound patterns and sound change phenomena more concretely (Pratiwi & Setiawan, 2023). Through articulatory visualizations, animations of sound production processes, and authentic audio examples, students are able to connect phonological theory with the actual realization of sounds in spoken language. This approach aligns with the principles of multimedia learning, which emphasize the integration of visual and auditory channels to enhance conceptual understanding, particularly when dealing with abstract linguistic content such as phonological sound change.

The use of learning applications and online platforms enables more active interaction between students and instructional materials. Features such as self-paced exercises, immediate feedback, and repeated exposure to content provide students with opportunities to continuously test and reflect on their understanding. In the context of phonology learning, these features contribute to students' ability to identify and analyze various types of phonological sound change in a more systematic manner. Consequently, digital media function not only as tools for information delivery but also as learning environments that support students' cognitive processes in developing a deeper understanding of phonological phenomena.

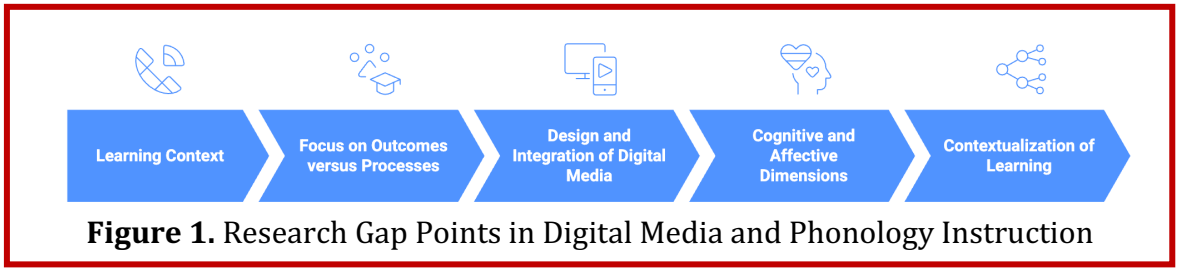

Figure 1. Research Gap Points in Digital Media and Phonology Instruction

The figure illustrates key research gaps in the use of digital media for phonology instruction by highlighting five interconnected dimensions. It shows that existing studies are largely situated in second or foreign language learning contexts, leaving limited evidence from Indonesian phonology instruction. Moreover, prior research tends to prioritize learning outcomes rather than examining instructional processes in depth. The figure also emphasizes that digital media are often used merely as supplementary tools, with insufficient attention to their systematic design and integration into phonological learning frameworks. In addition, while cognitive outcomes have been widely investigated, affective aspects such as motivation, confidence, and learner engagement remain underexplored. Finally, the figure indicates

a lack of contextualized research that situates digital media use within authentic and sustainable learning environments. Collectively, these gaps underline the need for more comprehensive and context-sensitive studies on digital media–based phonology instruction.

This study offers a novel contribution by focusing not merely on the use of digital media in language learning, but on the measurement of students' conceptual understanding of specific phonological sound change processes, namely assimilation, neutralization, and epenthesis. Unlike the majority of previous studies that predominantly emphasize pronunciation accuracy, phonological awareness, or speaking performance, this research positions phonological sound change as a core analytical construct in phonology learning. By employing a descriptive quantitative approach to examine students' levels of understanding after participating in digital media–based phonology instruction, this study provides empirical evidence that addresses a gap in the literature, particularly within the context of Indonesian language and linguistics education. Thus, the novelty of this research lies in its explicit focus on sound change comprehension rather than surface-level pronunciation outcomes, offering a more theoretically grounded perspective on digital media integration in phonology instruction.

A growing body of recent research indicates that the use of digital media in language learning can enhance phonological awareness and pronunciation skills. For instance, the use of video-based platforms such as YouTube has been shown to be effective in improving phonological understanding and sound accuracy among second language learners (McLaren, 2022) (Fitriasih et al., 2024). In addition, technology-enhanced phonology instruction has been found to increase student engagement and provide more contextualized learning experiences, allowing learners to interact with authentic language input in meaningful ways (Insani et al., 2023). Despite these positive findings, quantitative studies that specifically measure students' levels of understanding of phonological sound change within digital media–based phonology learning remain limited, particularly in the context of Indonesian language instruction. Most existing research tends to focus on general pronunciation outcomes or learning motivation rather than on systematic comprehension of sound change processes (Widyahety et al., 2024). Therefore, the present study is motivated by the need for empirical evidence to provide an objective description of students' understanding of phonological sound change after participating in digital media–based phonology learning.

This study offers a solution by applying digital media in phonology learning to help students better understand language sound changes. The main objective of this research is to analyze the level of university students' understanding of sound change in phonology when learning is supported by digital media, as well as to examine how digital media facilitate conceptual comprehension and learning engagement. This research is interesting to conduct because sound change in language is an abstract and complex topic that is often difficult for students to grasp through conventional instructional approaches. The use of digital media allows phonological concepts to be presented through audio, visual, and interactive elements, making them more concrete, contextual, and easier to understand. Therefore, this study is expected to contribute both theoretically to phonology learning and practically to the development of more effective instructional practices in linguistics education.

2. Research methods

This study employed a descriptive quantitative approach to obtain an objective overview of students' levels of understanding of phonological sound change after participating in digital media–based phonology learning. This approach was selected to describe and interpret empirical data as they naturally occurred, based on the results of standardized measurements, without any manipulation of research variables (Boulianne et al., 2023) (Khakim & Nidhom, 2024). By applying descriptive quantitative methods, the study aimed to provide an accurate representation of students' comprehension levels through numerical data and statistical descriptions. The research subjects consisted of 30 undergraduate students from the Indonesian Language and Literature Education Program at Universitas Muhammadiyah Makassar who had completed a phonology course during the first (odd) semester of the 2025 academic year. These participants were selected because they had been exposed to phonology instruction delivered through digital media, making them appropriate subjects for examining students' understanding of phonological sound change within a technology-enhanced learning context.

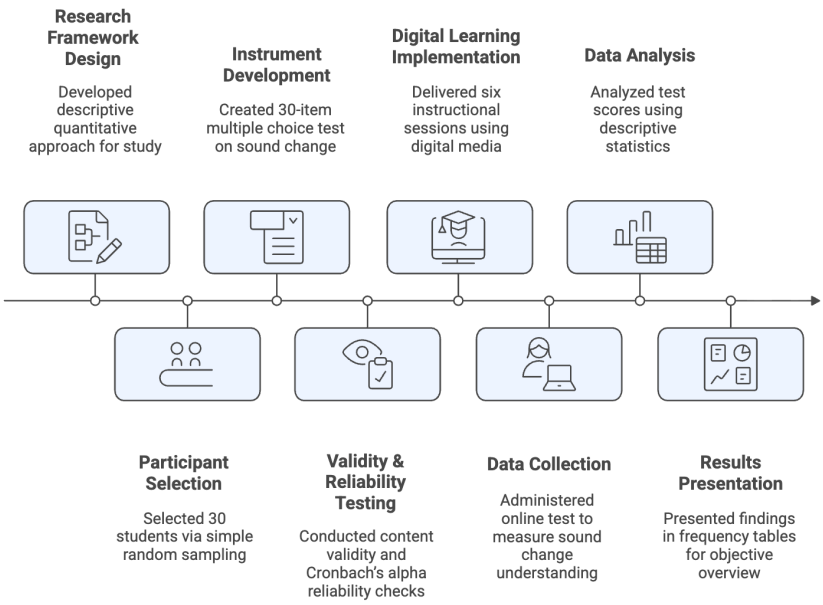

Figure 2. Research Procedures for Assessing Sound Change Understanding

The participants were selected using simple random sampling to ensure data representativeness and to reduce potential research bias. The research instrument was an objective test on phonological sound change consisting of 30 multiple-choice items designed to measure students' knowledge of sound change concepts. The test items underwent content validity assessment by linguistics experts and reliability testing, with a Cronbach's alpha coefficient of 0.82, indicating good internal consistency (Das, 2024). Data were collected after the students had completed six sessions of digital media–based phonology instruction. The instructional activities integrated lecture videos accompanied by authentic audio examples, interactive simulations illustrating phonological processes, and online practice exercises that allowed students to apply theoretical concepts (Isbandi et al., 2024). These learning sessions were designed to facilitate active engagement and to support students' comprehension of phonological sound change through multimodal learning experiences (Son, 2023). The assessment

was conducted through an online test with a time limit of 60 minutes to ensure consistency and standardization across participants. This testing procedure aimed to measure students' understanding of phonological sound change after their exposure to digitally mediated instructional materials, thereby providing an accurate reflection of learning outcomes achieved through digital media–based phonology instruction.

Data analysis was conducted using descriptive statistical techniques, including the calculation of mean scores, score distributions, and the percentage of students within each level of understanding. Students' comprehension levels were categorized as low (<60), moderate (≥60–<75), and high (≥75). The results were further presented through frequency tables to facilitate clear interpretation and visualization of the data. The data analyzed consisted of students' test scores on their understanding of phonological sound change, obtained through an objective multiple-choice test. Data analysis was conducted using descriptive statistical methods with the aim of providing an objective overview of students' levels of understanding. The stages of analysis included the calculation of individual scores, mean scores, and the distribution of students' scores. Furthermore, the scores were classified into categories of comprehension levels to determine the proportion of students within each category. The results of the data analysis were then presented in the form of frequency tables to ensure that the research findings could be interpreted systematically and clearly. This approach provides a comprehensive depiction of the effectiveness of digital media–based phonology learning in enhancing students' understanding of phonological sound change.

3. Results and Discussion

3.1 Results

The results of this study indicate that students demonstrated a strong level of conceptual understanding of phonological sound change after participating in digital media–based phonology learning. Overall, the majority of students achieved high comprehension scores, reflecting their ability to understand key concepts such as assimilation, dissimilation, epenthesis, sound deletion, and neutralization. Furthermore, analysis based on types of phonological sound change revealed that students showed the highest levels of understanding in assimilation and sound deletion processes, whereas relatively lower scores were observed in more complex processes such as dissimilation and neutralization. These findings suggest that digital media–based phonology instruction effectively supports students' comprehension of phonological sound change, while also highlighting variations in understanding across different types of sound change phenomena.

Students' Conceptual Understanding

Digital media–based phonology instruction has been shown to make a positive contribution to students' understanding of phonological sound change. The integration of instructional videos, phonetic audio materials, and interactive content enables students to comprehend abstract phonological concepts in a more concrete, contextual, and multimodal manner. By presenting sound change phenomena through both visual and auditory representations, digital media facilitate clearer conceptualization and support students in linking theoretical explanations with actual speech realizations. Furthermore, the use of digital media enhances students' active engagement in the learning process. Interactive features encourage students to explore phonological

patterns, practice sound analysis independently, and reflect on their learning through repeated exposure to instructional materials. As a result, students are not only passive recipients of information but also active participants in constructing their understanding of phonological sound change, which contributes to deeper and more sustained learning outcomes.

The results of the study indicate that digital-based phonology instruction makes a positive contribution to students' levels of understanding of phonological sound change. Through the use of digital media such as instructional videos, phonetic audio materials, and interactive content, students were able to grasp abstract phonological concepts that are often difficult to explain through conventional teaching methods. The learning process became more contextual and multimodal, thereby encouraging students' active engagement in observing, listening to, and analyzing phonological sound change phenomena in a more in-depth manner. Digital-based learning enables self-directed and repeated learning in accordance with individual students' needs. Flexible access to phonological learning materials allows students to reinforce their understanding beyond face-to-face classroom sessions, particularly in recognizing sound change patterns such as assimilation, neutralization, and epenthesis. Overall, these findings indicate that the integration of digital technology in phonology instruction not only enhances students' learning motivation but also plays a significant role in developing their conceptual understanding of phonological sound change.

The distribution of students' levels of understanding provides important insight into the effectiveness of digital media based phonology instruction. By examining how students' comprehension is spread across different categories, it is possible to identify overall learning trends as well as variations in individual achievement. This analysis helps clarify whether the instructional approach supports not only average performance but also broader conceptual mastery among students. To present this distribution clearly, students' understanding of phonological sound change was classified into three levels, namely high, moderate, and low, based on their test scores. Figure 3 illustrates the number of students in each category, allowing a clear comparison of comprehension levels after participating in digital based phonology learning.

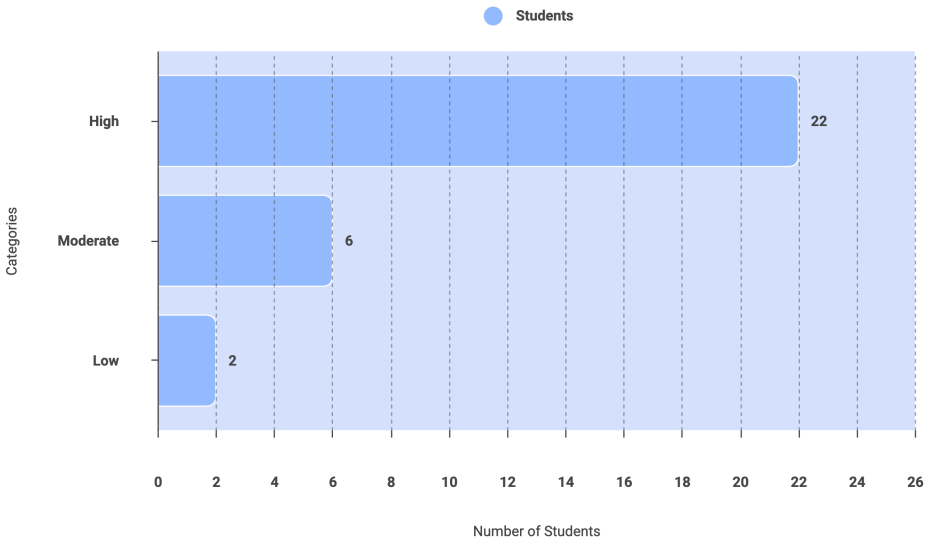

Figure 3. Student Understanding of Language Sound Change

The descriptive analysis revealed that the overall mean score of the students was 83.5 out of a maximum score of 100, placing the majority of participants in the high category of understanding of phonological sound change. Based on the score distribution table, 22 students (75%) were classified as having a high level of understanding, 6 students (20%) were in the moderate category, and 2 students (5%) were categorized as having a low level of understanding. This distribution indicates a positive trend regarding the effectiveness of digital media–based phonology instruction in enhancing students' comprehension of phonological sound change.

Figure 3 shows that the majority of students achieved a high level of understanding of phonological sound change. A total of 22 students were classified in the high category, indicating that most participants were able to comprehend key phonological concepts effectively after engaging in digital based instruction. This result suggests that the learning approach successfully supported students' conceptual understanding of sound change phenomena. In addition, 6 students were categorized as having a moderate level of understanding. This group indicates that although these students had not yet reached optimal mastery, they still demonstrated an adequate comprehension of phonological sound change. Their performance suggests that further improvement could be achieved through additional practice or reinforcement of learning materials.

Only a small number of students, specifically 2 participants, were classified in the low understanding category. The limited proportion of students in this category indicates that digital based phonology instruction was generally accessible and effective for most learners. Nevertheless, this finding highlights the importance of providing additional instructional support for students who experience difficulties in understanding phonological concepts. Overall, the distribution pattern presented in Figure 3 reflects positive learning outcomes and supports the effectiveness of integrating digital media into phonology instruction. The dominance of the high understanding category demonstrates that digital based learning not only improves general achievement but also contributes to deeper conceptual understanding of phonological sound change among students. These findings strengthen the pedagogical value of digital media in enhancing phonological competence within language education.

Understanding Based on Types of Sound Change

An analysis of students' understanding of phonological sound change is essential to evaluate the overall effectiveness of phonology instruction supported by digital media. Examining both the distribution of understanding levels and the average scores across different aspects of sound change provides a comprehensive picture of students' learning outcomes. This approach allows researchers to identify general achievement patterns as well as differences in students' mastery of specific phonological concepts. To support this analysis, students' levels of understanding were categorized into three groups, namely high, moderate, and low, based on their test scores. In addition, average scores for each aspect of phonological sound change were calculated to determine which types of sound change were more easily understood by students. The visual representation presented in the figure below illustrates the distribution of students' understanding levels following digital based phonology instruction.

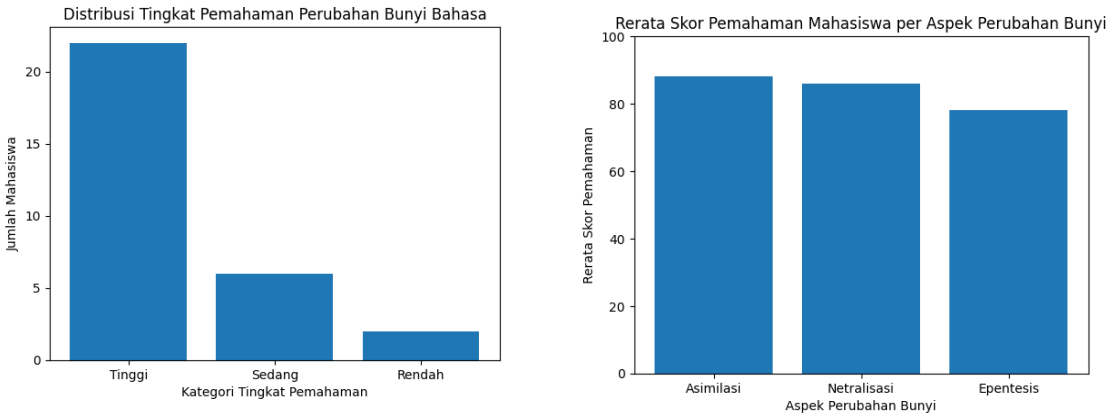

Figure 4. Distribution of Students' Understanding of Phonological Sound Change

A detailed analysis of specific sound change aspects reveals that students demonstrated the highest levels of understanding in assimilation and sound neutralization, with mean scores of 88 and 86, respectively. In contrast, the mean score for epenthesis was slightly lower at 78, although it still fell within the high understanding category. These results indicate dominant areas of comprehension as well as aspects of phonological sound change that present relatively greater challenges for students.

The figure shows that most students were classified in the high understanding category. This dominant distribution indicates that the majority of participants achieved a strong comprehension of phonological sound change concepts after engaging in digital based phonology learning. The high proportion of students in this category suggests that the instructional approach effectively supported students in grasping both theoretical and practical aspects of phonological change. A smaller number of students were categorized as having a moderate level of understanding. This group reflects students who demonstrated sufficient comprehension of phonological sound change but had not yet reached full mastery. Their results indicate the need for additional reinforcement or targeted practice to strengthen conceptual clarity and analytical skills related to sound change phenomena.

Only a limited number of students fell into the low understanding category. The small size of this group suggests that digital based phonology instruction was generally accessible and beneficial for most learners. However, it also highlights the importance of providing differentiated instructional support for students who may experience difficulties in understanding abstract phonological concepts. Overall, the distribution pattern and average scores across aspects of phonological sound change demonstrate positive learning outcomes. These findings indicate that digital media integration not only enhances overall student performance but also supports balanced understanding across different types of sound change. Consequently, digital based phonology instruction can be considered an effective approach for improving students' conceptual understanding of phonological sound change in language education.

N-Gain Statistics

The measurement of students' improvement in conceptual understanding of phonological sound change was conducted using the N-Gain index. N-Gain analysis was

employed to quantitatively describe the extent to which digital media–based phonology instruction was associated with improvements in students' understanding. This approach allows researchers to assess proportional changes in learning outcomes by comparing pre-instruction and post-instruction scores, without the intention of establishing direct causal relationships. The calculation of N-Gain in this study aimed to provide a descriptive overview of the level of students' conceptual improvement after participating in digital-based phonology learning. The N-Gain data were analyzed using descriptive statistical procedures in SPSS to obtain minimum and maximum values, mean scores, and standard deviations. These analytical results provide an empirical basis for interpreting overall trends in students' conceptual understanding improvement.

Table 1. Statistics of Students' Conceptual Understanding

Statistic	Value
N	30
Minimum	0.31
Maximum	0.78
Mean N-Gain	0.58
Std. Deviation	0.12
N-Gain Category	Moderate–High

Based on Table 1, the mean N-Gain value obtained was 0.58, which falls within the moderate to high category. This value indicates that digital media–based phonology learning is associated with a substantial level of improvement in students' conceptual understanding of phonological sound change. The N-Gain range, spanning from 0.31 to 0.78, reflects variability in the degree of improvement among students; however, the overall trend demonstrates a positive increase in understanding. Furthermore, the standard deviation of 0.12 suggests that the variation in students' improvement levels was relatively controlled and not widely dispersed. This finding indicates that most students experienced a relatively consistent level of conceptual improvement after participating in digital-based learning. Overall, these descriptive statistical results reinforce the conclusion that the integration of digital media in phonology instruction is associated with a high level of conceptual understanding, while the interpretation of the findings remains within the descriptive scope of the research design employed.

Students' Learning Activity Observation

The observation of students' learning activities was conducted to obtain empirical evidence regarding students' levels of engagement during digital media–based phonology instruction. Learning activities were observed as important indicators reflecting students' participation in examining instructional materials, listening to phonetic audio examples, interacting with digital media, and engaging in the analysis of phonological sound change phenomena. These observational data complement the results of the conceptual understanding tests by providing insight into the learning processes that occurred during instruction. The collection of learning activity data was carried out systematically using an observation sheet developed based on engagement indicators, including attention to instructional materials, active participation in questioning or discussion, involvement in interactive practice activities, and responsiveness to instructional feedback. The observation results were then analyzed using descriptive statistical techniques to determine the distribution of students'

learning activity levels across high, moderate, and low categories during the implementation of digital media–based phonology learning.

Table 2. Observation Results of Students' Learning Activities

Activity Level	Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
High	26	86.7	86.7	86.7
Moderate	4	13.3	13.3	100.0
Low	0	0.0	0.0	100.0
Total	30	100.0	100.0	

Based on Table 2, the majority of students demonstrated a high level of learning activity during digital media–based phonology instruction. A total of 26 students (86.7%) were classified in the high activity category, indicating active engagement in following instructional materials, utilizing digital features, and participating in the analysis of phonological sound change phenomena. This finding suggests that digital media are able to create a learning environment that encourages active student participation. In addition, 4 students (13.3%) were categorized as having a moderate level of learning activity, while no students were classified in the low activity category. This distribution indicates that digital-based phonology instruction is relatively inclusive and capable of engaging nearly all students in the learning process. Overall, the observation results strengthen the conclusion that the integration of digital media is not only associated with strong conceptual understanding but also with high levels of learning engagement, which is a crucial factor in supporting effective phonology instruction.

3.2 Discussion

The findings of this study indicate that digital media play a significant role in enhancing students' understanding of phonological sound change. These results suggest that phonology instruction becomes less effective when it relies solely on conventional lecture based approaches, particularly when addressing abstract and dynamic concepts such as sound change. Digital media offer an alternative instructional approach that is more responsive to the characteristics of phonological content and to students' learning needs (Fadlan & Anshor, 2022) (Luthfillah & Fauzia, 2023). The results are consistent with previous studies which argue that interactive digital media, especially instructional videos that integrate visual and auditory elements, are able to strengthen phonological representations and increase students' cognitive engagement in the learning process (Ritonga et al., 2024). The integration of visual and auditory channels supports more effective information processing, enabling students to construct a clearer and more stable understanding of phonological sound change.

The effectiveness of digital media based phonology learning is also influenced by the multimodal nature of digital instructional materials. Digital media allow the integration of phonetic audio, articulatory visualizations, animated sound production processes, and interactive exercises within a single learning environment. Through this approach, students are not limited to passive reception of theoretical explanations but are able to observe and experience sound change phenomena directly.

This multimodal approach enables students to connect abstract phonological concepts with concrete realizations of speech sounds. When students can visually observe articulatory movements, listen to sound variations, and practice phonological analysis simultaneously, the learning process becomes more meaningful. Such

experiences support the formation of stronger cognitive schemas and reduce the gap between phonological theory and practical linguistic analysis. In addition, digital media encourage active student engagement throughout the learning process (Yetkin & Özer-Altınkaya, 2024). Interactive features such as self paced exercises, online quizzes, and immediate feedback provide opportunities for continuous assessment and reflection. These activities contribute to the development of students' metacognitive awareness, as they are able to identify errors, refine their understanding, and gradually strengthen their knowledge of phonological sound change.

The findings further demonstrate that digital media based phonology instruction aligns with the principles of digital pedagogy, which emphasize experience oriented learning. In this context, students are positioned not merely as recipients of information but as active learners who engage in exploration, analysis, and interpretation of linguistic phenomena. This approach is consistent with the demands of twenty first century learning, which highlight learner autonomy, engagement, and critical use of technology.

From a pedagogical perspective, the results underscore the importance for phonology instructors to design learning activities that systematically and purposefully integrate digital technology. Digital media should not function merely as supplementary tools, but rather as integral components of instructional strategies aimed at strengthening students' conceptual understanding of phonological sound change. Overall, the findings reinforce the argument that the integration of digital media in phonology instruction makes a meaningful contribution to improving students' understanding of phonological sound change (Holm, 2024). By leveraging the multimodal, interactive, and flexible characteristics of digital media, phonology learning can become more effective, contextual, and relevant to students' academic needs in the digital era.

Although the overall results indicate a high level of student understanding, there is evidence that certain types of phonological sound change processes, such as epenthesis, continue to pose challenges for some students. This finding suggests that not all sound change categories are equally accessible through general instructional approaches, particularly when the processes involve more complex or less transparent phonological patterns. These results highlight the need for more focused instruction on specific phonological categories within digital learning materials. Targeted explanations, additional practice activities, and adaptive learning designs that address common student errors may help strengthen understanding in more challenging areas. Therefore, the redesign of digital phonology learning activities based on students' difficulties is essential to ensure more balanced and comprehensive mastery of phonological sound change concepts.

4. Conclusion

Based on the results and discussion, this study concludes that students' levels of understanding of phonological sound change after participating in digital media based phonology learning are generally high. Digital media have proven to be effective instructional tools in phonology learning, as they provide rich audio visual representations that support students' comprehension of abstract sound change concepts. Nevertheless, attention should be given to specific types of phonological sound change that continue to require additional instructional support. This study

further implies that the integration of digital media in phonology instruction should be continuously developed to enhance the quality of linguistic education in higher education. Purposeful and systematic use of digital technology can strengthen students' conceptual understanding and analytical skills in phonology, while also addressing learning difficulties associated with particular sound change processes. Consequently, digital media integration represents a promising direction for improving phonology teaching and learning practices at the university level.

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