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E-CDCCText Development: An Instructional Material for Facilitating Conceptual Change in Fluid Concepts

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ABSTRACT
Effective instruction of fluid concepts in physics requires a deep understanding of students' preconceptions and the implementation of pedagogical strategies that promote conceptual change. This study aims to develop the Electronic Conceptual Development and Conceptual Change Text (E-CDCCText), a digital instructional resource designed to foster conceptual change in students' understanding of fluid mechanics. Employing the Design and Development Research (DDR) methodology, the development followed the ADDIE model. Validation by five expert reviewers, supported by analysis using Facet software, confirmed the material's quality in terms of content accuracy, structural coherence, narrative clarity, and media design. The E-CDCCText comprises seven structured sections that guide students through a systematic process of constructing and reconstructing scientific concepts, integrating both conceptual development and conceptual change frameworks. The content targets three core fluid concepts: hydrostatic pressure, buoyant force, and the principles underlying floating, suspending, and sinking. The implementation phase involved 64 tenth-grade students, whose conceptual understanding was assessed using a validated four-tier diagnostic test. Results demonstrated a significant enhancement in students' scientific conceptions, indicating the efficacy of the E-CDCCText in reducing misconceptions. In conclusion, the E-CDCCText is a validated and effective digital instructional tool for supporting conceptual change and improving students' understanding of fluid concepts in physics education.

Keywords: *conceptual change, E-CDCCText, fluid concept, instructional material*

INTRODUCTION

One of the core competencies to be developed through physics education is students' comprehensive mastery of physics concepts (Bitzenbauer & Meyn, 2021; Wulandari et al., 2024; Ziad et al., 2021). This mastery is essential for understanding scientific phenomena and solving real-world problems. Physics education, therefore, must emphasize not only the comprehension of fundamental principles but also the cultivation of higher-order thinking and scientific inquiry skills. Conceptual understanding serves as the foundation for these competencies (Jonassen & Carr, 2020). However, students' conceptual frameworks are often shaped by pre-existing conceptions formed through daily experiences and prior education (Bouchée et al., 2022; Chen & Techawitthayachinda, 2021; Ozkan & Umdu, 2021). These preconceptions, while intuitive, frequently diverge from scientifically accepted explanations, leading to what are commonly referred to as alternative conceptions, misconceptions, or conceptual difficulties (Conrad & Libarkin, 2022; Mishra, 2020; Pacaci et al., 2024; Stylos et al., 2021; Yürük & Eroğlu, 2016).

The emergence of misconceptions can be attributed to various factors, including prior knowledge, lived experiences, linguistic and cultural influences, teacher explanations, textbook content, and inappropriate instructional methods (Fujii, 2020; Stefanou et al., 2024). When instructional methods fail to align with the nature of the content, conceptual clarity is compromised, and students are less likely to achieve a robust scientific understanding. A key contributor to the persistence of misconceptions is the limited pedagogical and content knowledge among teachers (Assem et al., 2023). Moreover, ineffective teaching strategies and instructional media that do not support cognitive engagement can further exacerbate misunderstanding.

Addressing student misconceptions early is critical to preventing their reinforcement and transfer to higher levels of learning. This necessitates the transformation of students' initial ideas into scientifically accurate conceptions through deliberate instructional strategies (Conrad & Libarkin, 2022; Fratiwi et al., 2017; Fujii, 2020; Sudirman et al., 2023). Among these strategies, the conceptual change approach has proven particularly effective (McLure et al., 2020; Potvin et al., 2020). Conceptual change involves a cognitive restructuring process in which learners replace erroneous beliefs with scientifically accurate ones, typically triggered by cognitive conflict when prior conceptions fail to account for observable phenomena (Posner et al., 1982; Thomas & Kirby, 2020). This process is central to physics education, as many scientific concepts directly contradict students' intuitive reasoning.

Despite growing interest in conceptual change within physics education, several research gaps remain. Much of the existing literature emphasizes remedial interventions for students who already hold misconceptions (Amin et al., 2018; Armagan et al., 2017), often overlooking students with no prior conceptual frameworks—who require different forms of instructional support (Amin et al., 2018). Additionally, although Conceptual Change Texts (CCTs) have demonstrated effectiveness in mitigating misconceptions (Armagan et al., 2017), their integration with conceptual development approaches into a unified, structured format is still limited. This is particularly true in the realm of digital learning environments that combine multimedia elements with structured diagnostic tools (Girwidz & Kohnle, 2022). In the Indonesian context, research into digital conceptual change materials that accommodate diverse cognitive profiles—both misconception-prone and novice learners—is notably scarce. These gaps underscore the need for instructional tools such as the Electronic Conceptual Development and Conceptual Change Text (E-CDCCText), which integrates conceptual construction and reconstruction processes within a digitally enriched learning framework.

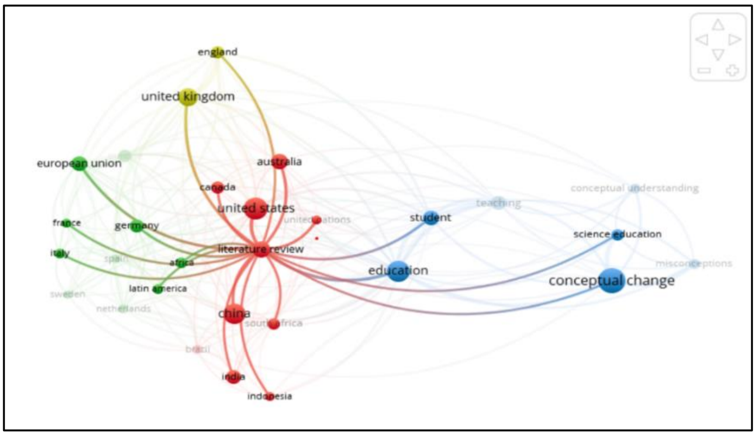


Figure 1. Results of VosViewer for Research on Conceptual Change in Various Countries

According to data retrieved from the Scopus database for the period 2014–2023, literature reviews on conceptual change have been widely conducted in various countries, as illustrated in Figure 1. However, the number of literature reviews originating from Indonesia remains limited.

This is evident from the small output node representing Indonesia in Figure 1, suggesting that scholarly contributions in this field are still minimal. These findings reinforce the significance of conceptual change research in education, particularly in understanding how learners revise their understanding of complex scientific phenomena.

Instructional media play a critical role in facilitating students' comprehension of physics concepts. In classroom settings, physics education typically employs multiple methods, including direct instruction, textbook-based learning, and laboratory activities. Nevertheless, studies indicate that approximately 90% of science educators continue to rely primarily on textbooks as their main instructional resource (Attakumah, 2020; Julie & Maat, 2021; Nurdini et al., 2018). Texts are an essential component of science learning, significantly influencing students' conceptual frameworks. Conceptual Change Texts (CCText), in particular, have been widely used in remedial contexts to address persistent misconceptions (Suhandi et al., 2020). For instance, Hermita et al (2019) examined the use of CCText in teaching the concept of boiling, Aydin (2012) explored its application in geometric optics, and Handayani et al (2022) investigated its effectiveness in teaching fluid pressure. Collectively, these studies highlight the value of CCText in enhancing students' conceptual understanding and promoting scientific thinking.

Despite these advancements, the application of CCText remains largely remedial in nature, focusing on correcting pre-existing misconceptions. Such an approach may not adequately address the diverse cognitive profiles found among students. Research has shown that learners enter the classroom with varying levels of prior knowledge—some possess misconceptions, while others have little to no foundational understanding of the subject (Graham et al., 2013; Taylor, 2022). Students lacking initial conceptions require support through the development of new conceptual frameworks, which calls for strategies that integrate both conceptual development and conceptual change processes. Achieving effective learning outcomes thus depends not only on restructuring inaccurate prior knowledge but also on constructing new scientific understandings.

To address this pedagogical challenge, the Conceptual Development–Conceptual Change Text (CDCCText) model was introduced, offering a more holistic instructional approach. CDCCText is designed to support learners across a spectrum of cognitive starting points by integrating both conceptual development for those without prior knowledge and conceptual change for those with misconceptions. Grounded in constructivist learning theory, this approach emphasizes active cognitive engagement and scaffolds the construction and reconstruction of scientific concepts (Figure 2).

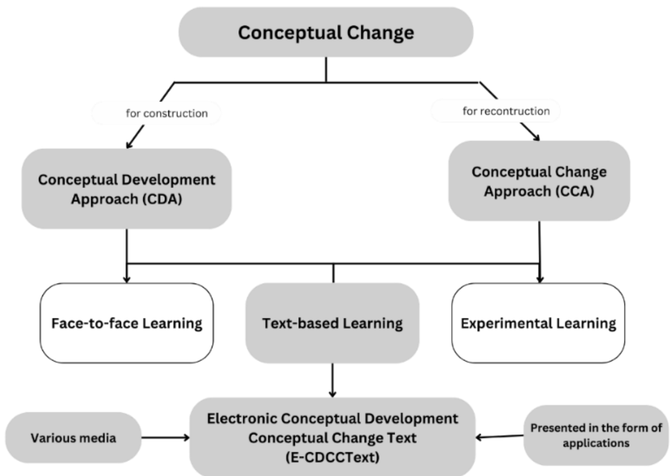


Figure 2. A Framework for Conceptual Change Using CDA and CCA Approaches Supported by Text-Based Learning

Figure 2 presents a conceptual framework that distinguishes between two key instructional approaches related to conceptual change: the Conceptual Development Approach (CDA) and the Conceptual Change Approach (CCA), both situated within the context of text-based learning. Recognizing that the construction and reconstruction of conceptions often occur concurrently in educational settings, this study expands upon the traditional Conceptual Change Text (CCText) model by developing the Conceptual Development–Conceptual Change Text (CDCCText). This integrated model is designed to accommodate the diversity of students' conceptual starting points—whether they lack prior conceptions or hold misconceptions—by combining the developmental construction of new ideas with the restructuring of inaccurate ones.

CDCCText represents an advancement over conventional conceptual change models by emphasizing not only the correction of misconceptions but also the systematic development of scientifically accurate conceptions. Previous research in science education has demonstrated that students benefit most from instructional materials that scaffold the gradual evolution of their conceptual understanding (Potvin et al., 2020). This dual-focus approach facilitates deeper learning through both cognitive conflict resolution and concept internalization.

To enhance the instructional potential of CDCCText, the integration of multimedia elements is essential. Visual aids—such as diagrams, animations, and videos—serve to concretize abstract physics concepts, making them more accessible and engaging for learners (Nurwianti et al., 2019; Syafaren & Gafur, 2023). Aligned with cognitive load theory, the use of combined visual and textual formats can optimize students' information processing capabilities (Tugtekin & Odabasi, 2022). Consequently, the CDCCText was transformed into a digital format, termed Electronic Conceptual Development–Conceptual Change Text (E-CDCCText), to provide an interactive, multimedia-rich learning experience. This digital version includes dynamic visualizations, simulations, and responsive content that supports various learning styles and helps clarify complex physics topics. In light of the increasing adoption of digital platforms in education, E-CDCCText has the potential to become a powerful instructional tool for promoting both conceptual development and conceptual change. It offers flexible, student-centered access to content that aligns with individual learning needs and cognitive profiles.

The primary objective of this study is to develop the E-CDCCText as a digital instructional resource aimed at facilitating conceptual change in fluid mechanics. Designed specifically to address misconceptions through the induction of cognitive conflict, E-CDCCText encourages students to reassess and revise their existing ideas. The unit of analysis in this research consists of senior high school students. This article is structured as follows: (1) research methodology outlining the development and validation stages of the E-CDCCText, (2) presentation of research findings, and (3) discussion of the characteristics and effectiveness of the E-CDCCText as applied to the topic of fluid concepts in physics.

METHODOLOGY

This study employs the Design and Development Research (DDR) approach to develop the Electronic Conceptual Development–Conceptual Change Text (E-CDCCText) as a digital instructional material aimed at facilitating conceptual change in fluid concepts. DDR is a research method focused on the systematic creation and refinement of educational products and tools through iterative stages of design, development, and evaluation (Richey & Klein, 2014). To guide the development process, this study adopts the ADDIE model, a widely used instructional design framework comprising five stages: Analysis, Design, Development, Implementation, and Evaluation (Spatioti et al., 2022). The ADDIE model is particularly well-suited for this research as it offers a structured and comprehensive framework that ensures the E-CDCCText is developed in a methodical and evidence-based manner.Each stage of the ADDIE model contributes to the rigorous design and validation of the E-CDCCText, ensuring that it effectively addresses students' conceptual needs and facilitates both the construction and reconstruction of scientific concepts. The detailed research flow, illustrating the sequential steps followed throughout this study, is presented in Figure 3.

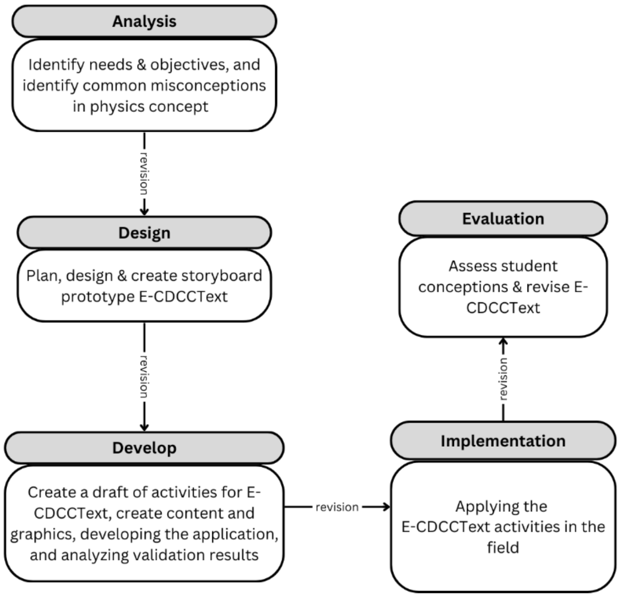


Figure 3. The Research Flow to Develop The E-CDCCText

The first stage, Analysis, begins with the identification of specific educational needs and learning objectives that guide the development of E-CDCCText activities. This stage draws on an extensive review of literature and previous studies to assess knowledge gaps and pedagogical demands, forming the foundation for designing effective learning experiences targeting fluid concepts. The second stage, Design, involves detailed instructional planning. At this stage, strategies are formulated to translate identified needs into actionable instructional materials. An initial prototype is created to visualize the conceptual framework, and a storyboard is developed to outline the sequential structure and interactive flow of the E-CDCCText activities. The third stage, Development, transforms the design into a functional product. This involves drafting activity content for the E-CDCCText, designing graphics, developing the digital application, and conducting a comprehensive validation of the materials. A key component of the E-CDCCText draft is the inclusion of a conception diagnostic instrument. The instrument used is the Multitier Instrument of Fluid Concepts (MIFO), developed by Nurdini et al. (2020), consisting of 12 items: three assess hydrostatic pressure, three evaluate understanding of buoyant force, and six address phenomena such as floating, suspending, and sinking. Each item integrates tiers of conceptual understanding, reasoning, and confidence, enabling a precise classification of students' conception states using a four-tier diagnostic model.

Validity testing of this diagnostic instrument includes both content and construct validity analyses. Content validity was assessed by expert raters using Minifac (Facets) software, revealing that the instrument is valid with no required revisions for goal indicators and answer keys, though revisions were needed for some writing indicators. Construct validity was analyzed using Rasch modeling, confirming the instrument's unidimensionality as evidenced by the proportion of raw variance explained by the measures. Reliability testing, also conducted using Rasch analysis, produced a satisfactory Cronbach's alpha value, indicating the instrument's consistency. While three items were flagged as requiring refinement, the overall tool was deemed reliable for measuring students' fluid conceptions. The validation of the E-CDCCText activities was also conducted during this stage by five expert reviewers. Their evaluations were analyzed using Minifac (Facets) software (version 3.80.4). The validation scoring system classified responses into three categories: Validation Without Revision (score = 3), Validation With Revision (score = 2), and Not Valid (score = 1). These scores were then processed for analysis. Additionally, the alignment between conception test results and the conception states identified in the E-CDCCText activities was reviewed by the same expert panel.

The fourth stage, Implementation, refers to the practical application of the E-CDCCText in a real educational setting. In this phase, the material was introduced and completed by students. The population consisted of 187 tenth-grade students across six classes in a selected school. A sample of 64 students (29 male and 35 female), aged approximately 15–16 years, was randomly selected, assuming population homogeneity. The final stage, Evaluation, focuses on assessing students' conceptual change using the four-tier diagnostic test administered at three key points in the E-CDCCText sequence: Section I (pre-instruction), Section III (post-development phase), and Section VII (post-conceptual change phase). These checkpoints provide insights into students' conceptual progression, enabling evaluation of both construction and reconstruction phases. Students' conceptions were classified into three categories: Scientific Conception (SC), No Conception (NC), and Misconception (MC) (Nurdini et al., 2019). The percentage of conceptual change for each student was calculated using the following formula:

$$\%Criteria\ for\ Conceptions = \frac{\sum Criteria\ for\ Conceptions}{\sum Students}\ x\ 100\% \quad (1)$$

This evaluation provides a comprehensive overview of the students' conceptual changes during the use of the E-CDCCText.

RESULT AND DISCUSSION

At the Analysis stage, a detailed conceptual analysis was conducted on the topic of fluids—an area in physics where misconceptions are frequently observed. This was complemented by a student needs analysis to inform the development of the E-CDCCText. The conceptual analysis identified several common misconceptions held by students, including: (1) the belief that hydrostatic pressure is influenced by the shape of the container; (2) the assumption that the greatest hydrostatic pressure depends solely on the height of the liquid above it; (3) the notion that an object weighs less in a fluid than in air; (4) the idea that larger or heavier objects are more likely to sink, whereas smaller or lighter objects are more likely to float; (5) the belief that denser liquids will always cause objects to float; and (6) the misconception that the orientation of an object (vertical or horizontal) in a fluid affects its buoyancy or position, as illustrated in Figure 4.

Beyond cataloging these misconceptions, the analysis also revealed that students' understanding of fluid mechanics is often fragmented and lacks coherence. These findings are consistent with previous research, which has documented similar conceptual difficulties in the domain of fluid physics. Notably, studies by Duit and Treagust (2003) and Qian and Lehman (2017) have emphasized that misconceptions about hydrostatic pressure, buoyant force, and related phenomena are pervasive due to intuitive reasoning and prior experiences that conflict with scientific principles.

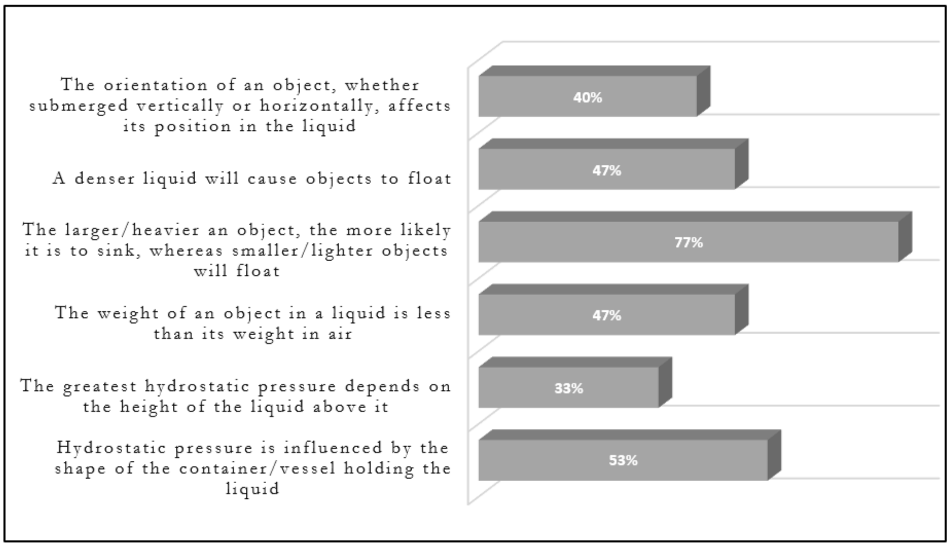


Figure 4. Student Misconceptions Found in The Topic of Fluids

The results of this analysis align with previous research, which consistently highlights persistent misconceptions in the domain of static fluids—particularly concerning hydrostatic pressure, buoyant force, and the phenomena of floating, suspending, and sinking. Studies have shown that students often possess deeply rooted misconceptions in these areas, underscoring the limitations of conventional teaching methods in promoting accurate scientific understanding (Samsudin et al., 2023; Chen et al., 2020; Ferrero et al., 2020; Nurdini et al., 2019; Qian & Lehman, 2017). These enduring conceptual inaccuracies reflect the inherent challenges in teaching fluid mechanics and emphasize the urgent need for targeted instructional strategies. Ferrero et al (2020) stress that effectively addressing such misconceptions requires learning experiences that actively engage students in confronting and revising their flawed beliefs. By gaining a deeper understanding of these common misconceptions, educators are better positioned to design pedagogical approaches that not only correct erroneous conceptions but also foster meaningful conceptual change. As Hamid et al.(2017) argued, facilitating the transformation of students' initial conceptions into scientifically accurate understanding necessitates the implementation of instructional strategies that are both intentional and research-informed.

The design of the E-CDCCText activities is strategically informed by the diverse initial conceptions held by students—ranging from the presence of misconceptions to a complete absence of prior knowledge. To effectively address this variation, the activities are intentionally structured to support both the construction and reconstruction of scientific conceptions. This dual focus is achieved through the integration of two pedagogical approaches: the Conceptual Development (CD) approach and the Conceptual Change (CC) approach, both of which are grounded in constructivist learning theory. By synthesizing these complementary strategies, the E-CDCCText framework facilitates a comprehensive learning process that accommodates students at different cognitive entry points. This integration yields a new instructional structure composed of seven interconnected sections, each designed to sequentially guide students through the processes of conceptual construction and conceptual revision. The detailed structure of the E-CDCCText activity is depicted in Figure 5.

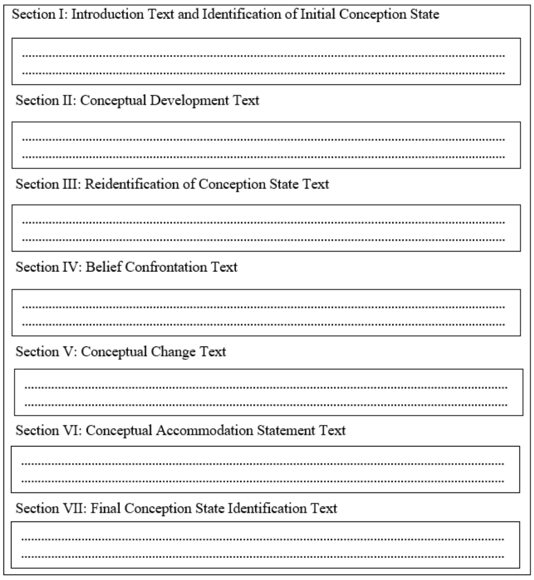


Figure 5. E-CDCCText Structure

Based on the framework illustrated in Figure 5, the E-CDCCText activity is structured into sequential sections to support both conceptual development and conceptual change. Section I introduces the topic and identifies students' initial conceptions. This begins with an introductory text that outlines the concept to be studied, followed by a conception test designed to assess students' prior understanding. Section II contains the conceptual development text, aimed at helping students construct scientifically accepted conceptions. This section is presented in a narrative format enriched with images and videos to enhance students' cognitive engagement and support their understanding. Reflective questions are integrated to encourage students to draw their own conclusions from the visualized material. Research by Kowalski & Taylor (2017) supports the effectiveness of this approach in improving students' conceptual understanding, particularly in addressing prevalent misconceptions.

To evaluate the effect of conceptual development, Section III re-administers the conception test to assess changes in students' understanding following Section II. The next set of sections applies the conceptual change approach. Section IV, titled belief confrontation, presents scenarios, narratives, and questions specifically designed to provoke cognitive conflict. The content in this section is developed based on the misconception patterns identified in Sections I and III and is supplemented with multimedia elements—such as images and videos—to further engage students and stimulate conceptual dissonance.

Section V contains the conceptual change text, which delivers scientifically accurate explanations of the phenomena introduced in Section IV. These explanations are also supported by visual media to enhance comprehension. After engaging with the text, students are guided through a set of reflective questions that encourage them to realign their conceptions with accepted scientific principles. Section VI provides a reinforcement activity, consolidating the corrected conceptions through interactive application tasks (note: you may include this only if it's actually in your framework—your original message skipped from Section V to VII). Section VII serves as the final re-identification of students' conceptions, using a post-test equivalent to the ones in Sections I and III, to evaluate conceptual change after the complete instructional intervention.

Following the development of this structured activity sequence, a storyboard was created to visualize the design and functionality of the E-CDCCText product. The storyboard plays a critical role in conceptualizing the product's interface and user interaction, ensuring alignment with the pedagogical objectives. Designed using Adobe XD in .xd format, the storyboard underwent a thorough revision process based on advisor feedback, which informed the refinement of the

CDCCText application design. Several representative sections of this storyboard are displayed in Figure 6.

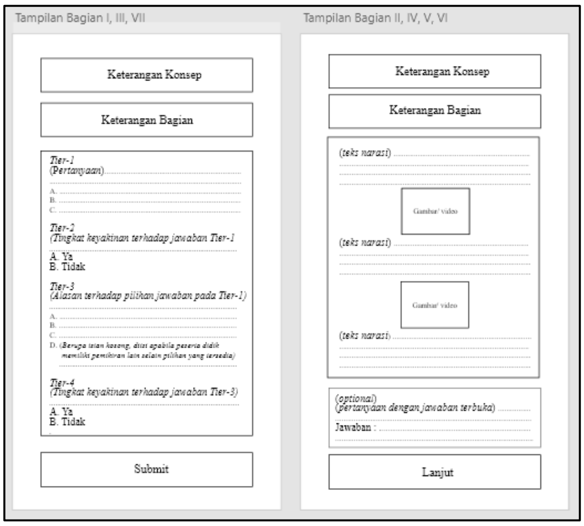


Figure 6. Storyboard on the Activity Section Display of E-CDCCText

After the activity structure and storyboard were finalized, the next phase involved the development of the E-CDCCText activities to actualize the design. This phase encompassed several key tasks: drafting the E-CDCCText activities, generating content such as images and videos, designing graphics for the E-CDCCText application, collaborating with a developer to build the application, and conducting expert validation of the completed E-CDCCText materials. Among all phases of this research, the development phase was the most time-intensive. The drafting of the E-CDCCText activities was grounded in previously piloted conception tests. The activities were segmented into four texts, each aligned with specific conceptions identified through diagnostic assessments. These included E-CDCCText-1, focused on hydrostatic pressure, addressing the misconception that "hydrostatic pressure inside a cavity and outside a cavity differs in magnitude." E-CDCCText-2, covering buoyant force, targeting the misconception that "the magnitude of buoyant force is proportional to the volume above the liquid's surface." E-CDCCText-3 and E-CDCCText-4, which addressed concepts of floating, suspending, and sinking. E-CDCCText-3 focused on the misconception that "an object will sink in a fluid if its density is greater than that of the fluid," while E-CDCCText-4 challenged the belief that "light and small objects float, while heavy and large objects sink." These drafts were meticulously constructed to ensure clarity, interactivity, and alignment with scientifically accurate concepts, fostering student engagement and deep learning.

Conception tests were embedded in Sections I, III, and VII, all based on the Multitier Instrument of Fluids Concepts (MIFO) developed by Nurdini et al (2020). Section II was designed as a construction text to foster concept development, especially for students lacking foundational understanding. Section IV presented belief-confrontation text based on diagnostic items from Sections I and II, aimed at generating cognitive conflict through narrative prompts, experimental videos, and reflective questions. Section V provided scientific explanations and conceptual clarification based on the phenomena explored in Section IV. Section VI featured guiding questions to consolidate students' newly formed conceptions, followed by Section VII, which reassessed their conceptual understanding post-intervention.

In parallel with content drafting, media development was conducted, which required significant time and effort. The images used throughout the E-CDCCText were primarily graphical illustrations created using Adobe Illustrator, tailored to present static visualizations of physical phenomena. Videos were captured in laboratory settings or lab-like environments, and virtual simulation videos were developed and recorded using screen capture software. Two video clips were curated from reliable internet sources. All video content was edited using Wondershare Filmora 9, ensuring clarity, conciseness, and alignment with instructional goals. A critical component of this process was the instructional design of media content for each section, ensuring that each visual and auditory element contributed meaningfully to students' conceptual development.

Once the content was finalized, application development commenced. The layout and interface designs were prepared using Adobe Illustrator, Adobe XD, and Canva, and subsequently handed over to a software developer. The developer was responsible for programming the E-CDCCText application, constructing the associated database, and deploying the system on a server to ensure it was accessible via the internet. The outcomes of the application development process, including interface design and user interaction features, are presented in Figure 7.

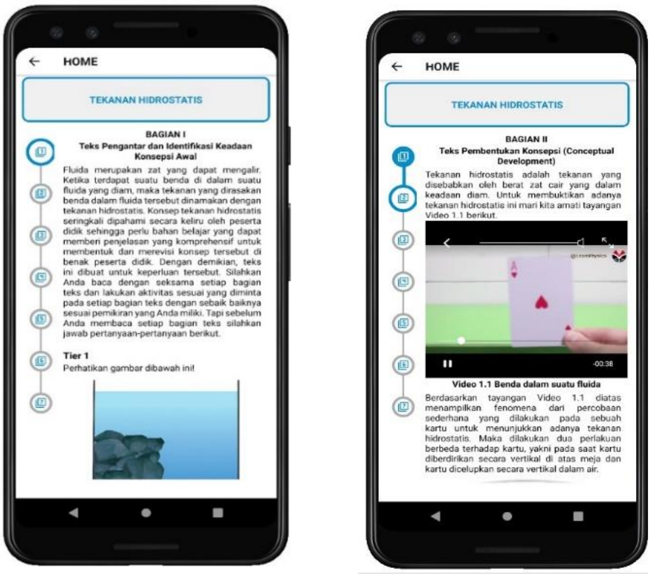


Figure 7. Display of the E-CDCCText Activity Application in Several Parts of the E-CDCCText Activity

Following several revisions and refinements to the application, expert validation of the E-CDCCText activities was carried out. This validation process involved a comprehensive expert evaluation guided by a structured set of indicators, systematically coded from A1 to D5. The construction of the E-CDCCText was assessed using indicators A1 to A9, which evaluated the alignment of each section with the CDCC (Conceptual Development and Conceptual Change) approach. These included the identification of initial conceptions (A2), conceptual building (A3), re-identification of conceptions (A4), cognitive conflict or belief confrontation (A5), conceptual transformation (A6), accommodation of new conceptions (A7), identification of final conceptions (A8), and overall effectiveness of the structure (A9).

Content presentation was evaluated using indicators B1 to B4, which addressed the coherence of the material, relevance to the topic, accuracy of scientific terminology, and the overall engagement of the content. Narrative quality was assessed using indicators C1 to C5, focusing on clarity, communicative effectiveness, grammatical precision, and typographic correctness. Media quality was reviewed through indicators D1 to D5, examining visual clarity, smoothness of application performance, user-friendliness, and the intuitiveness of the navigation design.These coded indicators served as the foundation for expert judgment, which was analyzed using Minifac (Facets) software, providing a detailed and statistically rigorous evaluation of the E-CDCCText activities' validity.

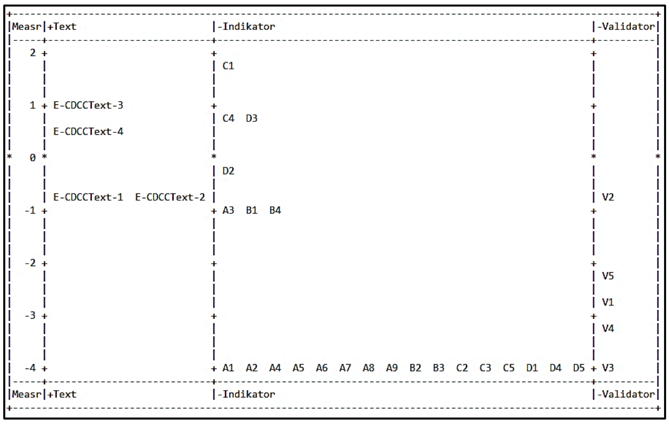


Figure 8. Validation Results of E-CDCCText Activities from Rater Analysis

The results of the validation of the E-CDCCText activities are illustrated in Figure 8, which shows that E-CDCCText-3 demonstrated superior quality compared to E-CDCCText-1 and E-CDCCText-2, based on expert evaluations. Among the indicators, C1 (narrative clarity and simplicity) posed particular challenges during assessment. Some validators, including Validator V2, recommended revisions to improve sentence structure and avoid repetitive phrasing to enhance overall effectiveness. In addition, Indicator C4, which evaluates adherence to correct Indonesian language conventions, also necessitated improvements in narrative quality. These findings suggest that revisions are essential to improve the textual clarity and linguistic accuracy of the E-CDCCText activities to ensure their validity.

Regarding media quality, Indicator D3 received mixed evaluations: Validator V2 assigned a score of 2 (Validation with Revision—VR), while the remaining four validators rated it as 3 (Validation without Revision—VWR). Similarly, Indicator D2, which concerns the clarity of visual media, was rated 2 (VR) by Validator V4, who advised enlarging text or symbol-containing images to improve legibility. Validator V1 rated Indicator A3 (related to conceptual construction), and Indicators B1 and B2 (pertaining to content presentation) as 2 (VR), suggesting the addition of further explanations regarding hydrostatic pressure in E-CDCCText-1. However, since the remaining validators rated these indicators as 3 (VWR), they can still be considered valid overall. For the remaining indicators (A1, A2, A4–A9, B3, C2–C3, C5, D1, D4–D5), all validators provided the highest rating, indicating that no revisions were required.

In conclusion, based on expert validation, the E-CDCCText activities are deemed valid overall in terms of their conceptual structure, content presentation, narrative quality, and media design. Furthermore, the validation results from all five experts regarding the alignment between concept test questions and the intended conceptual state confirm that the test instruments across Sections I, III, and VII of E-CDCCText-1 through E-CDCCText-4 are consistent with the conceptual states they aim to measure. The implementation of the E-CDCCText activities was conducted online, with each activity allocated a 50-minute session. These activities were administered to 64 tenth-grade students (29 male, 35 female) who had not yet studied the topic of static fluids. Students were given a period of two weeks to complete all four E-CDCCText activities, following a structured schedule of two activities per week.

Prior to implementation, the researcher provided students with comprehensive instructions on how to engage with the activities, including technical guidance, recommended pacing, and a reminder to complete all parts of each activity thoroughly. Although conducted independently, the activity execution was effectively monitored through strong coordination with the school. The selection of this school was strategic, as students were already familiar with online learning environments and demonstrated adequate ICT literacy, ensuring a smooth implementation process. The profile of students' conceptual change, specifically the construction type, is based on students who initially exhibited no conception and later developed scientific conceptions after completing the E-CDCCText activities. Changes in the number of students with no conception across each activity section, along with reductions observed over time, are presented in Figure 9.

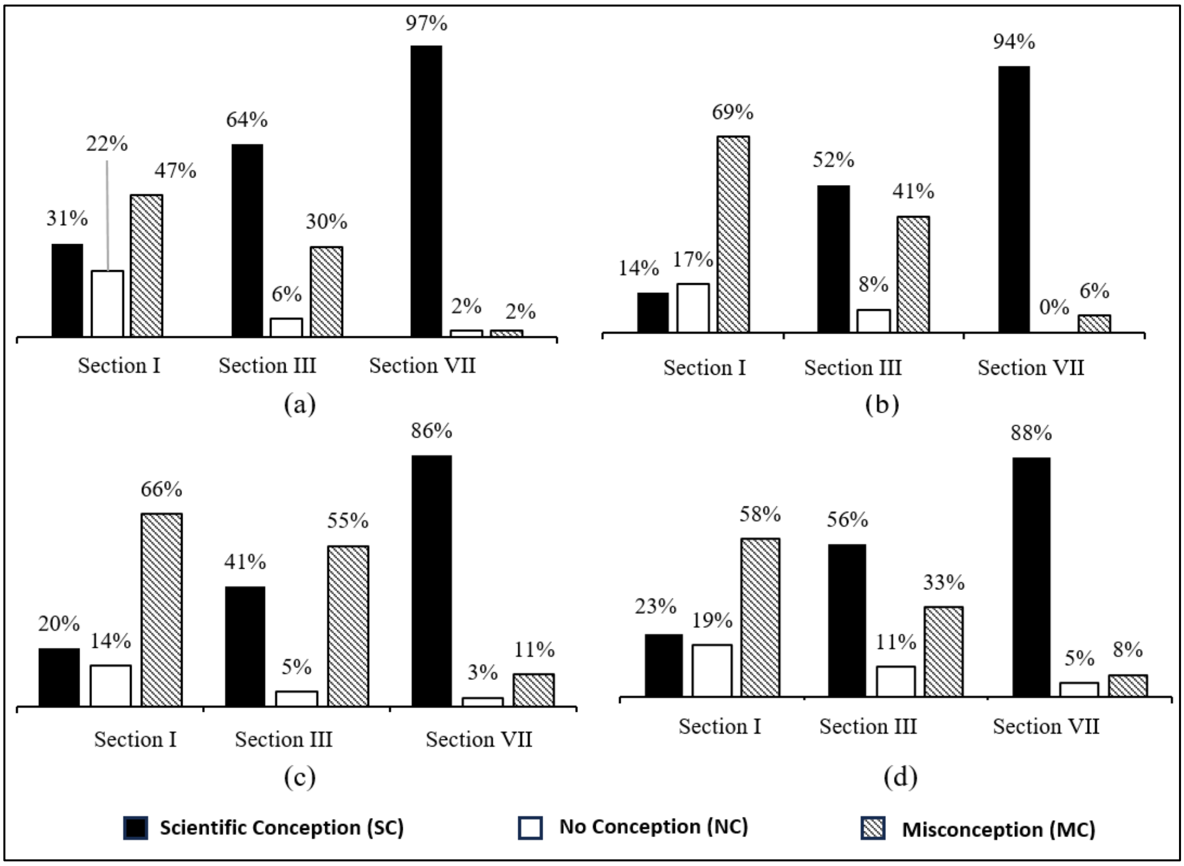


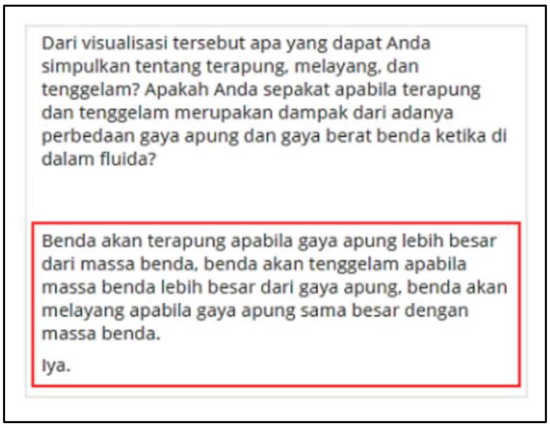
Figure 9. Student Conceptions in Activities (a) E-CDCCText-1, (b) E-CDCCText-2, (c) E-CDCCText-3, and (d) E-CDCCText-4

Figure 9 illustrates the profile of students' conceptual change after participating in the E-CDCCText activities across four sessions. In part (a), which represents E-CDCCText-1, a significant increase in the percentage of students demonstrating a scientific conception (SC) is observed in Section VII, reaching 97%, compared to only 31% and 30% in Sections I and III, respectively. This progression reflects the effectiveness of the E-CDCCText structure in fostering conceptual development and change. The observed trend is consistent with previous research by Sutopo (2016) and Wibowo et al (2017), who emphasized that conceptual change is a gradual process and that students tend to maintain their misconceptions unless provided with structured interventions explicitly aimed at conceptual restructuring.

The notable decrease in students classified as having no conception (NC) and misconceptions (MC) by Section VII further supports the assertion that targeted, conceptual change-oriented activities can facilitate a meaningful shift toward scientifically accurate understanding. These findings align with those of Samsudin et al (2019), who stressed that repeated exposure to accurate scientific information, especially when paired with cognitive conflict, is essential to correcting deeply held misconceptions. Similar trends are evident in parts (b), (c), and (d) of Figure 9, corresponding to E-CDCCText-2, E-CDCCText-3, and E-CDCCText-4, respectively. In each case, the proportion of students achieving scientific conception markedly increases in Section VII, with final percentages of 94% in E-CDCCText-2, 86% in E-CDCCText-3, and 88% in E-CDCCText-4. These consistent improvements mirror findings by Vale & Barbosa (2023), who noted that active learning methods and iterative conceptual engagement lead to more robust understanding of complex scientific ideas.

The consistent conceptual gains observed across all four E-CDCCText sessions affirm the success of the integrated CD-CC approach in promoting conceptual understanding, as supported by Strike (1992), who emphasized the importance of iterative learning processes that incorporate reflection and correction for effective conceptual change. Nonetheless, the persistently high proportions of MC and NC in Sections I and III highlight the ongoing challenges in early-stage conceptual recognition and development. This underlines the need for more refined and personalized instructional strategies, particularly during initial and intermediate phases of learning, to effectively address and transform students' pre-existing conceptions (Hermita et al., 2017; Schroeder & Kucera, 2022).

The misconception experienced by student S49 demonstrates an incorrect understanding of the principles of buoyancy and Archimedes' law. In Section I, when student S49 stated that the combined blocks would float because their larger size could balance the buoyant force, this indicates a misunderstanding that buoyant force does not depend solely on the size of the object, but also on the volume of water displaced by the object. Student S49 seemed to assume that the larger the object, the greater the buoyant force acting on it, without considering factors such as the object's and water's density.



Dari visualisasi tersebut apa yang dapat Anda simpulkan tentang terapung, melayang, dan tenggelam? Apakah Anda sepakat apabila terapung dan tenggelam merupakan dampak dari adanya perbedaan gaya apung dan gaya berat benda ketika di dalam fluida?

Benda akan terapung apabila gaya apung lebih besar dari massa benda, benda akan tenggelam apabila massa benda lebih besar dari gaya apung, benda akan melayang apabila gaya apung sama besar dengan massa benda.

Iya.

Figure 10. Example of Student S49's Answer in Section II of The E-CDCCTetx-2 Activity

In Section II of the E-CDCCText-2 activity, student S49 continued to exhibit the same misconception, as illustrated in Figure 10, indicating that the text-based learning intervention was insufficient to rectify this fundamental misunderstanding. This persistence suggests that the approach used may not have adequately engaged the student's prior knowledge or promoted the cognitive conflict necessary for conceptual change. A similar pattern was observed in Section III, where student S49 reasoned that a smaller piece of plasticine would float due to its reduced size and weight. This response reveals a common misconception—namely, the belief that floating depends primarily on an object's weight, rather than understanding that buoyancy is determined by the volume of displaced fluid and the relative density of the object and the fluid.

These findings highlight the complexity of addressing deep-seated misconceptions in physics, particularly within the topic of fluid statics. As noted by Anam et al (2019), misconceptions often arise when students fail to integrate new information with their existing cognitive frameworks. To effectively overcome these misconceptions, instruction must be more comprehensive and actively involve students in processes of exploration, reflection, and empirical testing. This approach allows learners to compare their pre-existing conceptions with scientifically accepted models, a strategy supported by Bigozzi et al., 2018; Chew & Cerbin, 2021; Prinz et al., 2022.

However, this study is not without limitations. First, the implementation of E-CDCCText activities was conducted with a limited sample of 64 tenth-grade students from a single school, which may affect the generalizability of the findings. Second, the assessment of conceptual change relied on a digital-based four-tier test, which could be influenced by variations in students' ICT literacy. Third, the intervention period was relatively short, limiting the ability to evaluate the long-term retention of students' conceptual understanding. Future research should aim to broaden the study population across varied educational settings, implement longitudinal assessments, and examine the integration of E-CDCCText with complementary instructional strategies, such as hands-on experiments or peer discussion, to maximize the effectiveness of conceptual change efforts.

CONCLUSION

Based on the results and discussion, it can be concluded that the E-CDCCText was successfully developed as an instructional tool aimed at facilitating conceptual change in students' understanding of fluid concepts, including hydrostatic pressure, buoyant force, and the phenomena of floating, suspending, and sinking. The structured design of E-CDCCText, which integrates both conceptual development (CD) and conceptual change (CC) approaches, resulted in a seven-part framework that effectively supported the progressive transformation of students' conceptions.

Validation by five expert evaluators confirmed that E-CDCCText met established quality standards in terms of activity construction, content presentation, narrative quality, and media design. The implementation with 64 tenth-grade students demonstrated a significant improvement in scientific understanding. For example, in E-CDCCText-1, the percentage of students exhibiting scientific conceptions increased from 31% in Section I to 97% in Section VII. Similar upward trends were observed across the remaining texts, with scientific conception rates reaching 94% in E-CDCCText-2, 86% in E-CDCCText-3, and 88% in E-CDCCText-4. These outcomes were assessed using a validated digital-based four-tier diagnostic test, ensuring accurate measurement of conceptual change. Given these positive results, it is recommended that future research explore the implementation of E-CDCCText in diverse educational contexts and across other subject areas to evaluate its broader applicability and long-term effectiveness. Furthermore, integrating E-CDCCText with complementary instructional strategies, such as hands-on experiments, peer discussions, or teacher-guided inquiry, may further enhance its impact and address a wider range of conceptual difficulties in physics education.

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