

Research Article

Decontextualized and Context-Linked Assessment in a Physics Course for SLT Students

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Abstract

The physics of sound is a foundational component of Speech and Language Therapy (SLT) education, yet students often struggle to transfer physics knowledge from traditional instructional settings to applied disciplinary contexts. This study investigated first-year SLT students' performance on decontextualized and context-linked physics assessments in a Physics of Sound course, together with their epistemological beliefs about physics. A quantitative, exploratory correlational design was employed with 21 undergraduate students. Data were collected from routinely administered course assessments, including a decontextualized midterm examination, a context-linked final examination, and the Colorado Learning Attitudes about Science Survey (CLASS). Descriptive and correlational analyses revealed strong relationships among midterm, quiz, and final exam scores, indicating coherence across assessments. However, concept-level analysis of the final examination showed substantial variation in student performance across sound physics topics. Higher and more consistent performance was observed for concepts closely aligned with SLT practice, such as vocal tract acoustics and acoustic measurement, whereas lower performance and greater variability were evident for abstract concepts, including filtering, resonance, and airflow-related principles. Relative gain analysis indicated that proportional improvement from decontextualized to context-linked assessments was not uniform across students. Relationships between epistemological beliefs and assessment performance were generally weak, suggesting that epistemological orientations were not directly reflected in summative outcomes. The findings underscore the importance of concept-level analysis for evaluating physics learning in interdisciplinary health science contexts and highlight challenges associated with transferring physics knowledge across assessment formats.

Keywords

Conceptual Understanding, Context-Based Assessment, Physics of Sound, Physics for Non-physicists, Speech and Language Therapy

1. Introduction

Introductory physics courses for non-physics majors are widely recognized as critical yet challenging components of undergraduate education. Research in physics education consistently shows that traditional instruction, often centered on abstract models, symbolic representations, and mathe-

matically formal problem solving, does not adequately support meaningful learning for students in life and health science programs [1-4]. These students are expected to use physics knowledge in applied, interdisciplinary, and professional contexts, yet they frequently experience physics as

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disconnected from their disciplinary goals.

Sound and acoustics constitute a particularly demanding domain within physics education. A large body of research demonstrates that learners at all levels struggle to develop a coherent, transferable understanding of sound phenomena [5-8]. Students commonly conceptualize sound as a material substance that travels from the source to the receiver, rather than as a process of transmitting vibrational motion through a medium. As a result, students' reasoning about sound is often fragmented, highly context-dependent, and sensitive to representational cues [6, 9].

For students in Speech and Language Therapy (SLT) programs, the physics of sound is foundational rather than auxiliary. Core professional topics, such as vocal tract acoustics, resonance, filtering, subglottal pressure, sound production, and acoustic measurement, are grounded in physical principles. However, despite this strong disciplinary alignment, physics of sound courses often rely on decontextualized representations that do not explicitly connect physical mechanisms to speech, hearing, and auditory health. Prior research shows that such instructional approaches can lead students to perform adequately on traditional physics assessments while failing to develop transferable understanding applicable to clinically relevant situations [10-12].

In response to these challenges, research on Introductory Physics for Life Sciences (IPLS) has emphasized the use of authentic contexts, interdisciplinary alignment, and conceptual coherence [13-15]. Context-based instruction has been shown to enhance motivation and engagement for non-physics majors. Nevertheless, design-based research on sound learning cautions that contextualization alone is insufficient. Without explicit attention to mechanisms, representations, and ontological distinctions, students may show local success in familiar contexts while failing to construct a generalized model of sound [6, 8].

In parallel, students' epistemological beliefs about physics influence how they interpret instructional goals and engage with learning tasks. These beliefs shape whether students view physics as a collection of formulas or as a sense-making enterprise. Although more expert-like epistemological orientations are associated with productive learning behaviors, their relationship with summative assessment performance, particularly in applied health science contexts, remains indirect and complex [16-18].

The present study investigates these issues by examining first-year SLT students' performance on both decontextualized and context-linked physics assessments in a Physics of Sound course, together with their epistemological beliefs about physics.

1.1. Statement of the Problem

Despite widespread agreement on the value of contextualizing physics instruction for non-physics majors, empirical research indicates that contextualization does not automati-

cally lead to generalized conceptual understanding. Studies of sound learning consistently show that students may apply correct reasoning in one situation while reverting to non-scientific explanations in another, reflecting fragmented knowledge structures rather than stable misconceptions [5-7].

Design-based research on sound, hearing, and health demonstrates that developing a scientific understanding of sound requires an ontological shift from matter-based reasoning to process-based reasoning, as well as explicit support for coordinating representations across media, disciplines, and contexts [6]. Without such support, students often fail to generalize sound transmission models across different media or applications.

In the context of SLT education, this challenge is particularly consequential. Students may demonstrate success on traditional physics examinations yet struggle with concepts that require integrating physics with physiological, acoustic, or clinical interpretations, such as airflow-based sound production or filtering in the vocal tract. Consequently, assessments that rely solely on total scores may obscure important concept-level learning difficulties.

Furthermore, while epistemological beliefs are known to influence engagement and learning orientations, weak or inconsistent correlations with exam performance may lead to underestimating their role. Research suggests that epistemological beliefs shape learning processes and reasoning strategies rather than directly determining summative outcomes [17-19].

Accordingly, the current study examines physics learning in health science contexts at a concept-specific level, situated within a theoretical framework that integrates contextual transfer and epistemological perspectives. Such research remains limited for physics of sound courses designed for SLT students.

1.2. Research Questions

This study addresses the following research questions:

- 1) What is the relationship between SLT students' performance on a decontextualized physics assessment and their performance on a context-linked sound physics assessment?
- 2) How are SLT students' epistemological beliefs about physics related to their performance on context-linked sound physics concepts?
- 3) How are SLT students' performances on decontextualized physics assessments related to their performance on context-linked sound physics assessments, including proportional changes across assessment contexts?
- 4) What concept-level performance patterns emerge across sound physics topics relevant to SLT program?

2. Theoretical Framework

The theoretical framework of this study integrates three complementary perspectives: (a) conceptual development in sound and wave physics, (b) contextual transfer, and (c)

epistemological beliefs in physics learning. Research on sound learning shows that sound is an abstract concept that requires learners to reconceptualize everyday experiences. Students frequently attribute material properties to sound and sound waves, treating them as objects that move through space rather than as emergent processes involving oscillatory motion [5-7]. Developing a scientific understanding of sound, therefore, involves an ontological reclassification from matter-based to process-based reasoning, a form of conceptual change known to be cognitively demanding and resistant to instruction [20].

From a resources-oriented perspective, students' ideas about sound are understood as context-sensitive cognitive resources rather than coherent misconceptions. Different resources may be activated depending on the medium, representation, or task, resulting in apparently inconsistent reasoning across situations [9, 21]. This perspective explains why students may succeed in some sound-related tasks while failing to generalize their understanding across contexts. Consequently, concept-level analysis is essential for interpreting learning outcomes in sound physics.

The IPLS framework emphasizes the importance of disciplinary authenticity and conceptual coherence in physics instruction for life and health science students. Effective IPLS curricula integrate physical principles directly into disciplinary narratives and practices, supporting students in using physics as a tool for reasoning rather than as an isolated prerequisite [13-15]. Longitudinal and design-based studies show that such approaches can foster durable reasoning skills, but only when conceptual mechanisms and representations are explicitly scaffolded [22].

Epistemological beliefs constitute the third component of the framework. Students' beliefs about the nature of physics knowledge influence how they engage with learning tasks, interpret difficulties, and persist in problem solving [16-18]. Research using instruments such as the Colorado Learning Attitudes about Science Survey (CLASS) indicates that epistemological orientations are more strongly associated with learning behaviors and engagement than with final exam scores, particularly in applied or interdisciplinary contexts [17, 19].

Together, these perspectives frame the present study as an investigation of contextualized learning in the physics of sound, in which performance reflects an interplay among foundational physics knowledge, selective contextual transfer, and epistemological orientations. This framework justifies the use of both decontextualized and context-linked assessments, as well as concept-level analysis, to capture the complexity of learning physics in an SLT context.

3. Materials and Methods

3.1. Research Design

This study employed a quantitative, exploratory correlational research design to examine relationships between SLT

students' performance on decontextualized physics assessments, context-linked sound physics assessments, and epistemological beliefs about physics. Exploratory correlational designs are appropriate when the purpose is to identify patterns, associations, or relationships among variables in contexts where prior empirical evidence is limited, and hypotheses are not yet firmly established [23]. The design was exploratory, given the small sample size and instructional context, with the primary aim of describing relationships rather than establishing causal explanations [24].

3.2. Sample

The sample consisted of 21 first-year undergraduate students enrolled in a Speech and Language Therapy program and registered in a compulsory Physics of Sound course. The participants included 18 female and 3 male students, reflecting the program's typical gender distribution. All students in the course participated in the study, and no additional sampling or selection procedures were applied. The sample size was considered appropriate for the exploratory nature of the study, which aimed to examine performance patterns and relationships within an authentic instructional context rather than to support statistical generalization.

3.3. Instrument

Students' epistemological beliefs about physics were assessed using the shortened Turkish version of the Colorado Learning Attitudes about Science Survey (CLASS). The original CLASS was developed by Adams et al. [17]. The Turkish shortened version, adapted and psychometrically validated for Turkish undergraduate students, was employed to ensure linguistic and cultural appropriateness [25]. This version consists of 20 five-point Likert-type items and yields a three-factor structure: Problem-Solving Effort, Conceptual Understanding, and Personal Interest and Real-World Connection. Validation studies of the Turkish adaptation reported strong construct validity, supported by exploratory and confirmatory factor analyses with acceptable-to-excellent model fit indices (e.g., RMSEA = 0.048; CFI = 0.901) [25]. Reliability analyses demonstrate satisfactory internal consistency, with Cronbach's alpha coefficients of .68 for Problem-Solving Effort, .64 for Conceptual Understanding, .78 for Personal Interest and Real-World Connection, and .85 for the overall scale. For the present sample, the shortened Turkish version of the CLASS showed limited but acceptable internal consistency for exploratory purposes (Cronbach's α = .59 for 20 items). While classical thresholds for Cronbach's alpha (e.g., $\geq .70$) are recommended for high-stakes decisions, lower values in the .50-.60 range have been considered acceptable for initial scale evaluation and exploratory research, particularly in short instruments [26-28].

Student achievement in physics of sound was measured using a midterm examination (35 points) and a final exami-

nation (50 points), both administered as part of the routine course assessment. The midterm exam assessed students' understanding of decontextualized physics concepts related to sound and wave phenomena and was scored using an analytic scoring scheme based on predefined solution steps. The final exam consisted of context-linked sound physics questions explicitly aligned with Speech and Language Therapy applications, including vocal tract acoustics, resonance, filtering, distortion, sound production, and acoustic measurement. Final exam items were weighted according to their conceptual scope and instructional emphasis, and partial credit was awarded using criterion-referenced rubrics to capture levels of conceptual understanding. To support reliability, all exam items were reviewed prior to administration for content alignment with course objectives, and scoring was conducted using standardized marking criteria. Final exam responses were further coded at the concept level for analysis, allowing examination of performance patterns across specific sound physics topics.

3.4. Course Content

The study was conducted in a compulsory Physics of Sound course designed for first-year Speech and Language Therapy students. The course introduced fundamental principles of sound and wave physics, beginning with the nature of sound waves, oscillatory motion, sound propagation, and energy transfer, and progressing to acoustic impedance, logarithmic scales, sound intensity, and sound pressure measurement using the decibel. Subsequent topics included complex waves and Fourier analysis, resonance and filtering, acoustic impedance in frequency-selective systems, distortion, and sound transmission phenomena such as reflection, refraction, diffraction, and inverse square law behavior. The latter part of the course emphasized applied and interdisciplinary topics directly relevant to speech and hearing, including room acoustics, speech intelligibility, signal processing and time-frequency representations, human voice production and vocal tract modeling, sound coding, and speech technologies. Assessment consisted of a midterm examination focused on decontextualized physics concepts and a final examination composed of context-linked sound physics problems aligned with speech and language therapy applications.

3.5. Data Collection Procedure and Ethics

Data was collected during the regular implementation of the Physics of Sound course during the fall semester of the 2025-2026 academic year. CLASS was administered in the second week of the semester to capture students' epistemological beliefs at an early stage of instruction. The midterm examination was administered in the eighth week, and the final examination was administered eight weeks later, as per the course syllabus. All data were obtained from routinely administered course assessments and anonymized prior to

analysis. Ethical approval was waived because the study involved no instructional intervention, no experimental manipulation, and no collection of sensitive personal data.

3.6. Data Analysis

Data analysis was conducted using IBM SPSS Statistics (Version 25). Descriptive statistics (means, standard deviations, and score distributions) were calculated for midterm exam scores, final exam scores, and CLASS measures to summarize overall performance and epistemological profiles. Given the exploratory nature of the study and the small sample size, correlational analyses were used to examine relationships between midterm and final exam scores and between CLASS subscale scores and students' performance on context-linked sound physics concepts.

Final exam responses were also analyzed at the concept level by grouping items into predefined sound physics categories (e.g., resonance, filtering, vocal tract acoustics, sound production, and measurement). This allowed examination of performance patterns across specific conceptual domains rather than relying solely on total scores. Reliability analyses were conducted using Cronbach's alpha to evaluate the internal consistency of the CLASS scale. All results were interpreted cautiously, with emphasis placed on identifying patterns and trends rather than making inferential or causal claims.

To examine proportional changes in student performance from the decontextualized midterm examination to the context-linked final examination, a relative gain index was computed by using equation (1):

$$\text{Relative Gain} = \frac{\text{FE Score} - \text{ME Score}}{50 - \text{ME Score}} \quad (1)$$

4. Results

4.1. Descriptive Statistics

Descriptive statistics for students' performance on course assessments and CLASS measures are presented in Table 1. Students' performance on the midterm examination, which assessed decontextualized physics concepts, showed a mean score of $M = 26.90$ ($SD = 7.18$) out of 40. Quiz scores, administered during the semester to assess ongoing understanding of sound-related physics topics, had a mean of $M = 10.48$ ($SD = 3.71$) out of 15. Performance on the final examination, which consisted of context-linked sound physics questions aligned with SLT applications, was more variable, with a mean score of $M = 22.52$ ($SD = 11.21$) out of 50.

Table 1. Descriptive Statistics for Assessment Scores and CLASS Measures.

Variables	N	Min	Max	Mean	SD
ME	21	5.25	34.50	26.90	7.18
Quiz	21	2.00	15.00	10.48	3.71
FE	21	0.00	38.50	22.52	11.21
CU	21	12.00	22.00	17.05	2.85
PI	21	17.00	26.00	21.81	2.27
PSE	21	14.00	26.00	22.14	2.80

*Note: ME: Midterm Exam, FE: Final Exam, CU: Conceptual Understanding, PI: Personal Interest, PSE: Problem-Solving Effort (PSE).

CLASS subscale scores indicated moderate dispersion across students. Mean scores were $M = 17.05$ ($SD = 2.85$) for Conceptual Understanding (CU), $M = 21.81$ ($SD = 2.27$) for Personal Interest (PI), and $M = 22.14$ ($SD = 2.80$) for Problem-Solving Effort (PSE). Minimum and maximum values show substantial individual variability in both performance and epistemological orientations (see Table 1).

4.2. Relationships Among Course Assessments

Correlational analyses were conducted to examine relationships among the midterm, quiz, and final exam scores (see Table 2). Midterm and quiz scores were strongly correlated ($r = .85$, $p < .01$), as were midterm and final exam scores ($r = .78$, $p < .01$). Quiz scores were also significantly related to final exam performance ($r = .69$, $p < .01$), indicating coherence across formative and summative assessments.

Table 2. Correlation Matrix.

Variables	ME	Quiz	FE	CU	PI	PSE
ME	1.00	.85**	.78**	.19	-.30	.31
Quiz	.85**	1.00	.69**	.13	-.15	.38
FE	.78**	.69**	1.00	-.01	-.14	.07
CU	.19	.13	-.01	1.00	-.08	.50*
PI	-.30	-.15	-.14	-.08	1.00	.39
PSE	.31	.38	.07	.50*	.39	1.00

* $p < .05$, ** $p < .01$. Note: ME: Midterm Exam, FE: Final Exam, CU: Conceptual Understanding, PI: Personal Interest, PSE: Problem-Solving Effort (PSE).

4.3. Relationships Among Course Assessments

Relationships between students' epistemological beliefs and academic performance were examined using the three CLASS subscales: Conceptual Understanding (CU), Personal Interest (PI), and Problem-Solving Effort (PSE) (Table 2). Correlations between CLASS subscales and assessment scores were generally weak and not statistically significant. Final exam performance showed no significant associations with CU ($r = -.01$), PI ($r = -.14$), or PSE ($r = .07$), indicating that students' epistemological orientations were not directly reflected in their performance on context-linked sound physics tasks in this sample.

Similarly, relationships between CLASS subscales and midterm or quiz scores were small and nonsignificant. The only statistically significant relationship involving CLASS measures was observed within the epistemological constructs themselves, with a moderate positive correlation between CU and PSE ($r = .50$, $p < .05$). This finding suggests internal coherence between students' emphasis on conceptual understanding and their reported problem-solving effort, rather than a direct linkage between epistemological beliefs and assessment outcomes.

4.4. Relative Gain from Decontextualized to Context-Linked Assessments

Gains ranged from -0.84 to $+0.26$, indicating substantial individual variability. Most students showed negative or near-zero relative gains, while a smaller subset demonstrated positive proportional improvement on the context-linked final exam. The mean relative gain across students was negative ($M = -0.18$, $SD = 0.32$), indicating that, on average, students did not demonstrate proportional improvement when transitioning from traditional physics assessments to applied, context-linked sound physics tasks.

Despite the overall negative trend, individual gain values varied substantially. A subset of students demonstrated positive relative gains, suggesting improved performance on context-linked tasks relative to their initial midterm performance, whereas others showed marked declines. These results indicate that successful transfer from decontextualized to context-embedded physics problems was not uniform across the sample, highlighting individual differences in adapting physics knowledge to disciplinary contexts.

4.5. Concept-Level Performance on the Final Examination

Students' responses on the final examination were analyzed at the concept level to examine patterns of performance across sound physics topics directly linked to SLT contexts. Mean scores and score distributions for each concept are presented in Table 3. Overall, students' performance varied substantially across conceptual domains, indicating differential

mastery of sound physics concepts within the same assessment.

Table 3. Concept-Level Performance on the Final Examination.

Concepts	N	Min	Max	Mean	SD
High-Pass Filter	21	0.0	2.0	0.83	0.99
Low-Pass Filter	21	0.0	2.0	0.93	1.00
Narrowly Tuned Systems	21	0.0	2.0	1.14	1.01
Tone-Burst (200 ms)	21	0.0	3.0	0.76	1.30
Tone-Burst (5 ms)	21	0.0	2.0	0.71	0.90
Half-Wave Resonator	21	0.0	3.0	1.33	1.49
Quarter-Wave Resonator	21	0.0	3.0	1.05	1.43
Vocal Tract – F0	21	0.0	5.0	2.05	1.80
Highest Distortion	21	0.0	2.0	1.24	1.00
Lowest Distortion	21	0.0	2.0	0.19	0.60
Reverberation	21	0.0	4.0	1.57	1.72
Subglottal Pressure	21	0.0	1.0	0.45	0.50
Source of Subglottal Pressure	21	0.0	1.0	0.40	0.49
Subglottal Pressure & Sound Production	21	0.0	1.0	0.71	0.44
Measure: PAS	21	0.0	1.0	0.36	0.39
PRAAT	21	0.0	5.0	2.33	1.62
Bernoulli Principle	21	0.0	6.0	4.76	1.64
Instruments	21	0.0	5.0	1.69	2.04

Relatively higher performance was observed on concepts closely aligned with applied and professional contexts, including vocal tract–fundamental (formant) frequency (F0), acoustic measurement tools (e.g., PRAAT), and instrumentation-related tasks. These concepts showed higher mean scores and narrower score dispersion, suggesting a more consistent understanding across students.

In contrast, lower performance and greater variability were observed for concepts involving more abstract or formal physics reasoning, such as filtering (high-pass and low-pass filters), tone-burst characteristics, and airflow-related principles, including Bernoulli’s principle and subglottal pressure. Several students demonstrated partial understanding in these areas, as reflected by frequent partial-credit responses.

Concepts related to resonance phenomena, including half-wave and quarter-wave resonators, showed mixed performance patterns, with some students achieving high scores while others demonstrated limited understanding. This variability suggests uneven conceptual transfer across related wave-based representations.

To aid interpretation of concept-level results, final examination topics were grouped into conceptual clusters (Table 4). Performance was generally higher in clusters aligned with SLT practice (e.g., Measurement and Instrumentation, Speech Production and Physiology) and lower or more variable in clusters involving abstract sound physics concepts (e.g., filtering and signal processing, resonance and wave phenomena).

Table 4. Conceptual Clusters of Final Examination Topics.

Concept Cluster	Included Concepts	Overall Performance Pattern
Filtering and Signal Processing	Filters, tone-bursts	Low mean scores and high variability

Concept Cluster	Included Concepts	Overall Performance Pattern
Resonance and Wave Phenomena	Half- and quarter-wave resonators	Moderate performance, mixed understanding
Speech Production and Physiology	Vocal tract–F0, Subglottal pressure, sound production, Bernoulli principle	Relatively higher performance on applied items
Measurement and Instrumentation	PRAAT, PAS, nasometer, EPG, EGG	Higher and more consistent performance
Acoustic Quality and Room Effects	Reverberation, Distortion	Variable performance across students

*Note: F0: Fundamental Frequency, PAS: Phonatory Aerodynamic System, EPG: Electropalatography, EGG: Electroglottography

Taken together, the concept-level analysis reveals that students' performance on the final examination was not uniform across sound physics topics. Instead, achievement appeared to be concept-dependent, with stronger performance on clinically and instrumentally relevant concepts and weaker performance on abstract or mathematically grounded principles. These patterns were not evident from total final exam scores alone, underscoring the value of concept-level analysis in evaluating learning outcomes.

5. Discussion

The present study examined relationships between decontextualized and context-linked physics performance and epistemological beliefs among first-year SLT students. The findings contribute to ongoing discussions in physics education regarding contextual transfer, concept-specific learning, and the role of epistemological orientations in interdisciplinary settings.

5.1. Relationship Between Decontextualized and Context-Linked Assessment Performance

Strong positive correlations were observed between students' midterm, quiz, and final examination scores, indicating coherence across course assessments. This result is consistent with prior research showing that general academic performance in physics tends to be stable across assessment formats, even when surface features of problems differ [1-3]. However, the presence of strong correlations at the total-score level did not imply uniform conceptual understanding across sound physics topics. As demonstrated by the concept-level analysis, students' performance varied substantially across individual sound concepts, supporting earlier findings that total scores can obscure important learning differences in complex domains such as sound and waves [5-7].

5.2. Proportional Performance Change Across Assessment Contexts

The relative gain analysis indicated that proportional improvement from decontextualized to context-linked assess-

ments was not systematic across the sample. Although some students demonstrated positive relative gains, the overall mean relative gain was negative, suggesting that many students did not readily transfer their physics knowledge to applied SLT-related contexts. This pattern aligns with design-based research on sound learning, which shows that contextualization alone does not guarantee generalized understanding unless students are supported in coordinating representations and mechanisms across contexts [6, 8]. The findings are also consistent with research in introductory physics for the life sciences, emphasizing that disciplinary relevance must be accompanied by explicit conceptual scaffolding to support transfer [13-15].

5.3. Concept-Level Performance Patterns in Sound Physics

Concept-level results showed higher, more consistent performance on topics closely aligned with SLT practice, such as vocal tract acoustics, sound production, and acoustic measurement tools. These findings support earlier work showing that authentic disciplinary contexts can enhance engagement and local reasoning success for non-physics majors [4, 10, 12]. At the same time, lower performance on filtering, tone-burst characteristics, and resonance-related concepts suggests persistent challenges with abstract representations and wave-based reasoning, which have been widely documented in the sound education literature [5-7]. These results highlight the importance of examining physics learning at the concept level rather than relying solely on aggregated assessment scores.

5.4. Epistemological Beliefs and Context-Linked Performance

Regarding epistemological beliefs, correlations between CLASS subscales and assessment scores were generally weak and non-significant. This finding is consistent with prior studies showing that epistemological orientations are more closely related to learning processes, engagement, and problem-solving strategies than to summative exam performance, particularly in applied or interdisciplinary contexts [16-19]. The moderate correlation observed between Conceptual

Understanding and Problem-Solving Effort subscales reflects internal coherence within students' epistemological profiles rather than a direct influence on assessment outcomes.

5.5. Limitations of the Study

Several limitations should be considered when interpreting these findings. First, the sample size was small and drawn from a single cohort of first-year SLT students, which limits the generalizability of the results. Second, the study relied on routinely administered course assessments rather than externally validated performance measures, which may constrain comparisons with other instructional contexts. Third, epistemological beliefs were measured at a single time point early in the course; therefore, potential changes in students' epistemological orientations over the semester were not examined. Finally, the exploratory correlational design does not permit causal inferences regarding instructional effectiveness or learning mechanisms. These limitations suggest that the findings should be interpreted as descriptive patterns that warrant further investigation with larger samples and complementary qualitative or longitudinal approaches.

5.6. Implications and Recommendations

Based on the present findings, several recommendations can be made for the physics of sound instruction in SLT programs. First, the observed variability in concept-level performance suggests that instructional design should move beyond general contextualization and incorporate explicit support for conceptual coordination across representations, particularly for abstract topics such as filtering, resonance, and wave-based reasoning. Prior research on students' learning of sound and waves has shown that difficulties often arise when learners are required to integrate multiple representations and mechanisms without sufficient instructional scaffolding [5-7]. Structured comparison tasks and guided interpretation of representations may therefore support more coherent conceptual understanding [1, 2].

Second, although students demonstrated relatively stronger performance on clinically aligned concepts, the relative-gain results indicate that contextual relevance alone is insufficient to ensure proportional transfer from decontextualized physics knowledge to applied problem-solving. This finding is consistent with research in physics education and introductory physics for the life sciences, which emphasizes that disciplinary relevance must be coupled with explicit conceptual and representational support to promote meaningful transfer [13-15]. Instructional approaches that deliberately bridge formal physics principles with applied SLT contexts, rather than assuming automatic transfer, may be particularly important in interdisciplinary health science settings [4, 10].

Third, the limited associations observed between epistemological beliefs and summative assessment performance suggest that epistemological orientations may be more closely

related to learning processes and engagement than to short-term outcome measures. This interpretation aligns with prior work indicating that epistemological beliefs influence how students approach learning and problem solving rather than directly predicting exam performance [16-19]. As such, epistemological development may be better supported by process-oriented instructional strategies, such as reflective activities, metacognitive prompts, and formative assessment practices, rather than solely through summative assessments.

From a research perspective, future studies would benefit from larger, more diverse samples and longitudinal designs that track changes in conceptual understanding and epistemological beliefs. Previous work on sound learning and interdisciplinary physics instruction suggests that fine-grained analyses, including concept-level assessments and complementary qualitative data, can provide deeper insight into how students construct and apply physics knowledge across contexts [6, 8]. Such approaches may help clarify how instructional design can better support meaningful learning of sound physics in SLT and other health science programs.

6. Conclusions

This study examined first-year SLT students' learning of sound physics through decontextualized and context-linked assessments, with attention to epistemological beliefs and concept-level performance. The results showed that students' performances across midterm, quiz, and final examinations were strongly related, indicating coherence across assessment formats. However, this coherence at the total-score level masked substantial variation in students' understanding of individual sound physics concepts.

Analysis of proportional performance change indicated that the transfer from decontextualized physics assessments to context-linked physics tasks was not uniform across students. While some students demonstrated positive relative gains, many did not show proportional improvement when applying physics knowledge in SLT-relevant contexts. Concept-level analysis further revealed that students performed more consistently on topics closely aligned with speech production, acoustics, and measurement practices, whereas concepts involving abstract wave representations, filtering, and resonance remained challenging.

Epistemological beliefs about physics, as measured by the CLASS, showed only a limited direct association with assessment performance, suggesting that these beliefs may not be readily reflected in short-term summative outcomes in applied physics courses. Taken together, the findings highlight the value of concept-level assessment and the need for cautious interpretation of aggregate scores when evaluating physics learning in interdisciplinary health science contexts.

Overall, the study underscores that contextual relevance alone is insufficient to ensure conceptual transfer and points to the need for instructional approaches that explicitly support coordination between foundational physics principles

and applied disciplinary contexts. Future research involving larger samples and longitudinal designs may further clarify how conceptual understanding of sound develops in Speech and Language Therapy education.

Abbreviations

CLASS	Colorado Learning Attitudes about Science Survey
CU	Conceptual Understanding
EGG	Electroglottography
EPG	Electropalatography
F0	Fundamental Frequency
FE	Final Exam
IPLS	Introductory Physics for the Life Sciences
ME	Midterm Exam
PAS	Phonatory Aerodynamic System
PI	Personal Interest
PSE	Problem-Solving Effort
SLT	Speech and Language Therapy

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Author Contributions

Kubra Ozmen: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

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Biography



Kubra Ozmen is an Assistant Professor in the Faculty of Health Sciences at Baskent University, where she teaches physics courses to students in audiology, physiotherapy, speech and language therapy, and pharmacy programs. She completed her PhD in Physics Education from Middle East Technical University (METU) in 2017. She also serves as Vice Chair of the Sustainable Environment and Research Center at Baskent University. Her research focuses on conceptual understanding, context-based assessment, and interdisciplinary physics instruction for non-physics majors, with particular emphasis on the physics of sound in health science education. She also contributes to research on personal epistemology and women in physics.

Research Field

Kubra Ozmen: physics education, conceptual understanding, personal epistemology, interdisciplinary physics instruction, equity and gender