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Designing Stoichiometry Learning with Multimedia Personalized Voice and Computational Thinking: Insights from a Mobile App

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Abstract: *In the era of rapid technological advancement and increasing demand for effective Science, Technology, Engineering, and Mathematics (STEM) education worldwide, there is a pressing need to innovate chemistry learning, particularly in challenging topics such as stoichiometry for pre-university students. This study explores chemistry lecturers' perspectives on integrating Multimedia Personalized Voice and Computational Thinking (CT) in designing stoichiometry learning through a mobile application designed for pre-university students. Employing a qualitative research approach with a basic qualitative inquiry design, data were collected via interviews with five experienced chemistry lecturers. Thematic analysis revealed that personalized voice multimedia enhances student engagement and reduces cognitive load, while CT supports structured and systematic problem-solving in stoichiometry. Despite technical and pedagogical challenges, the developed learning design model shows promise in improving students' conceptual understanding and problem-solving skills. This study contributes to the development of interactive and relevant learning models aligned with contemporary chemistry education needs. The findings provide valuable guidance for educators and educational app developers aiming to enhance the quality of stoichiometry teaching and learning at the pre-university level.*

Keywords: Stoichiometry, Multimedia Personalized Voice, Computational Thinking, Mobile Application, Learning Design

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1. Introduction

In recent years, rapid advancements in digital technology and the increasing global emphasis on Science, Technology, Engineering, and Mathematics (STEM) education have driven educators to reconsider conventional teaching and learning approaches. Within chemistry education, particularly at the pre-university level, students are expected to develop both conceptual understanding and strong quantitative problem-solving skills. However, many foundational chemistry topics remain challenging, with stoichiometry consistently identified as one of the most difficult concepts for students to master (Tan & Abdullah, 2021).

Stoichiometry requires learners to integrate abstract chemical concepts, symbolic representations, and mathematical reasoning simultaneously. Recent studies have shown that pre-university students often struggle with mole concepts, balanced equations, limiting reagents, and proportional reasoning, leading to surface-level learning and reliance on memorization rather than meaningful understanding. These difficulties are frequently associated with high cognitive load, especially when instruction relies heavily on text-based explanations and traditional lecture-oriented methods (Li et al., 2021).

To address these challenges, mobile learning has gained attention as an innovative instructional approach that supports flexible, learner-centered, and technology-enhanced learning environments. Mobile applications allow students to engage with learning materials anytime and anywhere, offering opportunities for repeated practice and personalized learning experiences (Liu et al., 2024; Nguyen, Do, & Le, 2023). When designed effectively, mobile learning environments can integrate multimedia elements that support learners' cognitive processing and enhance engagement.

One multimedia element that has shown promise in improving learning outcomes is Multimedia Personalized Voice. According to the latest research in multimedia learning, conversational and personalized audio narration can reduce extraneous cognitive load and facilitate deeper learning by presenting information in a more natural and learner-friendly manner (Johnson & Liu, 2021; Raehanah & Mubarak, 2025). Empirical studies have demonstrated that personalized voice narration can increase learner motivation, attention, and comprehension, particularly when explaining complex or abstract concepts (Singh & Verma, 2023). In the context of stoichiometry, personalized audio explanations may help students better follow step-by-step reasoning processes and reduce confusion during problem-solving.

In parallel, the integration of Computational Thinking (CT) has become increasingly important in STEM education as a means of strengthening learners' analytical and problem-solving abilities. CT emphasizes skills such as problem decomposition, algorithmic thinking, logical sequencing, and systematic reasoning (Kumar, Sharma, & Singh, 2022). When applied to chemistry problem-solving, CT can support students in breaking down stoichiometric problems into manageable steps, identifying known and unknown variables, and applying structured solution strategies consistently (Leu et al., 2024). This approach aligns well with the procedural and logical nature of stoichiometry calculations.

Despite growing interest in multimedia learning and CT, existing research has largely focused on student performance outcomes or experimental instructional interventions. Limited attention has been given to lecturers' perspectives, particularly regarding how these approaches can be meaningfully integrated into learning design through mobile applications. Lecturers play a crucial role in selecting appropriate pedagogical strategies, designing effective learning activities, and aligning instructional innovations with curriculum requirements and students' learning needs (Kim, Lee, & Cho, 2022; Li et al., 2021). Understanding lecturers' perspectives is therefore essential for developing practical and pedagogically sound learning models, especially for pre-university chemistry education.

Furthermore, there remains a lack of integrated learning design models that combine Multimedia Personalized Voice and CT within mobile learning environments for stoichiometry. Most existing instructional designs address these approaches independently, without considering how their integration may holistically address both conceptual understanding and problem-solving difficulties. Therefore, this study aims to explore chemistry lecturers' perspectives on the integration of Multimedia Personalized Voice and CT in designing stoichiometry learning through a mobile application for pre-university students. Specifically, the objectives of this study are to (1) explore lecturers' perspectives on the use of Multimedia Personalized Voice and CT in stoichiometry learning design, and (2) develop a stoichiometry learning design model based on lecturers' insights that integrates multimedia principles and CT. By addressing these objectives, this study seeks to contribute to the development of an innovative, practical, and contextually relevant learning design model that supports effective stoichiometry learning in contemporary chemistry education.

2. Literature Review

Research related to stoichiometry learning consistently shows that this topic is one of the most difficult components in chemistry for both pre-university and higher education students to master. Stoichiometry requires learners to simultaneously integrate deep conceptual understanding, quantitative calculation skills, and logical reasoning, making it cognitively demanding. Recent studies highlight that many students rely heavily on memorized procedures rather than developing a meaningful conceptual understanding of chemical reaction relationships and quantitative reasoning processes (Raehanah & Mubarak, 2025). Moreover, difficulties in stoichiometry persist even when students are able to correctly balance chemical equations, indicating underlying conceptual gaps in the cognitive processing of chemical phenomena (Tan & Abdullah, 2021). These findings suggest that procedural competence alone is insufficient for mastering stoichiometry and underscore the need for instructional approaches that emphasize conceptual clarity and structured problem-solving.

To meet these challenges, various technology-enhanced teaching methods have been introduced, including multimedia, animations, simulations and mobile applications. Previous research indicates that well-designed multimedia learning environments can improve students' understanding of complex scientific concepts through visual representation and guided instruction (Mayer, 2021; Li et al., 2021). Research reviews also demonstrate that careful integration of multimedia tools improves engagement, motivation, and learning outcomes across disciplines when grounded in strong pedagogical design. Multimedia environments can support learners’ cognitive processes by aligning instructional materials with dual channels of information processing (visual and auditory), leading to better organization and retention of knowledge.

One specific element gaining attention in multimedia instructional design is the use of voice narration that is personalized, conversational, and aligned with learners’ cognitive preferences. Cognitive Theory of Multimedia Learning (CTML) suggests that well-designed combinations of words and visuals help learners build coherent mental models and reduce extraneous cognitive load in learning complex topics (Mayer, 2024). In mobile learning contexts, the integration of multimedia channels like audio narration together with visual content allows learners to process information more efficiently by distributing cognitive load across dual channels and reducing overload (Manulang et al., 2024). Although research on personalized voice specifically for stoichiometry learning remains limited, evidence from broader educational contexts indicates that such approaches can increase engagement, clarify procedural steps, and enhance comprehension when integrated into digital learning environments.

In addition to multimedia, CT has emerged as an essential pedagogical approach within STEM education. CT encompasses processes such as decomposition, pattern recognition, abstraction, and algorithmic thinking, which are highly relevant to structured problem-solving in science disciplines. Studies in science education report that CT supports learners in breaking down complex problems into manageable parts and fosters systematic reasoning strategies (Wing, 2006. While CT research in chemistry instruction remains relatively new, related educational research in mathematics and science contexts suggests that CT promotes higher-order thinking and problem-solving abilities by encouraging students to follow logical, algorithmic sequences (Selamat, Nasir, & Adnan, 2024).

Another critical theme in the literature is the role of lecturers in designing technology-enhanced learning. Lecturers are not only transmitters of knowledge, but also designers of learning experiences that must align pedagogical approaches with student preparation and curricular requirements. Educational technology research highlights that the perspectives, beliefs and professional experience of instructors play a crucial role in determining how digital tools are selected, integrated and implemented into teaching practices, ultimately influencing students' learning experiences and outcomes (Kim et al., 2022; Liu et al., 2024). However, much existing research prioritizes students' perceptions or learning outcomes, often overlooking lecturers' insights into technology-driven instructional design. This gap creates a disconnect between theoretically sound instructional models and real-world classroom implementations.

Additionally, despite the growing body of research examining individual instructional elements such as multimedia learning or CT, there remains a clear shortage of studies that integrate these elements into a comprehensive learning design model for stoichiometry delivered through mobile applications. Existing studies have largely focused on the isolated effects of specific digital tools or instructional interventions, rather than exploring how multiple pedagogical strategies can be systematically combined within a coherent instructional framework (Lim et al., 2023; Selamat et al., 2024). Moreover, limited attention has been given to grounding such integrated designs in lecturers' lived experiences and pedagogical decision-making, despite evidence that educators' perspectives play a critical role in shaping effective technology integration. This gap highlights the need for research that not only synthesizes multimedia and CT principles but also anchors instructional design in the insights of education practitioners, particularly within the context of pre-university chemistry education.

Overall, the literature supports the necessity of this study to investigate chemistry lecturers' views and develop a learning design model that incorporates Multimedia Personalized Voice and CT for stoichiometry instruction. Such a model is expected to contribute to a deeper understanding of technology-enhanced instructional design and provide a solid conceptual foundation for future research in chemistry education.

2.1 Conceptual Framework

This study is guided by a conceptual framework, as illustrated in Figure 1, which explains the key relationships among the challenges of learning stoichiometry, chemistry lecturers' perspectives, and the integration of pedagogical approaches involving Multimedia Personalized Voice and CT. The framework proposes that learning challenges and lecturers' insights function as independent factors that directly inform the design of stoichiometry learning. The influence of these factors is mediated through the integration of the two pedagogical strategies, which together contribute to the development of an effective mobile application based learning design.

Multimedia Personalized Voice refers to the use of friendly, personalized, and interactive audio narratives aimed at reducing cognitive load and enhancing student engagement during learning. CT supports students in systematically solving problems through structured algorithms and logical reasoning. The integration of these approaches into mobile learning applications facilitates flexible, interactive, and learner-centered instruction that caters to the needs of today's pre-university students.

The framework further emphasizes the importance of continuous support and guidance from lecturers, alongside reliable technological infrastructure, to ensure the successful implementation of the learning design. By examining these relationships, this study aims to develop a comprehensive model that enhances conceptual understanding and problem-solving skills in stoichiometry through innovative pedagogical methods.

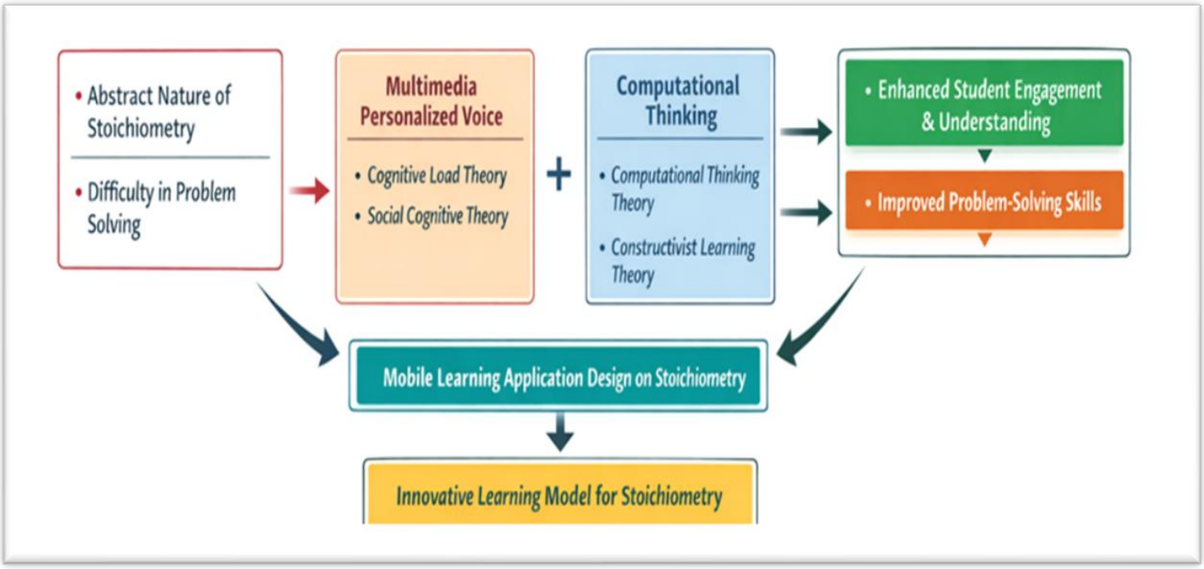

Figure 1: Conceptual Framework

3. Methodology

This qualitative approach is suitable for exploring how chemistry lecturers interpret their experiences and construct meaning related to teaching and learning design (Merriam & Tisdell, 2021; Saldaña, 2021). The development of a stoichiometry learning design model grounded in authentic teaching practices can only be informed by an in-depth understanding of lecturers' perspectives through this approach.

Data were collected primarily through semi-structured interviews with five chemistry lecturers from Malaysian Matriculation Colleges (Table 1). This method was chosen to gain in-depth insights into lecturers' experiences and pedagogical considerations rather than quantify variables (Creswell & Poth, 2023).

Table 1: Demographic of Chemistry Lecturers

Chemistry Lecturer	Gender	Age	Teaching Experience	Current Position	Academic Qualification
L1	Female	50	25	Excellent Chemistry Lecturer	Doctorate
L2	Female	58	25	Senior Chemistry Lecturer	Doctorate
L3	Female	49	22	Senior Chemistry Lecturer	Master
L4	Female	45	21	Excellent Chemistry Lecturer	Master
L5	Female	46	22	Senior Chemistry Lecturer	Master

Participants were selected through purposive sampling to ensure relevant experience teaching stoichiometry at the pre-university level (Palinkas et al., 2021). A sample of five lecturers was sufficient for this exploratory study, focusing on data saturation rather than broad generalization (Morse, 2021).

In addition to interviews, limited observations of teaching practices and instructional materials were conducted to enrich the data and provide context. This triangulation strengthened the credibility of the findings (Fusch et al., 2018). The semi-structured interview questions focused on gathering perspectives relevant to integrating Multimedia Personalized Voice and CT in stoichiometry learning. Sample questions included:

i *Based on your experience, what are the main challenges students face in understanding and solving stoichiometry problems?*
ii *What is your perspective on the use of multimedia elements, particularly personalized voice, in helping students grasp the concepts and calculation steps in stoichiometry?*
iii *In your opinion, to what extent is the CT approach such as step-by-step problem solving, pattern recognition, and algorithmic thinking suitable for application in stoichiometry learning?*
iv *If a mobile application were developed for stoichiometry learning, what design elements, features, or teaching approaches do you consider important to include to make learning more effective?*

For data analysis, open coding and thematic analysis were conducted manually using Microsoft Word. Interview transcripts were fully transcribed, coded, and organized into themes to identify patterns and insights (Nowell et al., 2017; Terry et al., 2017). Manual coding allowed close engagement with the data and deeper understanding (Castleberry & Nolen, 2018). Ethical standards were rigorously followed. Informed consent was obtained from all participants, confidentiality was ensured through pseudonyms, and institutional guidelines were observed (Orb et al., 2023).

To ensure trustworthiness, strategies such as aligning interview questions with research objectives, triangulating data, iterative theme review, and transparent analysis were employed (Lincoln & Guba, 2021). Including direct participant quotations further supported the credibility of the results. In conclusion, this methodology enabled a detailed exploration of chemistry lecturers' perspectives and supported the development of a learner-centered stoichiometry learning design model grounded in empirical evidence.

4. Finding

This qualitative study explored the challenges, needs, and potential application of multimedia elements, with a particular focus on personalized voice, in stoichiometry learning. Through in-depth interviews with experienced chemistry lecturers, a variety of perspectives and insights were gathered to develop a comprehensive understanding of how technology can address students' difficulties in grasping stoichiometry concepts. The findings are organized into four primary themes: challenges in teaching stoichiometry, the necessity and potential of Multimedia Personalized Voice, the role of CT in learning, and essential design elements for an effective learning model.

4.1 Challenges in Teaching Stoichiometry

Lecturers consistently identified students' difficulties in understanding and executing the precise, systematic steps involved in solving stoichiometry problems as a significant challenge. Many observed that students often lose concentration and experience cognitive overload when confronted with complex concepts and multi-step calculations. Nevertheless, the use of narrative voice within learning applications was perceived as a potentially effective means to alleviate these issues.

Participant 1 emphasized, *"The voice in the app creates a more relaxed feel, so students do not feel as pressured. I noticed that with this voice, they focus better."* This indicates that friendly, informal audio elements can reduce students' cognitive load and increase engagement. Nonetheless, not all narrative voices were positively received. Participant 2 commented, *"The voice can help students understand the steps more clearly, but sometimes it sounds less natural, which can reduce interest."* This suggests that while personalized voice aids comprehension, voice quality and naturalness are critical to maintaining motivation. Participant 3 suggested, *"Personalized voices are good for less confident students because they guide them slowly, but there should be voice variety to avoid monotony."* Balancing audio elements to avoid distraction was also highlighted. Participant 5 shared, *"Too many voices can confuse students, so the balance must be maintained."* Therefore, the use of personalized voice needs careful planning to provide effective support without overwhelming or confusing learners.

4.2 Needs and Potential of Multimedia Personalized Voice

Regarding multimedia, personalized voice shows great potential in enhancing stoichiometry learning. Several participants supported the multimedia approach for clarifying problem-solving steps progressively. Participant 4 stated, *"I like using voice in class because it helps students who get bored easily; it makes learning more lively and interactive."*

This underscores multimedia's role in boosting motivation and engagement. Personalized voice not only conveys information but also stimulates student interest in a challenging subject. Participant 5 remarked, *"The app is good, but it should be balanced with classroom activities so students don't get bored."* This finding emphasizes the need for a harmonious integration of technology and traditional teaching to maintain balanced learning experiences.

4.3 CT in Stoichiometry Learning

Another main theme is the effectiveness of CT in helping students understand stoichiometry more deeply. CT involves breaking down complex problems into smaller parts and following structured problem-solving processes.

Participant 1 said, "*This is important because it helps students break the problem into smaller parts. When they understand the steps, it's easier to digest."* However, challenges were noted for students unfamiliar with algorithms and logical calculations. Participant 2 reported, *"Some students find this difficult because they have to think like algorithms, but with proper teaching, it's manageable."* This highlights the need for adequate guidance and appropriate teaching methods to prevent students from feeling overwhelmed.

Additionally, CT helps students identify patterns and structures in stoichiometry questions. Participant 3 commented, "This thinking helps students focus on patterns and solve questions more accurately without confusion." By emphasizing abstraction, students avoid focusing on irrelevant information and concentrate on essential data. Participant 4 added, *"It teaches students to abstract and not focus on unnecessary details."*

Applying theory to practical situations was also considered crucial for students to connect concepts with real-world contexts. Participant 5 stated, "It must be applied practically, not just theory, or else students struggle to relate to stoichiometry concepts."

4.4 Design Elements of the Learning Model

Regarding the development of a mobile app-based learning model, participants agreed that a systematic and stepwise instructional design is vital. Participant 1 said, *"The learning model* *can give students a more systematic way to learn. With multimedia and voice, they don't get bored easily."* Clear, staged approaches help students avoid confusion and improve understanding. Participant 2 stressed that the model helps students understand each step sequentially, preventing confusion during problem solving. Participant 3 linked the model to CT: *"The model includes CT, helping students break down problems and think logically."*

The model's flexibility to adjust learning according to students' abilities was also seen as critical. Participant 4 mentioned, *"This model can adapt to the students' level and learning styles."* Finally, student confidence can be enhanced through clear voice guidance and orderly problem-solving steps, facilitating independent learning. Participant 5 added, *"This model will make students more confident because of voice guidance and clear steps; they feel more comfortable learning on their own."*

In summary, the participants emphasized that an effective learning model for stoichiometry should be systematic, stepwise, and adaptable to individual learner needs. The integration of multimedia personalized voice and CT within this framework not only clarifies complex concepts but also fosters student engagement and confidence. Such a flexible and well-structured model supports independent learning and provides the necessary scaffolding for students to master stoichiometry effectively.

4.5 Challenges in Using Mobile Applications

The findings also highlighted challenges when using mobile applications for stoichiometry learning. Student discipline was a major obstacle when they did not use the app seriously. Participant 1 stated, "*The hardest part is when students are undisciplined with the app; sometimes they just play around and don't focus."*

Technical issues, such as unstable internet connections, also caused frustration and decreased motivation. Participant 2 noted, *"Technical problems like unstable internet make students feel frustrated."* Moreover, app content that does not match students' ability levels made understanding difficult. Participant 3 commented, *"Sometimes the app content feels too complicated and not suitable for students' level."*

Continuous support from lecturers was deemed essential to keep students motivated and prevent them from giving up. Participant 4 added, *"Without lecturer support, students quickly give up on using the app."* A balanced approach between traditional teaching and technology use is necessary to maintain student interest and avoid boredom.

5. Discussions

5.1 Positive Effects of Multimedia Personalized Voice

The data from interviews highlight that multimedia personalized voice plays an important role in enhancing student engagement and reducing cognitive load in stoichiometry learning. Table 2 shows the coding and themes identified.

Table 2: Coding and Theme for Positive Effects of Multimedia Personalized Voice

Coding	Themes
Student engagement	Positive Effects of Multimedia Personalized Voice
Reduction of cognitive load	Positive Effects of Multimedia Personalized Voice
Friendly and clear narrative voice	Positive Effects of Multimedia Personalized Voice

The participants emphasized that multimedia personalized voice significantly helps students stay focused and feel relaxed during learning. As Participant 1 mentioned, *"The voice in the app creates a more relaxed feel, so students do not feel as pressured. I noticed that with this voice, they focus better."* This supports findings from Mayer (2021) that personalized audio can effectively reduce cognitive load and increase learner engagement, especially for complex scientific topics like stoichiometry.

5.2 Challenges and Improvement Needs for Multimedia

Despite the benefits, participants pointed out challenges related to voice naturalness and variety. Table 3 presents the coding and themes.

Table 3: Coding and Theme for Challenges and Improvement Needs for Multimedia

Coding	Themes
Lack of voice variety, monotony	Challenges and Improvement Needs for Multimedia
Voice naturalness issues	Challenges and Improvement Needs for Multimedia

Some participants noted that the voice could sometimes sound unnatural, which might reduce student interest. One remarked, "Sometimes the voice sounds less natural, which can reduce student interest." Another suggested the need for voice variation to avoid monotony and maintain engagement. This implies the technical and pedagogical aspects of voice personalization require further refinement to maximize impact (Lee & Kim, 2022).

5.3 Benefits of CT in Learning

CT was recognized as a valuable approach for organizing and solving stoichiometry problems systematically. Table 4 summarizes the relevant coding and theme.

Table 4: Coding and Theme for Benefits of CT in Learning

Coding	Themes
Problem decomposition, structured approach	Benefits of CT
Pattern recognition, logical thinking	Benefits of CT

Participants stressed that CT helps students break down complex problems into manageable steps and recognize patterns, improving accuracy and reducing confusion. For example, one lecturer noted, *"CT helps students focus on patterns and solve questions more accurately without confusion"*. This supports the notion that CT promotes logical thinking and systematic problem solving, which is essential in chemistry education (Kumar & Hassan, 2022; Lee & Park, 2024).

5.4 Challenges and Support in CT

While CT offers benefits, challenges were reported especially for students unfamiliar with algorithmic thinking. Table 5 shows the related coding and theme.

Table 5: Coding and Theme for Challenges and Support in CT

Coding	Themes
Difficulty understanding algorithms	Challenges and Support in CT
Need for continuous guidance	Challenges and Support in CT

Some participants highlighted that students struggle with the logic and abstraction involved in CT. One said, "*Some students find it difficult because they have to think like algorithms, but with proper teaching, it's manageable.*" The need for ongoing guidance and scaffolding was emphasized to ensure students can effectively adopt CT in learning (Kumar, Sharma, & Singh, 2022; Liu et al. (2024)

5.5 Challenges in Using Mobile Applications

The study also uncovered issues related to mobile application usage in learning stoichiometry. Table 6 lists coding and themes.

Table 6: Coding and Theme for Challenges in Using Mobile Applications

Coding	Themes
Student discipline issues	Challenges in Mobile App Usage
Technical problems	Challenges in Mobile App Usage
Content difficulty	Challenges in Mobile App Usage

Discipline and motivation were major concerns. As one participant shared, “The hardest part is when students are undisciplined with the app; sometimes they just play around and don’t focus.” Technical issues such as unstable internet connectivity further frustrated learners. Additionally, inappropriate content difficulty was reported as a barrier. These findings highlight the need for robust infrastructure and ongoing lecturer support to optimize technology-enhanced learning (Lim, Omar, & Chong, 2023; Nguyen & Smith, 2025).

This study demonstrates that integrating Multimedia Personalized Voice and CT into stoichiometry learning provides a promising approach to enhance understanding, motivation, and problem-solving skills. However, effective implementation requires addressing technical limitations, ensuring voice quality and variation, and offering sufficient pedagogical support to guide students through new cognitive strategies. The balance between technological tools and human facilitation is crucial to maximize educational benefits.

5.6 Unexpected or Contradictory Findings

Although the integration of Multimedia Personalized Voice and CT generally showed positive effects on stoichiometry learning, some unexpected or contradictory findings emerged from the interviews with chemistry lecturers. Firstly, while personalized voice was praised for reducing cognitive load and enhancing student engagement, some participants noted concerns regarding the naturalness and variety of the voice used. Participant 2 mentioned, *“The voice sometimes sounds less natural, which makes some students less interested”*. This finding contrasts with the anticipated uniform positive reception of personalized voice and highlights the importance of voice quality and diversity to sustain student motivation.

Secondly, despite the potential benefits of CT in structuring problem-solving, certain students experienced difficulties adapting to the algorithmic and logical thinking required. Participant 2 reported, *“Some students find this difficult because they have to think like algorithms”*. This indicates that without proper guidance, the CT approach may pose challenges, especially for students unfamiliar with computational concepts.

Additionally, some students reportedly found the use of audio elements overwhelming when excessively applied. Participant 5 expressed concern about *“too many voices”* causing confusion, suggesting that an imbalance in multimedia elements might reduce learning effectiveness rather than enhance it.

Finally, technical issues and student discipline were significant barriers to the effective use of mobile applications. Problems such as unstable internet connections caused frustration among students, and lack of discipline led to misuse or non-serious engagement with the app, as Participant 1 noted, *"Sometimes students just play around and don't focus"*. These factors underscore that technology integration alone is insufficient without adequate infrastructure and ongoing teacher support.

These contradictory findings emphasize the complexity of implementing technology-enhanced learning and the need for careful design, continual improvement, and comprehensive support systems to realize the full benefits of Multimedia Personalized Voice and CT in stoichiometry education.

5.7 Proposed Model for Stoichiometry Learning

This qualitative study explored the challenges and needs associated with stoichiometry learning, as well as the potential application of multimedia elements, especially personalized voice. The development of this model began by integrating two key elements: the use of multimedia with Personalized Voice and the application of CT principles. The Multimedia Personalized Voice component serves as a medium to reduce students' cognitive load by providing friendly and easily comprehensible audio narration, thereby enhancing student engagement and motivation throughout the learning process (Table 2). Simultaneously, CT forms the foundation to assist students in breaking down complex stoichiometry problems into smaller, structured steps through approaches such as algorithms and pattern recognition. This not only facilitates a deeper understanding of the concepts but also builds students' logical and systematic thinking skills.

The model also emphasizes flexibility, allowing content and teaching levels to be adapted according to students' needs and proficiency. Continuous support from lecturers and a balanced integration of mobile application use with traditional learning activities are essential to ensure sustained student motivation and persistence. Additionally, technical factors such as stable internet connectivity and user-friendly application design are given due attention to optimize the effective use of this technology.

In conclusion, this model is designed as a holistic solution that not only addresses the inherent abstractness and complexity of stoichiometry but also emphasizes an interactive, structured, and learner-centered approach. It reflects the synergy between technology and pedagogy capable of enhancing the quality of teaching and learning effectiveness, thereby helping students master stoichiometry concepts more confidently and effectively. Furthermore, this model opens opportunities for expansion and adaptation to other learning fields with similar challenges.

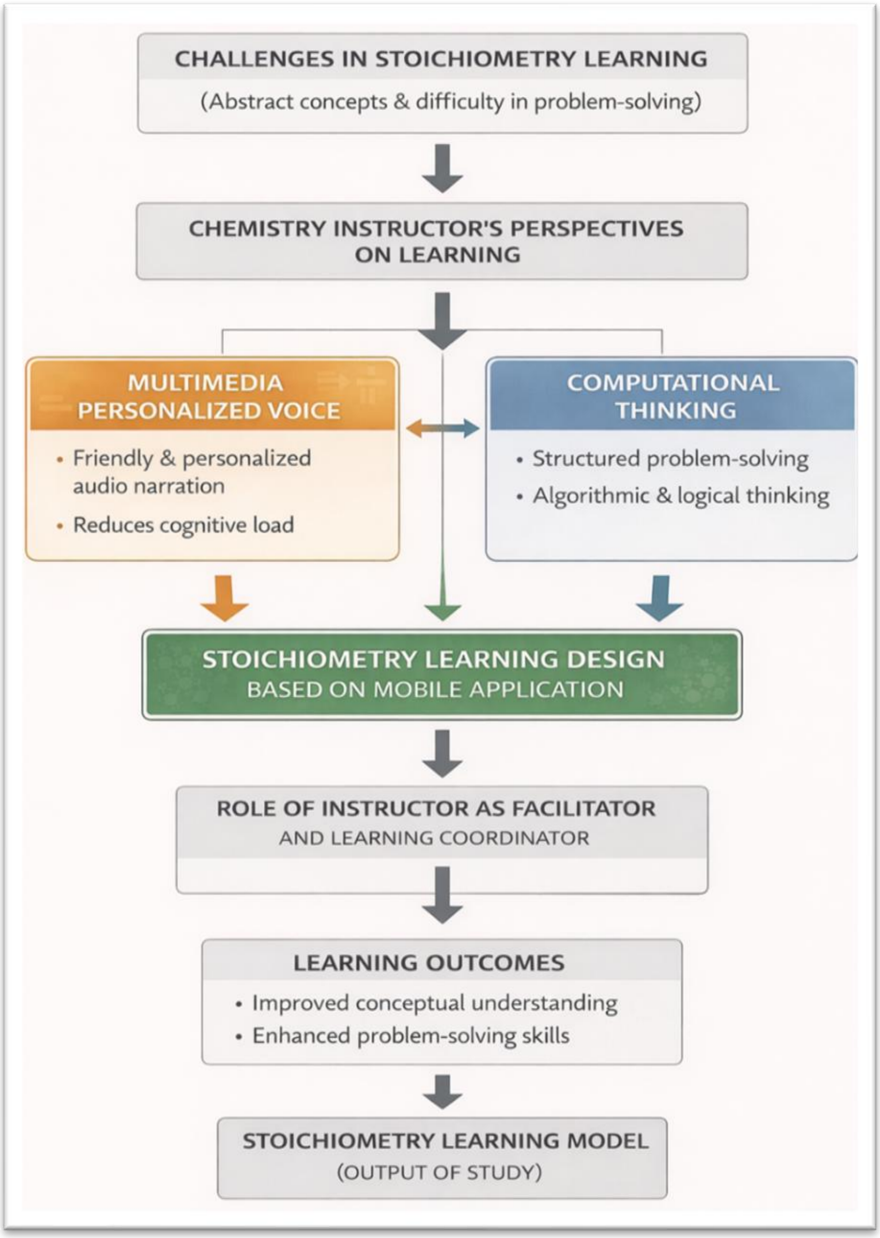

Figure 2: Stoichiometry Learning Design Model

6. Conclusion

This study has provided valuable insights into the use of Multimedia Personalized Voice and CT in designing stoichiometry learning via a mobile application. Based on in-depth interviews with five chemistry lecturers, the findings indicate that both approaches can positively influence students' understanding and problem-solving skills in stoichiometry. Lecturers emphasized that Personalized Voice helps reduce cognitive load and foster greater engagement by presenting complex content in a more accessible audio format, supporting recent research by Johnson & Liu (2021) on effective multimedia learning design.

CT was viewed as essential in guiding students to break down stoichiometry problems into logical, systematic steps, aligning with Lee and Park's (2024) findings on CT's role in promoting higher-order thinking and structured problem solving in STEM education. However, lecturers also identified challenges such as the need for more natural voice variations, student difficulties with abstract algorithmic concepts, and technical constraints of mobile platforms, echoing Nguyen and Smith's (2025) observations regarding the importance of design quality and educator readiness in technology integration.

The study's themes reveal that Multimedia Personalized Voice enriches learning by helping students grasp abstract concepts more effectively (Wong et al., 2023), while CT fosters the logical thinking necessary for tackling complex stoichiometry problems (Kumar & Hassan, 2022). Additionally, overcoming infrastructural and pedagogical barriers is crucial to successful implementation. Given the complexity of stoichiometry, integrating these two approaches provides an impactful alternative to traditional methods, supporting structured, learner-centered sequences adaptable to diverse student needs, consistent with pedagogical trends emphasized by Tan and Chong (2025).

This research contributes both practically and theoretically by offering a design model that merges multimedia technology and CT principles to improve stoichiometry learning. It further adds to the growing body of literature demonstrating how educational technologies enhance engagement and cognition (Lim et al., 2023). These findings provide valuable guidance for educators, technologists, and policymakers in creating effective, learner-centered experiences for today's students.

In conclusion, implementing Multimedia Personalized Voice and CT in stoichiometry learning contexts effectively addresses existing challenges while enhancing students' motivation, comprehension, and problem-solving abilities. These results support educational paradigms that emphasize multimodal, learner-centered instruction and establish a foundation for further research in similarly challenging domains.

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Conflict of Interest Statement

The author(s) declare(s) that there is no conflict of interest regarding the publication of this study.

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