Developing Context-Specific Digital Learning Materials for Vietnam's Reformed Natural Science Curriculum: A Needs-Based Approach for the "Living Things" Strand

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***Abstract*—Vietnam's 2018 General Education Program (GEP-2018) introduces a competency-based approach, posing significant challenges for the integrated Natural Science subject in lower secondary schools. Effectively teaching complex topics within the "Living Things" strand requires engaging Digital Learning Materials (DLMs) that are often unavailable in traditional settings. This study details the rationale and systematic development of a suite of DLMs tailored for this curriculum. Grounded in a needs analysis survey involving 284 Vietnamese science teachers and established pedagogical principles, a diverse set of DLMs—including virtual experiments, simulations, 3D models, and e-learning lectures—was designed and created. The needs analysis confirmed significant barriers for teachers, including lack of time (87.3%), inadequate instructions (86.3%), and a scarcity of suitable, curriculum-aligned materials (68.0%), alongside a strong preference for interactive DLMs. The developed resources directly target core concepts in the "Living Things" strand (Grades 6–9) to enhance student engagement and conceptual understanding. This paper outlines the theoretical underpinnings, the systematic 7-step development process, and the characteristics of the resulting DLMs. While this study is limited by the lack of empirical classroom validation, it provides a crucial context-specific model for educational resource creation. It is recommended that future work focuses on evaluating the impact of these DLMs, potentially through quasi-experimental or action research designs, and developing targeted teacher training to support their integration.**

***Keywords*—digital learning materials, curriculum development, e-learning, educational technology**

I. Introduction

Natural science literacy is increasingly recognized as crucial for individual empowerment and national progress in a globally interconnected world [1–3]. In response, Vietnam implemented its comprehensive 2018 General Education Program (GEP-2018), marking a significant shift from traditional knowledge transmission towards competency-based learning [2, 3]. This reform mandates substantial pedagogical adjustments and the integration of effective, updated learning resources. A key innovation of GEP-2018 is the introduction of an integrated Natural Science subject at the lower secondary level (Grades 6–9), combining concepts from Physics, Chemistry, Biology, and Earth Science [3]. This integration presents unique pedagogical challenges, particularly for abstract or dynamic topics such as those within the "Living Things" curriculum strand (e.g., cell division, photosynthesis, gas exchange).

However, facilitating engaging and effective science instruction faces hurdles, especially in Vietnam's diverse geographical and socio-economic landscape [4]. Many schools struggle with limited access to physical laboratory equipment, diverse biological specimens, and updated pedagogical tools, hindering inquiry-based learning and practical skill development. Traditional teaching methods often fail to adequately convey complex scientific processes. Digital Learning Materials (DLMs) offer promising solutions by providing electronically accessible resources that go beyond static text to include interactive simulations, virtual laboratories, animations, videos, and 3D models [4]. Well-designed educational technology can enhance learning by offering multiple representations of concepts [5], facilitating active exploration [2], personalizing learning pathways, and increasing accessibility [1]. Specifically, virtual experiments allow safe and repeatable investigations [6], while multimedia can foster positive emotions and motivation [6].

While the potential benefits of DLMs are widely acknowledged internationally [1, 7], their effective implementation is highly context-dependent [8, 9]. DLMs must be not only technologically sound but also pedagogically appropriate, curriculum-aligned, and sensitive to the specific needs and constraints of the local educational system [8, 10]. Simply adopting generic DLMs developed elsewhere may not adequately address the unique requirements of Vietnam's integrated Natural Science curriculum or the specific challenges faced by its teachers, such as varying levels of technological infrastructure and digital literacy [4, 7]. A clear need exists for high-quality, contextually relevant DLMs specifically designed for the Vietnamese GEP-2018, particularly for challenging content strands like "Living Things". This situation is not unique to Vietnam, as many developing nations in Southeast Asia and beyond face similar challenges in adapting curricula and integrating educational technology effectively [4, 6, 11].

This study was initiated to address this specific gap by pursuing two primary objectives, which are framed by the following research questions:

1) What are the current practices, perceived challenges, and needs of Vietnamese lower secondary Natural Science teachers regarding the use of DLMs, particularly for the "Living Things" strand?
2) How can a comprehensive suite of DLMs be systematically designed and developed to align with the GEP-2018 curriculum and address the identified needs of teachers?

This paper first reviews the relevant literature and theoretical framework underpinning DLM design. It then

details the mixed-methods approach employed for the needs analysis and DLM development. Subsequently, it presents the key findings from the teacher survey and describes the characteristics of the developed DLMs. Finally, it discusses the implications of the findings and the potential impact of the resources, concluding with concrete recommendations for future work.

II. Literature Review

A. Defining and Classifying Digital Learning Materials (DLMs)

The concept of DLMs has evolved from simple digitized versions of traditional materials to encompass a wide array of interactive multimedia resources designed for educational purposes [10]. According to Vietnamese Ministry of Education and Training (MOET) guidelines and international literature, DLMs include e-textbooks, reference materials, assessments, presentations, audio/video files, e-lectures, educational software, and virtual simulations [10, 12]. These materials offer flexibility, accessibility, and interactivity, allowing learners to engage with content anytime, anywhere, often through various devices [1]. DLMs can be classified based on several criteria [10]:

Format: Static (e.g., text files, slides) versus Dynamic (e.g., simulations, videos, interactive elements).

Content Type: Text, audio, video, images, simulations, databases, software.

Function: Teacher support (e.g., reference materials, lesson plans), student support (e.g., practice tools, self-study guides), or combined support.

Interactivity Level: Ranging from passive viewing to full interaction and modification [9]. Static E-learning offers minimal interaction, whereas dynamic E-learning allows users to influence content and receive feedback.

The role of DLMs extends beyond content delivery; they can facilitate interactive learning, foster creativity, support differentiated instruction, and provide assessment tools [1, 7]. Compared to print, DLMs generally offer enhanced accessibility, higher interactivity, customizable environments, and easier content updating [1, 5].

B. Design Principles and Development Processes

Effective DLM development must be grounded in established learning theories and instructional design principles. Constructivist approaches, emphasizing active knowledge construction by learners, are frequently applied [2]. This aligns with competency-based education goals, fostering critical thinking and problem-solving skills. Key development principles include ensuring alignment with learning goals, scientific accuracy, pedagogical soundness (e.g., managing cognitive load, providing scaffolding), aesthetic appeal, usability, modularity, and reusability [5, 8, 9]. Multimedia learning principles, such as those concerning cognitive load and multiple representations, are crucial for effective design [5, 6].

Various process models guide DLM development. Pedagogical frameworks like the 5E learning cycle (Engage, Explore, Explain, Elaborate, Evaluate) are particularly relevant for inquiry-based science education [13]. Su *et al*. [13] demonstrated the value of the 5E model combined with participatory design for creating effective science e-learning materials [14]. This study adapted a systematic 7-step process previously established in the Vietnamese context by Phuong [15]:

Step 1: Determine chapter/lesson objectives.

Step 2: Determine focus and basic knowledge required.

Step 3: Build a teaching scenario (program the teaching process).

Step 4: Select necessary content inputs for each activity.

Step 5: Select software tools and digitize the teaching scenario.

Step 6: Test run, seek expert and colleague feedback.

Step 7: Edit and finalize.

C. Theoretical Underpinnings for This Study

The design of the DLMs in this study drew upon principles emphasizing learner engagement and conceptual understanding rooted in constructivism [2]. This approach posits that learners actively build their own knowledge rather than passively receiving information. We operationalized this theory by leveraging multimedia learning principles to manage cognitive load and use multiple representations, which can enhance understanding and reduce extraneous processing [5]. For example, a 3D model of a human eye allows learners to rotate the object and toggle labels, providing spatial information that is superior to a static 2D diagram.

Furthermore, incorporating interactive elements, such as virtual laboratories and simulations, directly aligns with constructivist theory by enabling learners to actively explore phenomena, manipulate variables, and construct knowledge through experimentation [2, 13]. The overarching goal was to create materials that not only present scientific information clearly but also facilitate deeper cognitive processing, application of concepts, and the development of inquiry skills relevant to the GEP-2018 Natural Science curriculum [3].

III. Materials and Methods

This study employed a mixed-methods approach, integrating quantitative survey data for needs analysis with a qualitative, systematic process for DLM development and rationale construction.

A. Phase 1: Needs Analysis and Curriculum Alignment

Participants and context: The target population comprised lower secondary school teachers (Grades 6–9) responsible for the integrated Natural Science subject under GEP-2018. A convenience sample of 284 Natural Science teachers from schools across Northern, Central, and Southern Vietnam participated in an online survey. Participation was voluntary and anonymous. Data collection occurred between 2020 and 2024.

Instrumentation: An online questionnaire was developed based on literature [1, 4, 16, 17] and reviewed for content validity by a panel of educational experts. The instrument consisted of multiple-choice and Likert-scale questions assessing teachers' perspectives on DLMs, covering:

Demographic information (region).

Understanding of DLM definition and types.

Current frequency of use for various DLM types.

Perceived effectiveness of different DLM types.

Challenges encountered when using DLMs.

Preferences for specific DLM types for the "Living Things" topic.

Data analysis: Quantitative data from closed-ended survey questions were analyzed using descriptive statistics (frequencies, percentages) calculated using SPSS. Results were tabulated (Tables 1 and 2) and visualized (Figs. 1–3).

Curriculum analysis and design principles: A detailed analysis of the official 2018 Natural Science curriculum for the "Living Things" strand (Grades 6–9) was performed to identify specific learning objectives, core scientific concepts, and required competencies. The GEP-2018 curriculum is competency-based, integrating topics like cell structure, biodiversity, photosynthesis, and human biology, which are often challenging to teach with traditional methods. The DLM development was guided by constructivist principles [2] and the 5E learning cycle [13] where appropriate. Key priorities included direct alignment with GEP-2018 objectives, addressing needs identified in the survey, ensuring scientific accuracy, promoting interactivity, and maintaining usability on common platforms to ensure accessibility across diverse school contexts in Vietnam.

Development process: The adapted 7-step process [15] was followed:

Objectives and content focus: Defined specific learning goals for each DLM based on curriculum analysis, targeting challenging concepts (e.g., cell visualization, photosynthesis simulation).

Scenario design: Developed detailed scripts/storyboards for simulations and e-lectures; designed user interfaces for virtual experiments and 3D models.

Material selection and creation: Sourced scientifically accurate base assets. Created original digital assets using tools like Blender (3D models), Articulate Storyline (virtual labs), and Adobe Creative Suite (image/video editing).

Digitization and prototyping: Assembled assets into functional DLMs per the designs.

Testing and refinement: Conducted internal reviews and consulted with subject matter experts (science teachers/academics) and technology specialists. Conducted pilot testing with a small teacher/student group.

Finalization and packaging: Produced final versions, ensured compatibility, and organized them logically by grade/topic for easy access.

Edit and finalize: Final review before deployment.

B. Phase 2: DLM Design and Development

Curriculum analysis and design principles: A detailed analysis of the official 2018 Natural Science curriculum for the "Living Things" strand (Grades 6–9) was performed to identify specific learning objectives, core scientific concepts, and required competencies. The GEP-2018 curriculum is competency-based, integrating topics like cell structure, biodiversity, photosynthesis, and human biology, which are often challenging to teach with traditional methods. The DLM development was guided by constructivist principles [2, 18, 19] and the 5E learning cycle [13, 20, 21] where appropriate. Key priorities included direct alignment with GEP-2018 objectives, addressing needs identified in the survey, ensuring scientific accuracy, promoting interactivity, and maintaining usability on common platforms to ensure accessibility across diverse school contexts in Vietnam.

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IV. Result and Discussion

This section presents the key findings from the teacher needs analysis survey and summarizes the characteristics of the developed DLM suite.

A. Teacher Needs Analysis Findings

Understanding of DLMs: While most teachers recognized DLMs by their digital format (97.2% as materials stored on devices), fewer demonstrated a comprehensive understanding of their pedagogical potential (only 51.4% agreed DLMs are "all documents serving learning purposes") (Table 1). This suggests a focus on the medium rather than the pedagogical function.

Table 1. Survey results of teachers' understanding of the concept of digital learning materials

What are Digital Learning Materials (DLMs)?	Respondents aware of DLMs	Rate (%)
DLMs are all documents serving the purposes of learning, research and teaching.	146	51.4
DLMs are physical storage media that carry or reflect learning and research content.	112	39.4
DLMs are digitalized learning materials, stored on electronic devices such as CDs, USBs, computers, computer networks.	276	97.2
DLMs are texts, data tables, sounds, images, videos	258	90.8

Usage, Effectiveness, and Availability: Usage Frequency (Fig. 1): Usage varied significantly across DLM types. Simpler resources like digital picture sets were used more often than complex simulations or virtual experiments, likely due to their higher availability and ease of use.

Perceived Effectiveness (Fig. 2): Teachers rated most DLM types as 'Effective' or 'Very effective'. Notably, interactive resources like virtual experiments and

simulations, despite being used less frequently, were perceived as highly effective by many. This discrepancy between perceived value and actual use points to a significant barrier, which is availability.

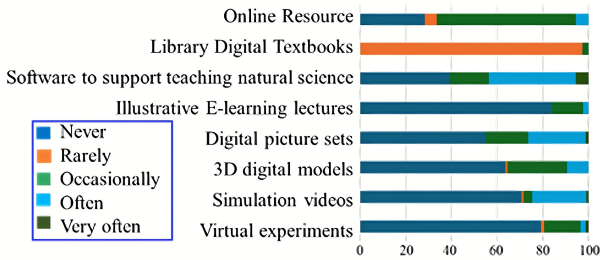

Fig. 1. Frequency of using digital materials in teaching natural sciences.

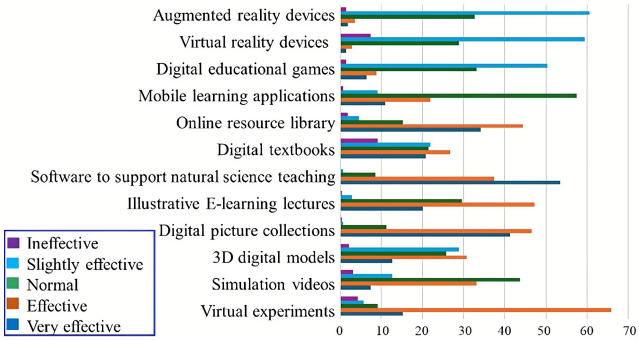

Fig. 2. Current situation of using DLMs in teaching natural science subjects.

Availability (Fig. 3): The data confirms the barrier identified above. While resources like digital textbooks were reported as widely available (100%), interactive materials such as virtual experiments (20.8%), simulation videos (29.2%), and 3D models (36.3%) were scarce. This lack of access is a primary obstacle to their integration.

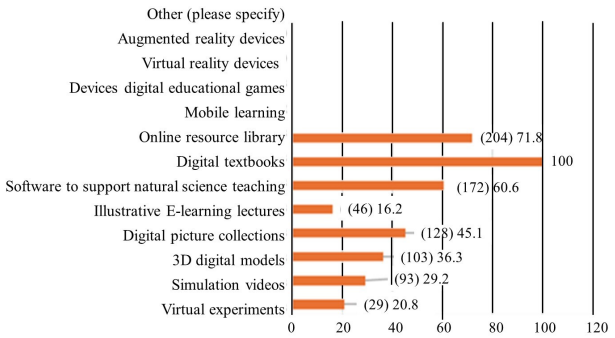

Fig. 3. Teacher-reported availability of various DLMs in Vietnamese secondary schools.

Table 2. Survey results of teachers on challenges when using DLMs in teaching natural science subjects

The challenges of using Digital Learning Materials (DLMs)	Agree (people)	Rate (%)
Lack of technology equipment	237	83.5
Lack of instructions for using digital learning materials	245	86.3
Lack of digital learning materials that are suitable for teaching content	193	68.0
Lack of time to prepare lessons with digital learning materials	248	87.3
Lack of skills for teachers in using digital learning materials	205	72.2
Difficulty for students to access digital learning materials	158	55.6
Unstable internet connection	125	44.0
Other	-	-

Challenges and Needs: Teachers reported significant challenges (Table 2). The most frequent obstacles were lack of time for preparation (87.3%), lack of clear instructions (86.3%), and lack of technology equipment (83.5%). Critically, a lack of suitable, curriculum-aligned content was a major concern (68.0%), reinforcing the central motivation for this study. Consistent with these challenges, when asked about their needs, teachers prioritized the development of interactive resources: virtual experiments, simulation videos, and 3D digital models.

B. Developed DLM Suite

Based on the needs analysis and GEP-2018 curriculum requirements, a suite of DLMs targeting the "Living Things" strand (Grades 6–9) was developed (Table 3). These materials directly address teacher preferences for interactive and visual resources. The development process included iterative cycles of design, expert review (content specialists, instructional designers, and language experts), and pilot testing with a small group of teachers and students to ensure content accuracy, pedagogical soundness, media appropriateness, and linguistic clarity. Feedback from these validation stages was systematically incorporated into the final versions of the DLMs.

Table 3. Classification of developed digital learning materials based on type and grade level

Classification	Number of classes				Total
	Grade 6	Grade 7	Grade 8	Grade 9	
Virtual Experiments	2	4	1	1	8
Simulation Videos	1	4	2	0	7
Digital Models	1	1	3		5
Digital Pictures	2 set	2 set	1 set	1 set	6
E-Learning Lectures	1	1	1	1	4

- **Virtual Experiments (8 total):** Interactive simulations where students can manipulate variables and collect data. For example, the *Photosynthesis Lab (Gr7)* allows students to change light intensity and CO_2 levels to observe the effect on oxygen production. The *Cell Observation Lab (Gr6)* enables students to use a virtual microscope to examine different cell types.
- **Simulation Videos (7 total):** High-quality animations illustrating dynamic and invisible processes. For instance, a video on *Cell Division (Gr6/9)* shows the stages of mitosis, while another on *Blood Circulation (Gr8)* traces the path of blood through the heart and body.
- **Digital 3D Models (5 total):** Interactive models for exploring complex structures. The *Human Digestive System (Gr8)* model can be rotated 360°, with components that can be isolated and clicked for detailed information.
- **Digital Image/Chart Sets (6 sets):** Collections of high-quality, scientifically accurate visuals (e.g., Levels of organization, Biodiversity, Food webs) to support explanations.
- **Illustrative E-learning Lectures (4 total):** Focused multimedia presentations combining visuals, narration, and quizzes for key or complex topics, designed for either teacher-led instruction or student self-study.

These materials were designed to be modular, visually engaging, interactive where appropriate, and directly

supportive of the 2018 curriculum learning objectives.

V. Discussion

The findings highlight both the recognized potential and the practical challenges of integrating DLMs into Vietnamese Natural Science education, justifying the development of the targeted resource suite.

A. Interpretation of Findings and a Model for Suitable DLMs

The teacher survey reveals a crucial gap: while teachers widely acknowledge DLMs' existence and potential effectiveness [1], significant barriers related to time, training, equipment, and content hinder their deep pedagogical integration. The finding that 68.0% of teachers lack suitable, curriculum-aligned materials is particularly salient. It suggests that generic or internationally sourced DLMs may not meet the specific needs of Vietnam's GEP-2018 integrated curriculum [10], emphasizing the importance of contextualization.

Teachers' strong preference for interactive DLMs (virtual experiments, simulations) is pedagogically significant. It indicates an awareness that such tools can uniquely address the difficulties of teaching abstract or dynamic biological processes inherent in the "Living Things" curriculum [5, 13]. This preference aligns well with constructivist learning approaches [2], where learners benefit from active exploration. The low reported availability of these interactive types (Fig. 3) likely reflects the very gap this study aimed to fill.

Based on these findings, we propose that effective DLMs for the Vietnamese context should possess the following characteristics:

- **Curriculum-Aligned:** Directly mapped to the learning objectives and competency requirements of GEP-2018.
- **Interactive and Visual:** Leveraging simulations, 3D models, and virtual labs to make abstract concepts tangible.
- **Contextually Relevant:** Using language, examples, and scenarios familiar to Vietnamese students.
- **Technologically Accessible:** Designed to be modular and function on common, low-specification devices with consideration for unstable internet connectivity.
- **Pedagogically Supported:** Accompanied by brief teacher guides on how to integrate them into lessons that follow frameworks like the 5E model.

B. Implications

This study holds several important implications for science education in Vietnam and similar contexts undergoing curriculum reform:

- **Resource Provision is Necessary but Insufficient:** Simply providing DLMs is unlikely to succeed without addressing teacher capacity and systemic barriers [7, 15, 22]. Comprehensive professional development focusing on pedagogical integration, not just technical skills, is critical [8, 11].
- **Contextualization Matters:** The needs-based approach employed here provides a model for developing relevant resources tailored to national reforms like GEP-2018.
- **Supporting GEP-2018 Implementation:** The developed DLMs offer concrete tools to help teachers achieve the competency-based goals of the new curriculum, particularly in fostering inquiry skills and deeper conceptual understanding [3].
- **Potential for Enhanced Learning:** While requiring further empirical validation, the interactive and visual nature of the developed DLMs holds significant potential to increase student engagement and improve understanding of complex biological topics compared to traditional methods [1, 5, 16, 22]. These implications underscore the need for sustained investment not only in resource creation but also in building the ecosystem required for their effective and sustainable use.

C. Limitations

This study has several limitations. First, the teacher survey relied on self-reported data, which may be subject to bias. Second, the use of a convenience sample (n = 284), while geographically distributed, may limit the generalizability of the needs analysis findings to all Vietnamese teachers. Third, the DLM development focused solely on the "Living Things" strand; other challenging strands also require attention. Most importantly, this paper focuses on the development and rationale; a rigorous empirical evaluation of the DLMs' actual impact on student learning outcomes and teacher practices in real classroom settings is a crucial next step that was beyond the scope of this study. Most importantly, this paper focuses on the development and rationale; a rigorous empirical evaluation of the DLMs' actual impact on student learning outcomes and teacher practices in real classroom settings, perhaps employing quasi-experimental designs to compare outcomes with traditional teaching methods or action research to refine DLM integration in specific classrooms, was beyond the scope of this study but is a crucial next step.

VI. Conclusion and Recommendations

This research addressed the pressing need for effective, curriculum-aligned digital learning materials to support Vietnam's 2018 Natural Science education reform. Grounded in a comprehensive needs analysis of 284 teachers that identified key challenges (lack of time, skills, suitable content) and resource preferences (interactive DLMs), this study detailed the systematic development of a suite of DLMs focused on the "Living Things" curriculum strand. These resources leverage educational technology to provide interactive and visually engaging tools designed to overcome traditional limitations, representing a practical contribution towards bridging resource gaps in Vietnam.

To maximize the potential of these and future DLMs, we recommend:

- **Feasibility and Impact Studies:** Conduct rigorous classroom-based research (e.g., quasi-experimental studies, mixed-methods action research) to evaluate the usability, effectiveness, and impact of the developed DLMs on student engagement, learning outcomes, and teacher pedagogical practices across diverse Vietnamese settings.
- **Targeted Teacher Training and Support:** Implement professional development programs focused on effectively integrating these specific DLMs into

teaching. These programs should model pedagogical strategies (e.g., using a virtual lab for inquiry-based learning) and provide ongoing support. This support could take various forms, including online training modules accessible at teachers' convenience, peer mentoring networks for collaborative learning, and integration into existing Continuing Professional Development (CPD) frameworks to ensure sustainability and broader reach.

- **Dissemination and Access:** Establish accessible platforms (e.g., national educational portals, integration with existing MOET resources) for wide and equitable distribution to all teachers and students.
- **Expansion and Iteration:** Based on feedback from impact studies, refine existing materials and consider expanding development to cover other challenging topics within Natural Science and potentially other subjects.

By systematically developing, evaluating, and supporting the use of contextually relevant DLMs, Vietnam can further harness educational technology to achieve its ambitious educational reform goals and enhance scientific literacy for all students.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, T.H.N. Nguyen; methodology, T.H.N. Nguyen and T.H. Pham; validation, T.H.N. Nguyen and T.H. Pham; survey and data analysis, T.H. Pham; writing—original draft preparation. All authors approved the final version of this paper.

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