JPPIPA 11(1) (2025)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Contextual Learning on Type 2 Diabetes Mellitus Based on Case Studies: Educational Media Innovation in Science Learning in Senior High Schools

Muhammad Syahrir[1*], Dewi Rahayu[2], T. Khairol Razi[3], Muzakir Muhammad Amin[4], Sulaiman[4], Flora Eka Sari[5]

[1] Public Health Study Program, Faculty of Public Health, Universitas Tompotika Luwuk, Indonesia
[2] Master of Public Health Study Program, Faculty of Health, Universitas Mitra Indonesia, Indonesia
[3] Sanitation Study Program, STIKes Jabal Ghafur, Indonesia
[4] North Aceh Nursing Study Program, Poltekkes Kemenkes Aceh, Aceh, Indonesia
[4] Department of Pulmonology and Respiratory Health Sciences, Faculty of Military Medicine, Universitas Pertahanan, Indonesia

Received: April 6, 2025
Revised: May 17, 2025
Accepted: July 25, 2025
Published: July 31, 2025

Corresponding Author:
Muhammad Syahrir
muhammadsyahrir546@gmail.com

DOI: 10.29303/jppipa.v11i7.12035

Abstract: In the context of science learning, the application of a contextual approach becomes increasingly relevant when learning themes are integrated with public health issues, one of which is Type 2 Diabetes Mellitus (T2DM), which has become a serious concern in recent years both nationally and globally. This study aims to develop and test the effectiveness of case study-based educational media on Type 2 Diabetes Mellitus in science learning at SMA Negeri 1 Luwuk, Banggai Regency, Central Sulawesi. The media was designed using a contextual learning approach (Contextual Teaching and Learning/CTL) and packaged in the form of interactive visual narratives relevant to the lives of adolescents. The study used the Research and Development (R&D) method with grade XI students as subjects and involved the principal and science teachers as supporting data sources. The instruments used included validation sheets, pretest–posttest questions, and interview and observation guidelines. The validation results showed the media was categorized as very feasible. Limited trials showed a significant increase in student learning outcomes, with a gain value of 0.57 (medium–high category). In addition, students showed emotional involvement and increased awareness of the importance of a healthy lifestyle. Teachers and the principal responded positively to the media's usefulness in supporting active and meaningful learning.

Keywords: Contextual learning; Educational media innovation; Science learning; Type 2 Diabetes Mellitus

Introduction

Science education at the senior high school (SMA) level plays a crucial role in shaping students' understanding of the scientific phenomena occurring around them, while also equipping them with critical thinking and problem-solving skills based on scientific data. In the *Merdeka Belajar* (Freedom to Learn) curriculum currently implemented in Indonesia, science learning is required to be not only theoretical but also contextual, enabling students to connect scientific concepts with the realities of everyday life (Abdullah & Boleng, 2023; Machpud, 2022). One approach considered capable of addressing this challenge is contextual teaching and learning (CTL) (Riza et al., 2024; Tamam et al., 2021), a strategy that encourages students to understand subject matter through real-life experiences, thus making the knowledge gained more meaningful and applicable (Komalasari & Saripudin, 2015). In the context of

How to Cite:
Syahrir, M., Rahayu, D., Razi, T. K., Amin, M. M., Sulaiman, & Sari, F. E. (2025). Contextual Learning on Type 2 Diabetes Mellitus Based on Case Studies: Educational Media Innovation in Science Learning in Senior High Schools. *Jurnal Penelitian Pendidikan IPA*, *11*(7), 1004–1015. https://doi.org/10.29303/jppipa.v11i7.12035

science learning, the application of a contextual approach becomes increasingly relevant when learning themes are integrated with public health issues, one of which is Type 2 Diabetes Mellitus (T2DM), which has become a serious concern in recent years both nationally and globally (Galicia-Garcia et al., 2020; Soleimani et al., 2024). T2DM is a non-communicable disease whose prevalence continues to increase significantly due to unhealthy lifestyles, excessive sugar consumption, and lack of physical activity (Joseph & C. Vadasseril, 2023); .

This disease not only impacts the individual who experiences it but also poses a social and economic burden on society. Ironically, public awareness, especially among the younger generation, regarding the prevention and control of T2DM remains relatively low (Komalasari & Saripudin, 2015). This is due to the lack of effective and engaging health education in schools. Therefore, integrating T2DM material into high school science learning through a contextual approach based on case studies is considered highly strategic (Ebneyamini & Sadeghi, 2018).This strategy not only enables students to understand biological concepts such as the metabolic system and insulin hormone, but also fosters critical awareness of healthy lifestyles from adolescence.

Several previous studies have demonstrated the effectiveness of contextual learning approaches in improving student understanding and engagement in science learning. For example, a study by Kamila et al. (2024); Nasor et al., (2023), concluded that local context-based learning can improve students' science learning outcomes in junior high school (Pursitasari et al., 2020; Saija et al., 2022). Meanwhile, research conducted by Habib et al. (2021), showed that the use of educational media based on real-life cases, such as infectious diseases and lifestyles, can stimulate analytical thinking and strengthen understanding of science concepts. In the context of Type 2 Diabetes Mellitus (DM), (Cabero-Almenara et al., 2023; Dornhoff et al., 2020; Zhang, 2025), examined the integration of health themes in biology learning and found that students were better able to understand the body's physiological processes when the material was linked to familiar health issues. However, most of these studies have not explicitly developed innovative educational media that combine Type 2 DM case studies with contextual learning based on the science curriculum at the high school level (Chrvala et al., 2016; Zha et al., 2025).

The novelty of this research lies in the development and application of educational media based on Type 2 DM case studies in science learning, which not only emphasizes cognitive aspects but also integrates health education values and students' critical thinking skills. This research was specifically developed at SMA Negeri 1 Luwuk, Banggai Regency, Central Sulawesi, representing a high school context in Central Indonesia where the development of contextual media based on health issues is still minimal. The developed media is innovative because it combines narrative case studies of adolescent patients with learning activities based on scientific problem-solving. Thus, this approach is expected to bridge the gap between theoretical science learning and the social realities faced by students. Based on this background, the research question is: How is the development and implementation of educational media based on a case study of Type 2 Diabetes Mellitus (DM) in contextual science learning at SMA Negeri 1 Luwuk? This research aims to explore the effectiveness of this media in improving students' understanding of science concepts and awareness of the importance of preventing non-communicable diseases through a learning approach that is more meaningful and relevant to their lives.

The purpose of this research is to develop educational media based on a case study of Type 2 Diabetes Mellitus (DM) that can be used in contextual science learning at the high school level, specifically at SMA Negeri 1 Luwuk. This research also aims to test the effectiveness of the developed media in improving learning outcomes and student engagement, as well as assess student and teacher responses to its use. By achieving this objective, it is hoped that this research will provide a real contribution to the development of a science learning model that is contextual, innovative, and oriented towards strengthening health literacy among students.

Method

This research is a research and development (R&D) approach aimed at producing educational media based on a case study of Type 2 Diabetes Mellitus in contextual science learning at the senior high school level. The development model used in this study refers to a systematic approach to producing valid, practical, and effective learning products, and goes through continuous evaluation and revision stages based on input from experts and users (Zamiri & Esmaeili, 2024). This research and development approach was chosen because it allows researchers not only to produce learning media products but also to test their applicability and usability in the field, according to the needs and characteristics of students. This research was conducted at SMA Negeri 1 Luwuk, Banggai Regency, Central Sulawesi Province, which was chosen because of its enthusiasm for developing learning

innovations based on local contexts and relevant public health issues.

The subjects of this study were eleventh-grade students who had received science instruction on the excretory system and metabolic disorders. Therefore, they were deemed to have sufficient basic knowledge to understand the Type 2 Diabetes Mellitus case study. In addition to the students, other key informants also served as important data sources for this study. These included the principal of SMA Negeri 1 Luwuk, Mr. Ardi, who provided administrative and policy support for the learning innovation; and the science teachers, Mrs. Endang Irianti, Mr. Sudarso, and Mr. Abd Rahman, who served as evaluators and early adopters of the developed educational media. The development model in this study encompassed needs identification, media design, expert validation, product revision, readability testing, and limited field trials. The instruments used in the data collection process included educational media validation sheets by material experts and media experts, which were used to assess the appropriateness of the media's content, presentation, language, and visual appearance. Pretest and posttest questions were also used to measure improvements in students' conceptual understanding before and after media use.

Another instrument was a semi-structured interview questionnaire designed to elicit student and teacher responses to the clarity of the media content, the relevance of the case context to the science material, and the ease of use of the media in the learning process. Data collection in this study was conducted using several techniques: observation of the classroom learning process using the developed media to directly observe student engagement, documentation to record student work and assessment of the media, and in-depth interviews with students and science teachers to obtain qualitative data to strengthen the product evaluation results. Interviews were used to elicit user perceptions and experiences in using the developed learning media, including input for further improvement. The data obtained were analyzed qualitatively, following the stages of data reduction, data presentation, and conclusion drawing. During the data reduction stage, the researcher filtered important information relevant to the research focus, such as student responses to the media, the effectiveness of material delivery, and the suitability of the case context to learning needs. The reduced data were then presented in descriptive narrative form, tables, and direct quotes from the interviews to strengthen interpretation.

An in-depth analysis was conducted to interpret the media development results and relate them to contextual learning theory and the case studies used. With this approach, it is hoped that the resulting educational media will not only be theoretically sound but also relevant and applicable to science learning practices at SMA Negeri 1 Luwuk.

Results and Discussion

Results

Educational Media Product Description

The educational media developed in this research was designed in response to the need for Natural Science (IPA) learning that is not only theoretical but also contextual, applicable, and able to build students' awareness of health issues relevant to their lives. In this case, the topic of Type 2 Diabetes Mellitus (T2DM) was chosen as the main material to be developed into a structured case study integrated with the basic science competencies for grade 11. This media is presented in the form of an interactive digital booklet that can be used independently by students or under teacher guidance, both offline and online. This media format was chosen because it is flexible, easy to disseminate, and allows for the integration of narrative, visualization, and cognitive activities into one complete learning package. In general, the structure of this educational media is divided into five main sections: introduction and instructions for use, narrative case study on Type 2 Diabetes Mellitus, scientific explanation and enrichment of science concepts, student activities and learning reflection, and formative assessment (Młynarska et al., 2025).

Each section is designed to foster active student engagement and encourage critical thinking about the problems presented. The narrative case study is structured contextually, featuring the story of a teenager named Raka, an eleventh-grade student who experienced early symptoms of Type 2 Diabetes Mellitus, such as frequent urination, thirst, fatigue, and weight loss. This story was developed using a problem-based approach, so students were guided to analyze symptoms, explore causes, and understand disease mechanisms through the lens of biology. The visualizations in this media are designed to be engaging and support the narrative flow presented. Infographics are used to explain the mechanism of insulin action, the process of glucose metabolism in the body, and the risk factors that contribute to Type 2 Diabetes (Hardani et al., 2023). One section that greatly assists students in understanding the material is the flowchart of biological processes in a normal body compared to a diabetic body. This diagram is presented in an illustrative and simple style for easy

understanding by high school students. The following is a schematic representation used in the media.

Table 1. Comparison of Insulin Mechanisms of Action in a Normal Body and in a Type 2 Diabetes Patient

Aspects	Normal Body	Type 2 DM Patients
Insulin production	Normal, as needed	Normal or increased
Cellular response to insulin	Sensitive and responsive	Cellular resistance to insulin
Glucose absorption	Optimal	Not optimal, glucose remains high in the blood
Blood sugar levels	Stable	Increased (hyperglycemia)

In addition to presenting scientific knowledge, this media also features reflective and applicable student activities. Students are directed to complete a learning journal about a healthy lifestyle, assess their daily eating habits, and conduct mini-interviews with family members about their history of non-communicable diseases. These activities are designed to connect classroom learning with the real world they experience daily, in line with the principles of contextual teaching and learning. Thus, this media not only conveys biological information but also integrates affective and social aspects into the learning process. In terms of design, this digital booklet uses a clean layout, soft yet contrasting colors, and easy-to-read typography (Bonochdita et al., 2022). The illustrations used are created in vector format to ensure print quality and display on digital devices. This is important because many students at SMA Negeri 1 Luwuk access the material through their devices, and visual comfort is a crucial factor in maintaining their engagement. The choice of dominant blue and green colors aims to create an educational and calming impression.

The material in this educational media also refers to the Standard Competencies and Basic Competencies of the Independent Curriculum for 11th grade science. The topic of Type 2 Diabetes Mellitus (DM) is linked to competencies covering the human excretory system, disorders of the regulatory system, and lifestyle and health (Alam et al., 2021; Handelsman et al., 2022). The case narrative is designed to stimulate students' scientific literacy skills, including the ability to identify problems, find solutions, and make decisions based on scientific evidence. This reflects the integration of problem-based learning, contextual learning, and the scientific approach in the national curriculum. In developing this media, researchers also developed a teacher's guide to help teachers understand the media's purpose, how to integrate it into lesson plans (RPP), and alternative evaluation strategies. This guide is crucial because not all teachers are accustomed to using case-based or narrative-based media. With this guide, teachers can adapt it to their respective classroom contexts.

The media's suitability was first tested through a validation process by material experts and media experts. Validation results indicate that the media content aligns with scientific principles, is relevant to student needs, and is suitable for use in learning contexts. Furthermore, a limited trial with eleventh-grade students demonstrated that the media increased student engagement and curiosity about the material. Many students expressed that they felt that learning science became more "lively" and meaningful because it directly linked them to health issues they saw and experienced in their surroundings. By considering its structure, content, visuals, and pedagogical integration, this educational media has great potential for broader use in science learning, particularly in biology topics related to the human body and health. This product serves not only as a teacher's aid but also as a tool for reflection and fostering critical awareness in students about the importance of maintaining health and making better life choices. Amid the rising incidence of Type 2 Diabetes among adolescents, this media also serves as a strategic health literacy tool for prevention and early education.

Media Validation and Trialing

The validation and trialing process for educational media (Syamsidah, 2015), based on the Type 2 Diabetes Mellitus (Type 2 DM) case study is a key step in ensuring that the developed product is not only scientifically valid but also suitable for use in real-life learning contexts at SMA Negeri 1 Luwuk. Validation was conducted in two main areas—material substance and media design—involving competent experts. While limited field trials focused on target student groups to obtain authentic feedback on readability, appeal, and instructional effectiveness, the entire process was carried out sequentially to address any findings from the previous stages through revisions, ensuring the final product truly meets academic and pedagogical standards. The first stage began with validation by two subject matter experts with backgrounds in health biology and science pedagogy, and one media expert experienced in educational technology.

The validators received a complete draft of the interactive digital booklet along with a teacher's guide and student activity sheets. Each participant was asked to evaluate four main aspects: the validity of the

scientific concept, alignment with the Independent Curriculum (Kurikulum Merdeka), language accuracy, and visual appeal and media navigation. The assessment instrument used a five-point Likert scale with indicators adapted from the Instructional Materials Evaluation Rubric standard for secondary education contexts. In addition to providing quantitative scores, the experts also provided in-depth qualitative comments for each indicator, providing researchers with a detailed overview of the product's strengths and weaknesses. In aggregate, the validation results indicated the media was in the "very appropriate" category. The average score from the material experts reached 87 percent, indicating that the concepts of insulin's mechanism of action, cell resistance, and risk factors for Type 2 Diabetes were presented accurately and comprehensively, while also being contextually relevant for adolescents.

However, the experts recommended adding visuals of glucose metabolism pathways to help students more easily map the biochemical processes involved. The media expert, on the other hand, gave a score of 85 percent, emphasizing the strength of the clean and consistent design but recommending balancing the proportion of text and images to avoid overwhelming the reader. These suggestions were then accommodated through revisions: illustrations of metabolic pathways were emphasized with contrasting color icons, medical terms were given a mini glossary, and text margins were relaxed to make white space more comfortable on mobile screens.

Table 2. Recapitulation of expert assessment results

Validator	Aspects Assessed	Score (%)	Category	Key Suggestions
Material Expert 1	Conceptual Accuracy, Curriculum Relevance	88	Very Eligible	Include a diagram of glucose metabolism
Material Expert 2	Information Completeness, Case Novelty	86	Very Eligible	Add a glossary of medical terms
Media Expert	Visual Design, Navigation	85	Very Eligible	Balance text and images, increase white space

The Table 2 summarizes the results of the expert assessment and indicates the focus of improvements that were subsequently implemented. Post-validation revisions were not merely cosmetic; the narrative storyboard structure was also refined to ensure the story follows a logical cause-and-effect sequence: symptoms–diagnosis–physiological mechanisms–prevention. This step was crucial to maintain the coherence of the story of a teenager named Raka, the central figure in the case study, so that students could follow the development of Raka's condition while gradually building scientific understanding. After the revised version was completed, the research proceeded to a limited field trial phase involving 15 11th-grade Mathematics and Natural Sciences students representing the target group. The trial was conducted over two sessions: the first focused on independent exploration of the booklet using digital devices, while the second focused on case discussions and collaborative completion of activity sheets. Participatory observations were conducted to record student behavior, particularly levels of engagement, frequency of questions, and ease of content navigation.

Researchers also distributed questionnaires on readability and learning motivation immediately after the session, while semi-structured interviews with several students and teachers were conducted to explore their experiences with the media. Quantitative data showed a very positive response: 82 percent of students stated that the media was "very interesting" and "easy to understand," while 18 percent rated it "quite interesting," noting that the font size on some pages needed to be enlarged when printed. Observation results confirmed the questionnaire findings: students appeared enthusiastic, asked many critical questions, and engaged in active discussion when asked to analyze Raka's blood glucose level graph compared to WHO standards. The accompanying science teachers assessed that the booklet facilitated a smooth transition from individual exploration to group work because each student had a shared story context to base their discussions on. They also noted that Raka's narrative was emotionally engaging, motivating students to reflect on their sugar consumption habits. Qualitatively, the interviews yielded four main findings. First, students appreciated the language style, which "didn't feel like a textbook," as the narrative was peppered with dialogue and expressive illustrations. Second, the revised illustrations of the metabolic diagrams made it easier for them to connect concepts in cell biology with clinical symptoms. Third, the presence of the reflection sheet encouraged them to reflect on their own diet and physical activity, creating meaningful learning in the affective domain.

Fourth, teachers appreciate instructional guides that include alternative HOTS-level questions, so they don't need to create additional questions to spark discussion. Based on the synthesis of validation and trial data, it can be concluded that the media meets the

criteria for content suitability, design, and pedagogical usefulness. More importantly, the iterative validation-revision-trial process affirms the principle of formative evaluation in R&D research, where each feedback loop is processed into product quality improvements. Therefore, this interactive digital booklet on Type 2 Diabetes Mellitus (DM) is ready to proceed to a broader implementation stage, namely a main field trial involving a larger student population to statistically assess the impact on learning outcomes. Preliminary findings have strongly indicated that contextual, case-study-based media can be an effective strategy for fostering health literacy while deepening the understanding of science concepts among middle school adolescents.

Improving Student Learning Outcomes

One of the main aspects measured in this study was the extent to which case-study-based educational media on Type 2 Diabetes Mellitus (DM) improved student learning outcomes (Berutu & Tambunan, 2018; Suardi et al., 2021), in the eleventh-grade science subject. Measurements were conducted by administering a pretest and a posttest to students after using media in the learning process. The pretest was administered before students were introduced to the educational media, while the posttest was administered after the learning session had concluded, using the media as the primary tool in delivering the material. Both tests were structured around the same learning indicators to allow objective comparison of the results. The evaluation instrument used in the pretest and posttest consisted of 15 multiple-choice and short essay questions covering three cognitive domains: conceptual understanding (C2), application (C3), and analysis (C4). The questions were developed based on learning achievement indicators from the Basic Competencies, covering the topics of the excretory system, glucose metabolism, and disorders of the body's regulatory systems. Prior to use, the questions were validated by two science teachers and one biology education lecturer to ensure content validity, and piloted in small groups to determine reliability and difficulty level.

The results showed a significant increase in students' average scores after using the media. The average pretest score for students was 61.2, with a range of scores between 45 and 72. After learning using media, the average posttest score increased to 83.4, with a range of scores between 75 and 95. This increase in scores reflects a better understanding of concepts and improved analytical thinking skills in responding to case-based problems. The following is a summary of the pretest and posttest results for 11th-grade students based on the quantitative data obtained.

Table 3. Average Student Pretest and Posttest Scores

Test Type	Average Score	Highest Score	Lowest Score	Improvement Category
Pretest	61.20	72	45	Low
Posttest	83.40	95	75	Tall
Score	+22.20			

To determine the level of improvement more objectively, a gain score analysis was conducted using the Hake formula: Gain = (Posttest - Pretest) / (100 - Pretest). Averaging the pretest and posttest scores, the gain score was calculated at 0.57, which falls into the moderate to high improvement category according to the Hake classification. This indicates that the educational media used was quite effective in improving student learning outcomes. Furthermore, the improvement was not only numerical but also evident in the quality of students' responses, which demonstrated a deeper understanding of disease mechanisms and the application of biological concepts in real-life contexts.

Qualitatively, the improvement in learning outcomes was also identified through changes in students' thinking about the topics studied. In the pretest, most students were only able to state a general definition of Diabetes Mellitus without understanding the underlying physiological processes. They also had difficulty explaining the relationship between lifestyle and the function of the hormone insulin.

However, after using the media, in the posttest, they were able to connect the symptoms experienced by the case study characters with relevant science concepts, such as the function of the pancreas, insulin resistance, and the importance of physical activity in maintaining balanced blood glucose levels. This change in the quality of students' understanding is also reflected in the analysis of essay-type questions. Before the lesson, students tended to give rote and brief answers, without logical reasoning. After the lesson, their answers were more structured, included appropriate scientific terminology, and demonstrated the ability to integrate information from the case narrative with biological concepts. For example, in a question asking students to explain why Raka experienced weight loss despite his strong appetite, the majority of students were able to explain that glucose was not optimally absorbed into cells due to insulin

resistance, causing the body to break down other energy reserves such as fat and protein.

The science teacher who assisted with the post-test also noted that class discussions became more lively after students understood the context of the narrative. They appeared more confident in expressing their opinions, dared to question the logic of disease symptoms, and even shared their personal views on a healthy lifestyle. This indicates that media serves not only as a learning aid but also as a trigger for reflective and critical thinking, two important aspects of 21st-century learning. Furthermore, student learning outcomes also strengthened in the affective domain. Several students stated in interviews that after learning Raka's story, they became more aware of the importance of a healthy diet and reduced their consumption of sugary drinks. This awareness is an indirect learning outcome, yet crucial for developing sustainable healthy behaviors.

Case study-based media, in this case, has been shown to simultaneously engage students' emotional and cognitive aspects, making the learning process more comprehensive and meaningful. Based on these overall findings, it can be concluded that the use of case study-based educational media on Type 2 Diabetes in science learning has proven effective in improving student learning outcomes, both quantitatively and qualitatively. Improved grades, changes in students' thinking, and affective awareness demonstrate that the contextual approach designed through this media successfully leads students to a learning experience that is not only informative but also transformative. This media has the potential to be adapted to other science topics, particularly those related to public health issues, lifestyle, and science-based decision-making.

Principal, Teacher, and Student Responses

One important aspect in assessing the success and relevance of educational media in an educational context is responding to stakeholders within the school environment, including principals, teachers, and students (Widyarti et al., 2024). In this study, educational media based on a case study of Type 2 Diabetes Mellitus was not only quantitatively tested against student learning outcomes but also examined through a qualitative approach to understand the perceptions and experiences of media users directly. The responses obtained from the principal, teachers, and students provide a comprehensive picture of the media's effectiveness, usability, and appeal in science learning settings at SMA Negeri 1 Luwuk. The principal of SMA Negeri 1 Luwuk, Mr. Ardi, fully supported this media innovation from the initial planning stage through the trial implementation. In an in-depth interview, he stated that this contextual learning approach is highly relevant to the demands of the Independent Curriculum, which prioritizes learning that is liberating, meaningful, and close to students' real lives.

According to him, the developed media successfully addressed the challenges of science learning, which has been perceived as being too theoretical and difficult to directly relate to students' daily experiences. He also emphasized that the Type 2 Diabetes mellitus case highlighted in the media represents a current health issue and needs to be introduced to the younger generation early on, especially in areas like Banggai, which are experiencing lifestyle changes due to urbanization. Positive responses also came from the science teachers involved in the media implementation: Ms. Endang Irianti, Mr. Sudarso, and Mr. Abd Rahman. All three generally stated that the media had a systematic structure, dense yet easy-to-understand material, and attractive visuals. They assessed that the use of case study-based narratives was able to bridge abstract concepts in biology into more concrete ones that could be directly related to conditions that students or their families might experience.

One teacher stated that the story of Raka, the fictional teenager who is the central character in the case study, served as an "empathetic bridge" that helped students focus and engage with the material more easily. Teachers also appreciated the availability of teacher guides that included alternative discussion and assessment strategies, making it easier for them to facilitate active learning without having to significantly modify the media. In interviews, teachers highlighted that this media successfully engaged students in class discussions. Many previously passive students began to actively engage in answering questions and responding to classmates' opinions. This demonstrated that this media served not only as a source of information but also as a catalyst for emotional and social engagement in the learning process. Teachers stated that this more communicative approach significantly helped them, as it fostered a more dynamic and dialogical classroom atmosphere.

Meanwhile, student responses generally demonstrated high levels of enthusiasm and engagement with the media. Through questionnaires distributed after the learning process and interviews with student representatives, the majority stated that they felt more interested in learning science because the material was connected to real life. The narratives in the media were considered touching and inspiring, particularly because they depicted teenagers their age experiencing the consequences of unhealthy lifestyles.

Many students stated that after learning about Raka's case, they began to pay attention to their sugar intake and the frequency of sugary drinks they consumed, which had previously been a daily habit. Beyond the affective aspects, students also found this media easier to understand previously confusing scientific concepts. For example, the explanation of insulin resistance and the role of hormones in regulating blood sugar levels was presented in a coherent storyline, accompanied by simple yet effective visualizations. Students stated that they were not only "learning science" but also "learning to live healthily." This is a strong indicator that this educational media not only transfers knowledge but also shapes awareness and attitudes toward public health issues. The following is a summary of responses from each respondent group by thematic category.

A consistent thread emerged from the three groups of respondents: that this educational media effectively connects science concepts with real-life situations. This success is due to the use of a narrative approach and case studies, which integrate cognitive, affective, and social aspects into a unified learning experience. Both teachers and students believe that this type of media model needs to be developed for other science topics, such as hypertension, obesity, or heart disease, to bring science learning closer to the local context and current public health challenges. Thus, the responses received from the principal, teachers, and students indicate that the educational media based on the Type 2 Diabetes Mellitus case study developed is not only appropriate in content and design, but also contextually relevant and impactful in changing students' attitudes and mindsets. This is a positive signal that contextual learning innovation has a crucial place and role in supporting the transformation of science education towards a more humanistic and real-life-oriented one.

Table 4. Summary of Principal, Teacher, and Student Responses to Educational Media

Respondents	Key Findings	Implications
Principal	Contextual media supports the Independent Curriculum and addresses current health issues.	Expanding implementation to other classes and themes
Science Teacher	Systematic media, comprehensive guides, facilitate discussion and visualization of difficult concepts.	Encouraging active, case-based learning models
Students	Emotional stories facilitate understanding and motivate a healthy lifestyle.	Media encourages emotional engagement and personal reflection

Discussion

The results of this study demonstrate that the development of case study-based educational media on Type 2 Diabetes Mellitus has made a positive contribution to improving the quality of science learning at SMA Negeri 1 Luwuk. From the design, implementation, and student learning outcomes aspects, this media has proven to be able to create more contextual, communicative, and meaningful learning. The effectiveness of this media is demonstrated not only by the significant increase in pretest and posttest scores, but also by the positive responses from students, teachers, and the principal, who stated that the narrative and contextual approach used successfully bridged the understanding of biological concepts previously considered abstract and difficult to grasp. Contextual Teaching and Learning (Contextual Teaching and Learning) was the primary approach underlying the media development in this study. CTL, as proposed by (Anggreni et al., 2020), emphasizes that learning will be more meaningful if students are able to connect the knowledge they learn with real-life experiences (Ananda & Hayati, 2022). In this context, presenting science material through a case study of a teenager experiencing the symptoms and impacts of Type 2 DM is an appropriate pedagogical strategy, as it exposes students not only to theoretical material but also to a narrative that fosters empathy, awareness, and personal involvement. The case study serves as a bridge connecting scientific knowledge with real-life phenomena in the students' social environment.

The case study-based approach is also firmly grounded in constructivist theory, particularly Mahabatillah's understanding of learning as a social process. When students are presented with realistic and relevant case studies, they engage in a meaning-making process involving social interaction, exchange of perspectives, and independent and collaborative conclusion formation (Hamdani & Islam, 2019). In this study, students were not simply asked to passively understand material about metabolic systems and health disorders, but were also directed to analyze symptoms, identify biological connections, and reflect on their own lifestyle habits. This process reflects the practical application of learning scaffolding, where media serves as a tool that enriches the context and expands students' zone of proximal development. Furthermore, the use of narrative-based media has its own value in building students' depth of understanding. Narratives enable students to form emotional connections with the characters or situations in the case studies. This aligns with narrative learning

theory, which states that stories have the power to help individuals construct meaning from experiences.

When students felt emotionally engaged in the story about Raka, who suffers from Type 2 DM, they not only cognitively understood the concept but also experienced an affective process that changed their perspective on a healthy lifestyle. Therefore, learning through narrative media is not only a transfer of knowledge but also a transformation of awareness.The findings of improved student learning outcomes in this study also confirm the effectiveness of the CTL approach in improving critical thinking skills. In the pretest, many students were only able to provide definitional or descriptive answers. However, in the posttest, there was a shift in the quality of answers, becoming more analytical, argumentative, and evidence-based. This indicates that media serves not only as a source of information but also as a thought stimulus that encourages students to explore cause-and-effect relationships and apply biological concepts in real-life contexts. This confirms the findings of research by (Jamshidi et al., 2021), which stated that problem-based learning within a health context can improve students' analytical and decision-making skills.

From a teacher perspective, this media is seen as highly helpful in the learning process because it provides a strong narrative structure supported by in-depth visualizations. Teachers find it helpful in explaining complex topics such as insulin resistance, as the media presents them visually and narratively. This reinforces the role of learning media as a crucial visual aid in science learning. Research by Latip (2022), also shows that media that combine visualization, real-world context, and narrative flow tend to increase the effectiveness of science teaching at the secondary school level. In terms of implementation in schools, the principals' responses to this media demonstrate the urgent need for such innovations in the regional education system. In many secondary schools outside Java, the limited availability of contextual learning media remains a major challenge in implementing the Independent Curriculum (Curriculum Merdeka). Therefore, developing media based on socially and culturally relevant local case studies could be a model worthy of replication. Principals consider health themes such as Type 2 Diabetes to be highly appropriate because they address a current issue that is increasingly emerging among adolescents due to the increasing consumption of high-sugar, low-nutrient foods.

This study also found that the developed educational media not only improved cognitive learning outcomes but also shaped students' health attitudes and awareness. In interviews, several students stated that they began reducing their consumption of sugary drinks and became more conscious of their diet after understanding the consequences of bad habits (Eni, 2021). This demonstrates that science learning with a contextual approach can have a long-term impact on fostering healthy lifestyle behaviors, something often difficult to achieve when learning relies solely on lectures and memorization of concepts. In terms of novelty, this study presents a unique contribution through the comprehensive integration of contextual learning, narrative case studies, and health literacy. Unlike previous research that solely developed media based on animation or infographics, this study presents media that combines narrative, illustration, reflective activities, and teacher guidance in one integrated learning package. Furthermore, the research's location in Central Sulawesi adds significance because it broadens the geographic base for science learning media development, which has previously been largely concentrated in Java. Thus, this research not only provides practical contributions to the schools where the trials were conducted, but also theoretical and applied contributions in the field of contextual science education.

Although the results of this study demonstrate a significant impact, there are several limitations worth noting. First, the limited number of test subjects and the fact that it was conducted in a single school mean that generalizations of the findings must be made with caution (Jerrim, 2021; Lim, 2025). Second, the long-term impact on changes in healthy lifestyle behaviors could not be comprehensively measured due to time constraints. Therefore, further research could be directed at long-term studies with quasi-experimental designs involving more schools and a more diverse student population, as well as longitudinal integration of quantitative and qualitative data. Overall, this discussion confirms that the educational media based on the Type 2 DM case study developed in this study is capable of encouraging a transformation in the science learning process, from one focused on memorization to one that is meaningful, reflective, and applicable (Dubinsky & Hamid, 2024; Li et al., 2023). This approach provides significant opportunities for teachers to design more lively, down-to-earth learning that directly impacts students' mindsets and lifestyles. Within the framework of 21st-century educational development, innovations such as this represent a concrete step toward an education system that fosters a generation that is intelligent, critical, and physically and mentally healthy (González-Pérez & Ramírez-Montoya, 2022).

Conclusion

This research demonstrates that the development of case study-based educational media on Type 2 Diabetes Mellitus in science lessons at SMA Negeri 1 Luwuk significantly improves the quality of student learning processes and outcomes. The media, designed in a contextual, interactive, and narrative manner, has proven effective in bridging abstract biological concepts with the realities of students' daily lives, particularly regarding health issues relevant to adolescents. This approach encourages meaningful, active, and reflective learning. Expert validation results indicate that the media is highly appropriate, both in terms of content and visual design. Field trials also demonstrated significant improvements in student learning outcomes, with average post-test scores higher than pre-test scores. Gain score analysis demonstrates the media's effectiveness in fostering students' conceptual understanding and critical thinking skills. Furthermore, positive responses from the principal, teachers, and students further reinforce the media's effectiveness not only academically but also socially and emotionally. The success of this media is attributable to the strength of the contextual learning approach and narrative case studies, which activate students' cognitive, affective, and social dimensions. The findings of this study also have broad implications for the development of science learning media in the regions, particularly in integrating local issues and public health into the learning process. Therefore, case study-based educational media like this are worthy of recommendation as pedagogical innovations in the implementation of the Independent Curriculum, which focuses on liberating, relevant learning that has a real impact on students' lives.

Acknowledgments
We express our deepest gratitude to all parties, both individuals and institutions, who have contributed to the implementation of this research. Every form of support—whether moral, technical, or administrative—is crucial in ensuring the smooth running of the research process and achieving maximum and meaningful results. We hope that all assistance provided will be a beneficial contribution to the development of knowledge.

Author Contributions
Conceptualization: MS, DR, TKR, MMA, SLM, FES; Methodology Design: MS, DR; Validation Process: MS; Data Analysis: MS; Data Collection and Field Investigation: MS, DR; Resource Provision: MS, DR, SLM, MMA; Data Management: MS, DR, TKR, SLM; Writing Original Draft: MS, MMA; Drafting and Re-Editing: DR, FES; Visualization and Presentation: MS, DR, TKR. All authors have reviewed and approved the final manuscript for publication.

Funding
This research activity received financial support from each author's respective institution, in accordance with the mutual understanding that was agreed upon at the initial planning stage.

Conflicts of Interest
This research was conducted as part of the institution's commitment to improving the capacity and professionalism of lecturers and strengthening academic quality. The findings are expected to make a tangible contribution to human resource development and support the advancement of learning innovation in higher education.

References

Abdullah, A. N., & Boleng, B. (2023). Penerapan Model Pembelajaran Inkuiri dalam Meningkatkan Hasil Belajar IPA pada Siswa Sekolah Dasar. *Jurnal Basicedu*, *6*(6), 10174–10180. https://doi.org/10.31004/basicedu.v6i6.3779

Alam, S., Hasan, Md. K., Neaz, S., Hussain, N., Hossain, Md. F., & Rahman, T. (2021). Diabetes Mellitus: Insights from Epidemiology, Biochemistry, Risk Factors, Diagnosis, Complications and Comprehensive Management. *Diabetology*, *2*(2), 36–50. https://doi.org/10.3390/diabetology2020004

Ananda, R., & Hayati, F. (2022). Influence Of Learning Strategy and Independence Learning on The Learning Outcomes of Islamic Education. *Journal Of Education and Teaching Learning (JETL)*, *4*(2), 140–149. https://doi.org/10.51178/jetl.v4i2.599

Anggreni, W., Yensy B, N. A., & Muchlis, E. E. (2020). Penerapan Model Pembelajaran Contextual Teaching and Learning (CTL) untuk Meningkatkan Hasil Belajar Matematika Siswa Kelas VII SMP Negeri 06 Kota Bengkulu. *Jurnal Penelitian Pembelajaran Matematika Sekolah (JP2MS)*, *4*(2), 229–237. https://doi.org/10.33369/jp2ms.4.2.229-237

Berutu, M. H. A., & Tambunan, M. I. H. (2018). Pengaruh Minat Dan Kebiasaan Belajar Terhadap Hasil Belajar Biologi Siswa SMA Se-Kota Stabat. *Jurnal Biolokus*, *1*(2), 109. https://doi.org/10.30821/biolokus.v1i2.351

Bonochdita, M. V. V., Rampengan, S. H., Nelwan, J. E., Manampiring, A. E., & Rombot, D. V. (2022). Faktor-faktor yang mempengaruhi keputusan adopsi aplikasi hermina mobile pada pasien rawat jalan poli eksekutif di Rumah Sakit Hermina Manado. *Intisari Sains Medis*, *13*(1), 11–18. https://doi.org/10.15562/ism.v13i1.1288

Cabero-Almenara, J., De-La-Portilla-De-Juan, F., Barroso-Osuna, J., & Palacios-Rodríguez, A. (2023). Technology-Enhanced Learning in Health

Sciences: Improving the Motivation and Performance of Medical Students with Immersive Reality. *Applied Sciences*, *13*(14), 8420. https://doi.org/10.3390/app13148420

Chrvala, C. A., Sherr, D., & Lipman, R. D. (2016). Diabetes self-management education for adults with type 2 diabetes mellitus: A systematic review of the effect on glycemic control. *Patient Education and Counseling*, *99*(6), 926–943. https://doi.org/10.1016/j.pec.2015.11.003

Dornhoff, M., Hörnschemeyer, A., & Fiebelkorn, F. (2020). Students' Conceptions of Sustainable Nutrition. *Sustainability*, *12*(13), 5242. https://doi.org/10.3390/su12135242

Dubinsky, J. M., & Hamid, A. A. (2024). The neuroscience of active learning and direct instruction. *Neuroscience & Biobehavioral Reviews*, *163*, 105737. https://doi.org/10.1016/j.neubiorev.2024.105737

Ebneyamini, S., & Sadeghi, M. R. (2018). Toward Developing a Framework for Conducting Case Study Research. *International Journal of Qualitative Methods*, *17*(1), 1609406918817954. https://doi.org/10.1177/1609406918817954

Eni, N. (2021). Hubungan Mengonsumsi Makanan Manis Terhadap Tingkat Kejadian Karies Pada Anak Usia Sekolah Dasar (Studi Literatur). *Media Kesehatan Gigi: Politeknik Kesehatan Makassar*, *19*(2). https://doi.org/10.32382/mkg.v19i2.1944

Galicia-Garcia, U., Benito-Vicente, A., Jebari, S., Larrea-Sebal, A., Siddiqi, H., Uribe, K. B., Ostolaza, H., & Martín, C. (2020). Pathophysiology of Type 2 Diabetes Mellitus. *International Journal of Molecular Sciences*, *21*(17), 6275. https://doi.org/10.3390/ijms21176275

González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability*, *14*(3), 1493. https://doi.org/10.3390/su14031493

Habib, M. K., Nagata, F., & Watanabe, K. (2021). Mechatronics: Experiential Learning and the Stimulation of Thinking Skills. *Education Sciences*, *11*(2), 46. https://doi.org/10.3390/educsci11020046

Hamdani, R. H., & Islam, S. (2019). Inovasi Strategi Pembelajaran Inkuiri dalam Pembelajaran. *PALAPA*, *7*(1), 30–49. https://doi.org/10.36088/palapa.v7i1.180

Handelsman, Y., Anderson, J. E., Bakris, G. L., Ballantyne, C. M., Beckman, J. A., Bhatt, D. L., Bloomgarden, Z. T., Bozkurt, B., Budoff, M. J., Butler, J., Dagogo-Jack, S., De Boer, I. H., DeFronzo, R. A., Eckel, R. H., Einhorn, D., Fonseca, V. A., Green, J. B., Grunberger, G., Guerin, C., … Weir, M. R. (2022). DCRM Multispecialty Practice Recommendations for the management of diabetes, cardiorenal, and metabolic diseases. *Journal of Diabetes and Its Complications*, *36*(2), 108101. https://doi.org/10.1016/j.jdiacomp.2021.108101

Hardani, H., Sukmana, D. J., Atfal, B., & Pertiwi, A. D. (2023). Potential Antimicrobial Ethyl Acetate Extracts of Ur Burst Shells Against Saureus Bacteria from Diabetic Foot Wounds. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1045–1049. https://doi.org/10.29303/jppipa.v9i3.2880

Jamshidi, H., Hemmati Maslakpak, M., & Parizad, N. (2021). Does problem-based learning education improve knowledge, attitude, and perception toward patient safety among nursing students? A randomized controlled trial. *BMC Nursing*, *20*(1), 70. https://doi.org/10.1186/s12912-021-00588-1

Jerrim, J. (2021). National tests and the wellbeing of primary school pupils: New evidence from the UK. *Assessment in Education: Principles, Policy & Practice*, *28*(5–6), 507–544. https://doi.org/10.1080/0969594X.2021.1929829

Joseph, T., & C. Vadasseril, J. (2023). Diabetes – A Silent Killer: A Threat for Cardiorespiratory Fitness. In H. Sözen (Ed.), *Cardiorespiratory Fitness – New Topics*. IntechOpen. https://doi.org/10.5772/intechopen.108164

Kamila, K., Wilujeng, I., Jumadi, J., & Ungirwalu, S. Y. (2024). Analysis of Integrating Local Potential in Science Learning and its Effect on 21st Century Skills and Student Cultural Awareness: Literature Review. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 223–233. https://doi.org/10.29303/jppipa.v10i5.6485

Komalasari, K., & Saripudin, D. (2015). Integration of Anti-Corruption Education in School & rsquo;s Activities. *American Journal of Applied Sciences*, *12*(6), 445–451. https://doi.org/10.3844/ajassp.2015.445.451

Latip, A. (2022). Penerapan Model ADDIE dalam Pengembangan Multimedia Pembelajaran Berbasis Literasi Sains. *Diksains: Jurnal Ilmiah Pendidikan Sains*, *2*(2), 102–108. https://doi.org/10.33369/diksains.2.2.102-108

Li, M., Ma, S., & Shi, Y. (2023). Examining the effectiveness of gamification as a tool promoting teaching and learning in educational settings: A meta-analysis. *Frontiers in Psychology*, *14*, 1253549. https://doi.org/10.3389/fpsyg.2023.1253549

Lim, W. M. (2025). What Is Qualitative Research? An Overview and Guidelines. *Australasian Marketing*

Journal, *33*(2), 199–229. https://doi.org/10.1177/14413582241264619

Machpud, M. (2022). Pendekatan Model Inquiry Untuk Meningkatkan Motivasi Belajar Mata Pelajaran SBK Kelas VI Semester 2. *Teaching: Jurnal Inovasi Keguruan dan Ilmu Pendidikan*, *2*(2), 240–248. https://doi.org/10.51878/teaching.v2i2.1343

Młynarska, E., Czarnik, W., Dzieża, N., Jędraszak, W., Majchrowicz, G., Prusinowski, F., Stabrawa, M., Rysz, J., & Franczyk, B. (2025). Type 2 Diabetes Mellitus: New Pathogenetic Mechanisms, Treatment and the Most Important Complications. *International Journal of Molecular Sciences*, *26*(3), 1094. https://doi.org/10.3390/ijms26031094

Nasor, A., Lutfi, A. L., & Prahani, B. K. (2023). Science Literacy Profile of Junior High School Students on Context, Competencies, and Knowledge. *IJORER: International Journal of Recent Educational Research*, *4*(6), 847–861. https://doi.org/10.46245/ijorer.v4i6.436

Pursitasari, I. D., Suhardi, E., Putra, A. P., & Rachman, I. (2020). Enhancement of Student's Critical Thinking Skill through Science Context-based Inquiry Learning. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 97–105. https://doi.org/10.15294/jpii.v9i1.21884

Riza, S., Mardhatillah, Rizki, D., & Ihsan, M. A. N. (2024). The Effect of The Use of Contextual Teaching and Learning (CTL) Learning Model on The Cognitive Value of Students of Elementary School. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2702–2710. https://doi.org/10.29303/jppipa.v10i5.6988

Saija, M., Rahayu, S., Fajaroh, F., & Sumari, S. (2022). Enhancement of High School Students' Scientific Literacy Using Local-Socioscientific Issues in OE3C Instructional Strategies. *Jurnal Pendidikan IPA Indonesia*, *11*(1), 11–23. https://doi.org/10.15294/jpii.v11i1.33341

Soleimani, N., Ebrahimi, F., & Mirzaei, M. (2024). Self-management education for hypertension, diabetes, and dyslipidemia as major risk factors for cardiovascular disease: Insights from stakeholders' experiences and expectations. *PLOS ONE*, *19*(9), e0310961. https://doi.org/10.1371/journal.pone.0310961

Suardi, S., Razak, A., Amiruddin, R., Ishak, H., Salmah, U., & Maria, I. L. (2021). Effectiveness of Diabetes Self-management Education Against Diet Behavior in Patients Type 2 Diabetes Mellitus: A Literature Review. *Open Access Macedonian Journal of Medical Sciences*, *9*(E), 364–368. https://doi.org/10.3889/oamjms.2021.6033

Syamsidah, -. (2015). Permainan Bola Estafet Sebagai Media Pembelajaran Pada Anak Usia Dini. *Jurnal Pendidikan Anak*, *2*(2). https://doi.org/10.21831/jpa.v2i2.3047

Tamam S., Luthfiyah N, & Sukma, P. (2021). Contextual Teaching and Learning (CTL) Model to Students Improve Learning Outcome at Senior High School of Model Terpadu Bojonegoro. *IJORER: International Journal of Recent Educational Research*, *2*(5), 528–535. https://doi.org/10.46245/ijorer.v2i5.143

Widyarti, O., Rokhmaniyah, R., & Suryandari, K. C. (2024). Penerapan Model RADEC untuk Meningkat Kemampuan Berpikir Kreatif Siswa Sekolah Dasar dalam Pembelajaran IPA. *Kalam Cendekia: Jurnal Ilmiah Kependidikan*, *12*(1). https://doi.org/10.20961/jkc.v12i1.75374

Zamiri, M., & Esmaeili, A. (2024). Strategies, Methods, and Supports for Developing Skills within Learning Communities: A Systematic Review of the Literature. *Administrative Sciences*, *14*(9), 231. https://doi.org/10.3390/admsci14090231

Zha, S., Bragdon, M. M., Gong, N., Wang, J., Leavesley, S., Eaton, R., & Bosarge, E. (2025). A Case Study of Integrating AI Literacy Education in a Biology Class. *International Journal of Artificial Intelligence in Education*. https://doi.org/10.1007/s40593-025-00476-8

Zhang, Y. (2025). Impact of dietary habit changes on college student physical health insights from a comprehensive study. *Scientific Reports*, *15*(1), 9953. https://doi.org/10.1038/s41598-025-94439-7