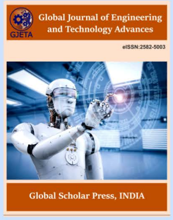
Global Journal of Engineering and Technology Advances

eISSN: 2582-5003

Cross Ref DOI: 10.30574/gjeta

Journal homepage: https://gjeta.com/



(REVIEW ARTICLE)

Check for updates

The DIVE Model: Designing Interactive Videos for Experimental Science Learning Online

ELRHOUAT OUSSAMA *

Master's Degree in E-learning and Intelligent Educational Systems, École Normale Supérieure, Abdelmalek Essaadi University, Tétouan, Morocco.

Global Journal of Engineering and Technology Advances, 2026, 26(01), 079-090

Publication history: Received on 01 December 2025; revised on 07 January 2026; accepted on 09 January 2026

Article DOI: https://doi.org/10.30574/gjeta.2026.26.1.0008

Abstract

The shift to online learning has presented a formidable challenge for experimental science education, especially the quality of lab-based instruction. Standard videos place students in a passive role and weaken inquiry and hands-on reasoning. This article studies interactive videos as a way to support active experimental learning online. Interactive elements include short tasks, clickable notes, and instant feedback during viewing.

The study draws on Cognitive Load Theory, Dual Coding Theory, and Constructivism.

- It introduces the DIVE Model (Designing Interactive Videos for Experimentation).
- The model follows six clear phases for design, production, and classroom use.
- It turns video viewing into a guided exploration that reflects real scientific practice.
- The DIVE Model supports strong experimental learning in online settings at scale.

Keywords: Distance Education; Interactive Digital Video; Video-Based Learning; Instructional Design; E-Learning Systems; Active Engagement; Science Education

1. Introduction

Experiment is central to science education. It lets students observe theory in practice. This process builds essential skills: analysis, interpretation, and scientific reasoning (Hofstein and Lunetta, 2004). Practical work leads to deeper understanding and better use of knowledge in new situations (Abrahams and Millar, 2008).

The shift to online learning creates a clear problem. Students often lack physical lab access. This limits hands-on engagement and inquiry-based learning (Brinson, 2015; Chatterjee et al., 2020). Without direct experience, student motivation may fall. Conceptual clarity can suffer, and key scientific skills may not develop.

Interactive videos offer a potential solution. These are not passive recordings. They integrate clickable elements, embedded quizzes, and decision points. These features require active student response. This approach guides observation and provides real-time feedback (Zhang et al., 2006; Kay et al., 2017). It transforms viewing into an engaged, participatory process.

However, a gap exists between theory and practice. Learning theories support interactive media use. Yet, educators lack clear, tailored frameworks for applying these tools in science. A structured guide is needed to design effective virtual experiments.

* Corresponding author: ELRHOUAT OUSSAMA.

The article has two primary goals:

- Examine the pedagogical value and cognitive benefits of interactive science videos.
- Introduce the DIVE Model to help teachers design and use these videos.

This article addresses that need. First, it examines the pedagogical value of interactive videos for science. It connects their design to established cognitive and learning theories. Second, the article introduces the DIVE model (Designing Interactive Videos for Experimentation). This is a practical design framework. It provides teachers with a step-by-step method. The goal is to create videos that do more than simulate a lab. They should foster active exploration, critical thinking, and autonomous learning in digital environments.

Methodologically, this study follows a design-based and conceptual research approach. It does not report empirical experiments. Instead, it brings together learning theories, instructional design principles, and findings from prior studies to develop the DIVE Model. The model serves as a structured guide for designing interactive videos for experimental science. Its purpose is to support educators in the design, production, and use of interactive video-based laboratory activities in online learning contexts.

2. Theoretical Background

2.1. Cognitive Load Theory

Cognitive Load Theory (Sweller, 1988) asserts that learners have a limited capacity in their working memory when processing new information. Effective instructional design must therefore minimize unnecessary cognitive load to optimize learning. Interactive videos address this need by breaking down complex concepts into manageable segments and integrating visual and verbal cues that facilitate comprehension. Features such as pause points, layered information, and embedded guidance allow learners to control the pace of instruction, helping to balance intrinsic and extraneous cognitive demands.

2.2. Dual Coding Theory

According to Dual Coding Theory (Paivio, 1991), learning is enhanced when information is processed simultaneously through verbal and visual channels. Interactive videos leverage this principle by combining narration, text, images, animations, and embedded prompts. This multimodal approach supports deeper processing and greater retention, especially in science contexts where abstract ideas often benefit from visual representation

2.3. Constructivist Learning Theory

Rooted in the work of Vygotsky (1978), Constructivism posits that learners actively build new knowledge by connecting new information with prior experiences. Learning is most effective when students are engaged in inquiry, exploration, and reflection. Interactive videos support this process by allowing students to manipulate variables, make decisions, and receive immediate feedback mirroring the hands-on, exploratory nature of physical experiments. This aligns with constructivist ideals by fostering engagement, curiosity, and critical thinking.

2.4. Experiential and Inquiry-Based Learning

Science education is not solely about acquiring facts; it involves reasoning, testing, and revising ideas based on evidence. Experiential learning theories emphasize the importance of direct engagement with phenomena. Tiberghien (1996) and Méheut (2005) highlight how experimentation helps students transition from intuitive or naïve conceptions to scientifically valid understandings. Through observation and interpretation, students build connections between empirical evidence and theoretical models.

As Bachelard (1938) notes, scientific knowledge often challenges preconceived ideas. Thus, well-designed experiments whether physical or virtual can foster epistemological awareness, analytical thinking, and the capacity to deal with cognitive conflict. Interactive videos, when structured around this principle, do more than simulate lab procedures; they immerse learners in authentic scientific inquiry.

3. Interactive Video as a Learning Tool

3.1. Interactive Videos Pedagogical Value

Recent empirical research confirms that active cognitive engagement with instructional videos is a strong predictor of learning outcomes in STEM education. Learner behaviors such as pausing, rewinding, and selectively navigating video content have been shown to correlate positively with conceptual understanding and retention. These findings suggest that engagement is not merely behavioral or motivational, but deeply cognitive in nature, reinforcing the importance of embedding purposeful interaction within video-based learning environments (Students' active cognitive engagement with instructional videos predicts STEM learning, 2024).

3.2. Promoting Active Engagement

Unlike passive videos, interactive videos make learners act. They answer questions, make predictions, or choose outcomes. This follows constructivist learning theory, which says learners build knowledge actively, not passively (Vygotsky, 1978).

Engagement improves when students are mentally active. Guo et al. (2014) found short, interactive segments boost attention and learning more than longer, passive videos. Priyakanth, Abburi, and Praveena (2022) showed that interactive videos in higher education increase engagement and improve assessment performance.

3.3. Supporting Dual Coding and Working Memory

Interactive videos also support dual coding theory, which suggests that learning improves when information is processed both visually and verbally (Paivio, 1986). Videos with embedded visuals, narration, and interactive prompts help learners process content through multiple cognitive pathways, improving understanding and memory.

This approach also addresses cognitive load (Sweller, 1988). By segmenting complex information and allowing learners to interact with the content at their own pace, interactive videos reduce overload and support more effective learning.

3.4. Enhancing Motivation and Emotional Connection

The combination of visuals, interactivity, and narrative structure can stimulate learners emotionally. According to Immordino-Yang and Damasio (2007), emotional engagement such as curiosity or surprise activates brain regions associated with memory and attention, helping to reinforce what is learned.

3.5. Facilitating Feedback and Self-Regulation

Interactive videos often include embedded quizzes, feedback, and decision-making scenarios. These elements support metacognitive skills and self-assessment, which are critical for effective learning, especially in online settings. They also promote self-regulation by allowing students to manage pacing and revisit difficult concepts as needed (Priyakanth et al., 2022).

4. Designing Effective Interactive Videos

4.1. Instructional Design Guidelines for Interactive Science Videos

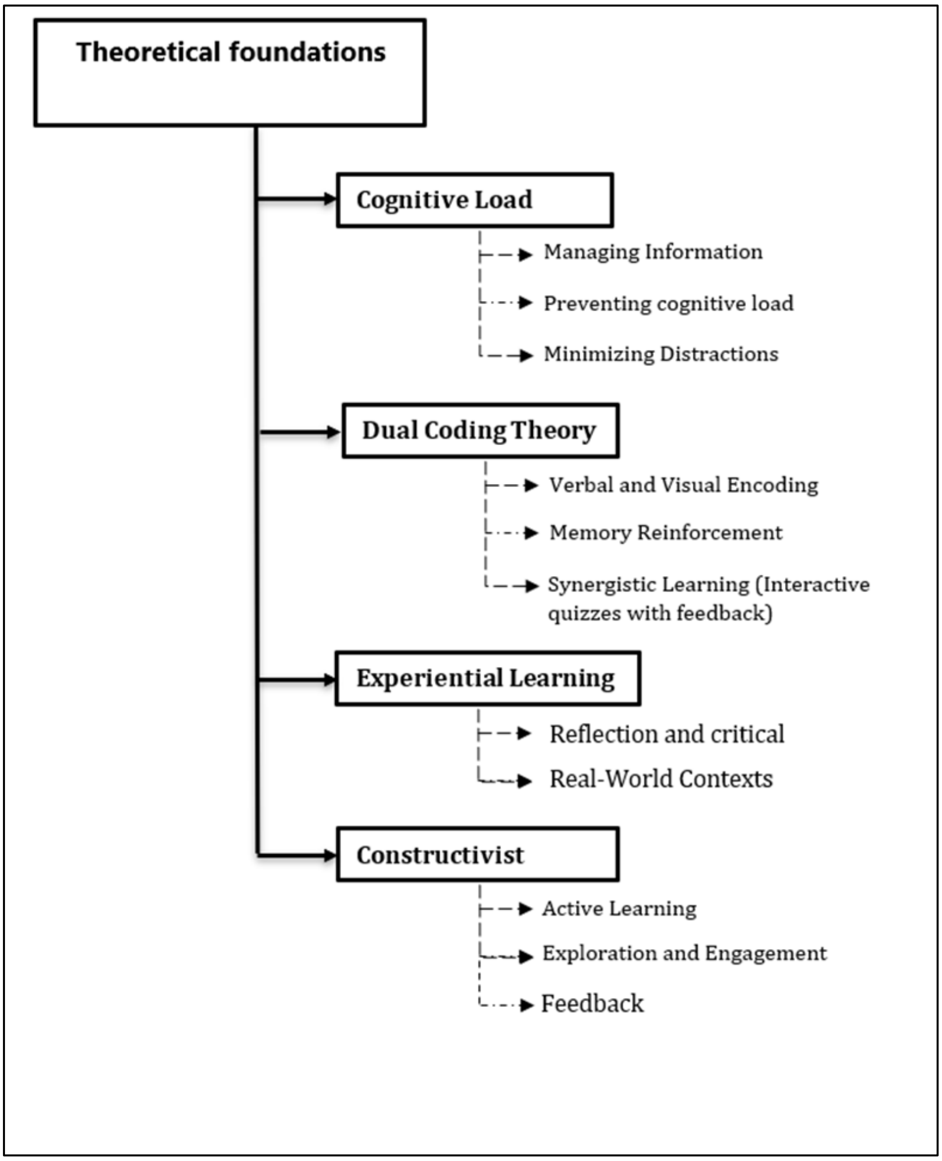


Figure 1 Conceptual mapping of core learning theories

To be effective, interactive videos should follow specific instructional design guidelines:

Define clear learning objectives: Each video should focus on a specific scientific concept or skill. For example, a video on chemical reactions might center on identifying evidence of chemical change, collecting data, and forming hypotheses. Objectives should follow the SMART criteria and be aligned with Bloom's Taxonomy.

Ensure alignment between interactions and learning objectives: Interactive elements such as quizzes, clickable icons, and prediction tasks should directly support the defined learning outcomes. This ensures pedagogical coherence and prevents interactivity from becoming a distraction.

Keep it short and focused: Shorter videos (<6 minutes) help maintain attention and reduce cognitive overload (Guo et al., 2014; Afify, 2020). Each video should focus on one idea at a time.

Use interactions strategically Questions, prompts, and decision points should appear at key moments not randomly. These moments should encourage thinking, not just recall. For example: *"What would happen if we used a different reactant?"*

- Minimize distracting elements

Reducing unnecessary animations, background music, or unrelated visuals helps optimize cognitive load and keeps learners focused on the core content.

- Provide immediate feedback

If a student answers incorrectly, the video should offer an explanation or send them back to the relevant part. This supports learning from mistakes.

- Support autonomy and control

Let learners pause, rewind, or skip parts they understand. This flexibility respects individual pacing and supports better learning in online settings (Mayer, 2009).

- Reinforce Memory and Understanding

Use recap icons and short summaries after major segments to reinforce learning and aid long-term retention.

4.2. . Types of Interactivity Used in the Video

Clickable Tool Identification Icons

Students can click on the icons that are placed next to each experimental component (such as the thermometer or beaker) during the video. Each item's name, function, and handling guidelines are displayed when you click. Even in a virtual environment, this aids in students' familiarization with lab equipment.

4.2.1. Observation Guidance through Multiple-Choice Pauses

At key moments during the experiment, the video pauses to ask a multiple-choice question. These questions direct the learner’s attention to important visual cues, such as color change, gas formation, or temperature shift. This supports observational skills and encourages active engagement. These questions also play a crucial role in ensuring that learners make accurate observations, which directly influence their interpretation of the experiment and the conclusions they draw. Guiding learners at this stage helps prevent misinterpretation and reinforces scientific reasoning.

4.2.2. Interpretation Checks

Later in the experiment, the video pauses again to ask questions that guide interpretation. For example, learners might be asked to choose the most likely explanation for an observed change. These prompts help students connect observations to scientific reasoning.

4.2.3. Feedback and Scaffolding

After each question, learners receive immediate feedback. Correct answers confirm understanding, while incorrect responses trigger brief explanations or a rewind to the relevant part of the video. This feedback loop helps correct misconceptions and supports learning from error.

4.2.4. Recap Icons for On-Demand Review

Learners can click recap icons that appear after major steps. These icons let them rewatch a summary of key moments, such as setting up the apparatus or reviewing a data table. This supports self-paced learning and memory reinforcement.

4.2.5. Final Evaluation with Conditional Progress

At the end of the video, learners must complete a short quiz summarizing the experiment's key outcomes. If the learner answers correctly, they proceed to the next module. If not, they are prompted to rewatch the relevant sections. This reinforces mastery learning principles.

4.3. Production Workflow

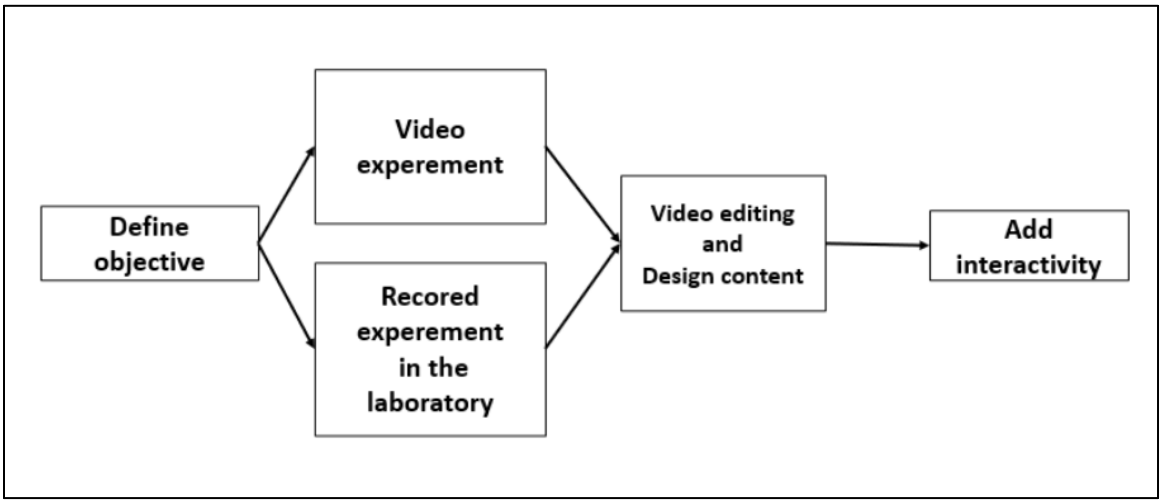


Figure 2 Video Production and Editing Workflow

Step-by-Step Process for Creating Interactive Science Experiment Videos:

- **Define a Clear and Specific Learning Objective:** Begin by identifying a well-defined and measurable educational goal that the video experiment aims to achieve A clear learning goal guides the structure of the video, the choice of interactions, and the integrated assessments. To ensure clarity and effectiveness, it is recommended to use the **SMART model/Bloom's Taxonomy** .
- **Search for Existing Experiment Videos:** Look for existing high-quality experiment videos that align with the defined objective. If a suitable video is not available, proceed to the next step.
- **Create a Laboratory Experiment Video:** Conduct and record the experiment in a laboratory setting, ensuring clarity, scientific accuracy, and safety.
- **Video Editing and Information Management:** During the Editing phase, organize and present information in a coherent and pedagogically sound manner. Minimize distracting elements, keep the video short and focused, and use **Text-to-Speech (TTS)** narration along with **subtitles** to enhance accessibility and understanding.
- **Design content: Interactive Structure Design**: Develop a coherent and progressive learning sequence that guides students through the stages of observation, interpretation, and conclusion.

  Observation → Interpretation → Conclusion

MCQ (Multiple-Choice Question) Design:

- **Observation Phase**: Create questions that focus on accurately identifying key experimental phenomena.
- **Interpretation Phase**: Design questions that encourage deeper reflection and the connection of observations to underlying scientific concepts.
- **Feedback Design**: Provide immediate, clear, and targeted feedback after each response to reinforce understanding and correct misconceptions.
- **Evaluation Design**: Implement summative assessments at the end of each video or module to verify students' mastery of the intended learning outcomes.
- **Add Interactivity:** Integrate interactive elements, such as **Multiple-Choice Questions (MCQs)**, at key phases of the scientific process (e.g., observation, interpretation, and conclusion). Ensure that all questions and feedback are **aligned with the initial learning objective**, reinforcing critical thinking and comprehension.

4.4. System Workflow

the system workflow governs how students interact with the video environment, from login to final assessment.

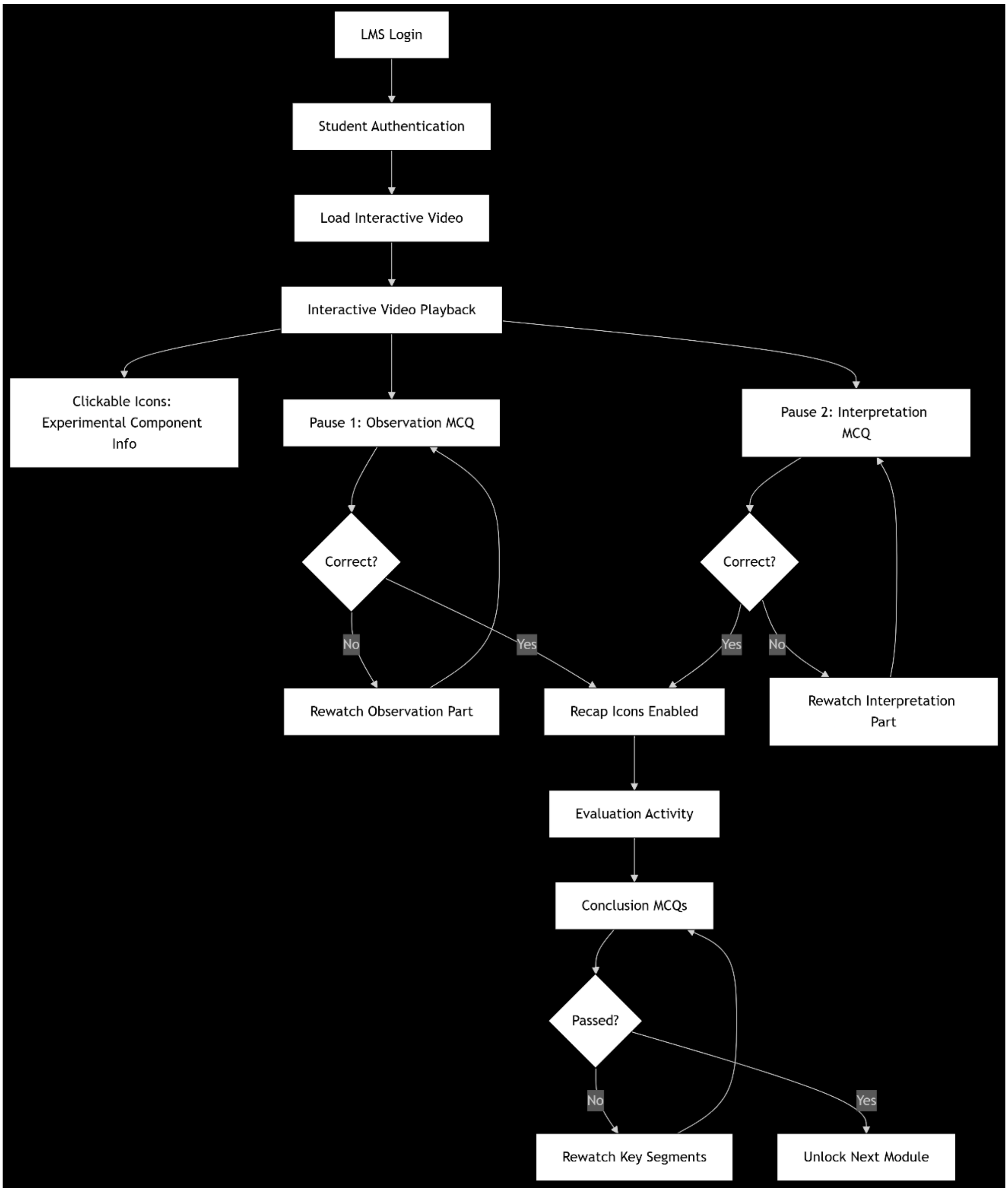


Figure 3 System workflow diagram

Once a learner accesses the platform and authenticates their identity, the interactive video module is loaded. During playback, students encounter embedded clickable icons that provide detailed information about experimental components These interactive labels help familiarize students with the virtual lab setup.

The video then strategically pauses at two key points. The first pause involves an observation-based multiple-choice question (MCQ) that prompts students to interpret visible phenomena. Based on their response:

- A correct answer unlocks progress and enables recap icons for later review.
- An incorrect answer triggers a rewind to the relevant segment for re-engagement and reinforcement.

The second pause presents an interpretation MCQ, encouraging learners to connect their observations with scientific reasoning. Again, feedback is immediate: incorrect responses lead to a targeted review, while correct answers enable forward progress.

After completing these checkpoints, learners proceed to an evaluation activity, followed by conclusion MCQs that verify mastery of the key concepts. If learners succeed, they unlock the next module. If not, they are directed to rewatch critical segments before retrying.

This cyclical and responsive workflow fosters active learning, metacognitive regulation, and retention, while aligning with core principles from Constructivism and Cognitive Load Theory. It also allows learners to progress at their own pace, ensuring understanding before moving on one of the major strengths of well-designed interactive video instruction.

5. The DIVE Model: A Conceptual Instructional Design Framework

As a result of synthesizing the theoretical foundations, instructional design practices, and multimedia strategies explored throughout this article, I developed the **DIVE Model** a comprehensive instructional design framework specifically developed for creating effective interactive science experiment videos in online learning environments.

The DIVE Model is composed of 6 phases each phase builds upon the previous one that guide educators through both the **design** and **production** of pedagogically effective interactive videos.

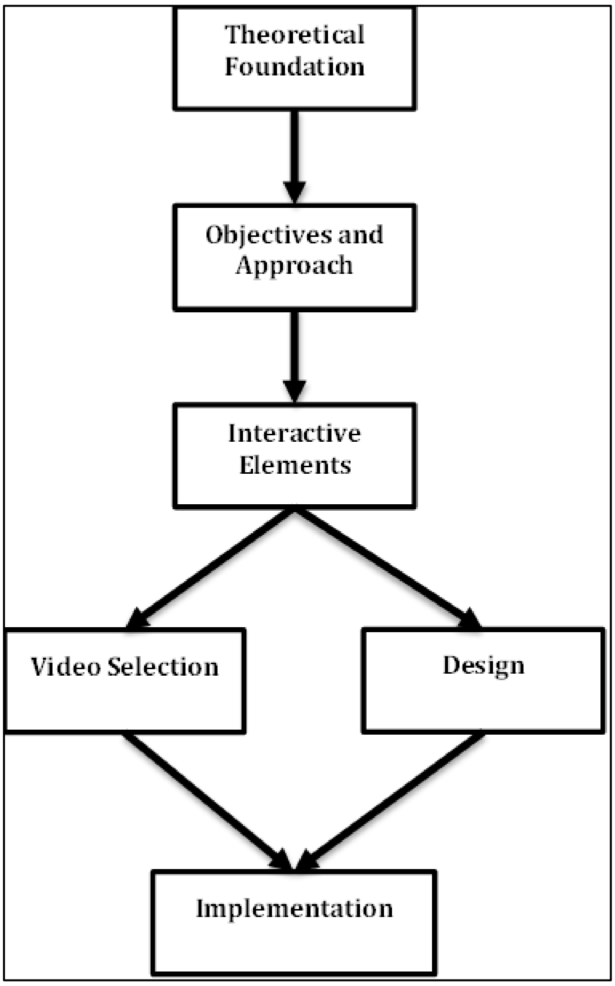


Figure 4 Schematic representation of the DIVE Model

The model includes the following key components:

- **Theoretical Foundation** – Establishes cognitive and pedagogical principles.
- **Define Clear Video Objectives and Approach** – Sets SMART goals using Bloom's Taxonomy and aligns the pedagogical approach with Constructivist and Experiential learning.
- **Interactive Elements** – Specifies the integration of tool interaction, observation guidance, and interpretation checkpoints.
- **Video Selection, Creation, and Editing Adaptation** *(parallel phase)* – Focuses on the pedagogically-aligned production and editing of video material.
- **Design of Interactive Structure, Feedback, and Evaluation** *(parallel phase)* – Involves the design of MCQs, feedback loops, and structured learning sequences.
- **Implementation** – Encompasses deployment, pilot testing, refinement, and integration into learning platforms.

The DIVE model operates through the continuous interaction of three interdependent layers: Pedagogical, Didactical, and Technical. These layers are not sequential but rather function in a dynamic, reciprocal relationship, as visualized in Figure 5.

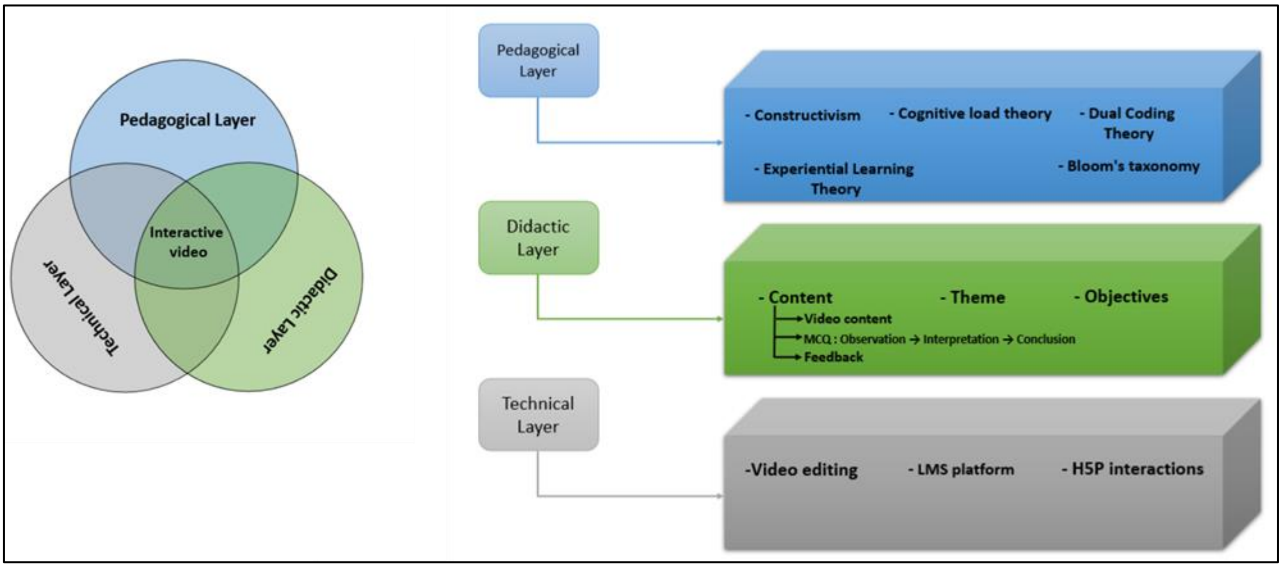


Figure 5 DIVE Model's three interdependent layers

Cross-Layer Interactions :

- Pedagogical ↔ Didactical (Instructional):
  - Theories guide how learning is structured.
  - Didactic feedback and experience can lead to a re-evaluation of pedagogical choices.
- Didactical (Instructional) ↔ Technical:
  - The design of activities defines functional requirements (e.g., when do MCQs appear? how is feedback provided?).
  - Technical constraints (video formats, platform limitations) shape didactic choices.
- Technical ↔ Pedagogical:
  - Tools influence how pedagogical objectives are achieved (e.g., interactivity supporting learner autonomy).
  - Collected data (learning analytics) enable the evaluation of pedagogical effectiveness.

DIVE model Phases

- **Phase 1: Theoretical Foundation Layer**
- **Cognitive Load Theory:** Manage cognitive resources effectively by segmenting complex information.
- **Dual Coding Theory:** Use combined visual and verbal materials to enhance comprehension.
- **Constructivist Theory:** Promote active learning through direct interaction with content.

- **Experiential Learning Theory:** Integrate sensory and procedural experiences to solidify theoretical understanding.
- **Phase 2: Define Clear Video Objectives and Approach**
- **Clear Learning Objectives:** Define Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) goals.
- **Pedagogical Approaches:** The Constructivist and Experiential Learning approaches are particularly well-suited to this model. Constructivism encourages learners to build their understanding through active exploration, while Experiential Learning emphasizes learning by doing mirroring the structure of observation, interpretation, and conclusion in the DIVE model.
- **Bloom's Taxonomy Integration:** Structure objectives according to Bloom's cognitive domains: remembering, understanding, applying, analyzing, evaluating, creating.
- **Focused Content:** Ensure videos concentrate on a single concept or experiment.
- **Accessibility:** Incorporate subtitles and text-to-speech (TTS) features to support diverse learner needs.
- **Phase 3: Interactive Elements Layer**
- **Clickable Tool Identification:** Allow interactions for detailed lab equipment descriptions.
- **Observation Guidance Pauses:** Integrate pauses for targeted observation via multiple-choice questions.
- **Interpretation Checks:** Include questions guiding learners to connect observations with theoretical knowledge.
- **Parallel Phase 4: Video Selection, Creation, and Editing Adaptation**
- **Video Selection or Creation:** Select existing or record new high-quality lab experiment videos.
- **Editing Adaptation:** Adapt videos respecting theoretical foundations by:
    - Minimizing distractions (Cognitive Load Theory).
    - Structuring information clearly for efficient processing.
    - Adding subtitles and TTS narration (Dual Coding Theory).
    - Encouraging active engagement and interactivity (Constructivist Theory).
    - Demonstrating practical, experiential learning elements.
- **Parallel Phase 5: Design of Interactive Structure, Feedback, and Evaluation**
- **Interactive Structure Design:** Create a structured sequence (Observation → Interpretation → Conclusion).
- **MCQ Design:**
    - **Observation Phase:** Design MCQs for accurate observation.
    - **Interpretation Phase:** Craft MCQs that prompt deeper reflection linking observations to concepts.
- **Feedback Design:** Provide immediate, targeted feedback after each MCQ response.
- **Evaluation Design:** Develop comprehensive summative quizzes for concept mastery verification.
- **Phase 6: Implementation Layer**
- **Production Workflow:**
    - Finalize objectives clearly.
    - Professional filming and editing for clarity.
    - Systematic integration of interactive components.
    - Conduct pilot testing and feedback collection.
    - Refine based on feedback.
    - Integrate into online learning platforms ensuring ease of access and learner tracking.

6. Discussion

The DIVE Model is a design-based, conceptual framework. It is not a tested experimental method. Its purpose is to guide the design of interactive experimental science videos. It combines cognitive, pedagogical, and didactical principles. The model shows how these principles can support authentic scientific inquiry in video design.

Unlike generic instructional design models such as ADDIE or SAM, which provide broad development stages, the DIVE Model is specifically tailored to experimental science learning. Its originality lies in aligning each phase of video interaction with core scientific practices rather than general learning tasks. The structured sequence (Observation → Interpretation → Conclusion) mirrors how knowledge is constructed in real laboratory settings, reinforcing the epistemological nature of scientific inquiry.

The model functions by balancing cognitive demands and active engagement. It manages the mental effort required from students by breaking experiments into short, focused segments. This prevents information overload.

While these foundations strengthen the model, its practical application faces specific challenges and opportunities for growth. These are detailed in the following sections regarding limitations and future research directions.

6.1. Limitations

There are some challenges to using this model. First, it lacks physical touch. Students can watch and click, but they cannot feel the laboratory equipment or chemicals. Second, it requires technical skills. Teachers must know how to edit videos and use tools like H5P. Third, creating these videos takes a lot of time and planning. Finally, if there are too many buttons or questions, it might distract the student from the actual science lesson.

6.2. Future Work

Future research for the DIVE Model centers on two main goals. These focus areas aim to improve how the model functions and expand where it can be used.

The first goal is AI integration to improve the learning experience. Future versions should use Large Language Models (LLMs) to provide specific, personalized advice when students miss "Interpretation Checks". This moves the model beyond static, pre-written answers. Research by Pellas (2024) suggests that AI-generated instructional videos can significantly impact problem-based learning in science education by providing more dynamic content. Additionally, AI can study student results in real-time to create adaptive paths. The video could then change its difficulty or content based on what the student knows. AI tools for video editing and Text-to-Speech (TTS) will also help with the " Editing Adaptation" phase. This makes it faster and easier for busy teachers to create professional content.

The second goal is expanding the model into new subject areas. The DIVE framework is currently designed for experimental science. Future work can adapt these six phases for other fields like Engineering, Medical Simulations, or Vocational Training. Research will also look at using DIVE to build a large, standardized library of virtual experiments. This would provide a steady level of quality for all online STEM classes and ensure consistent learning outcomes.

7. Conclusion

The move to online learning has made it harder to teach experimental sciences in meaningful ways. Without access to hands-on lab work, many students miss out on key aspects of scientific learning. But interactive videos offer a powerful alternative. By simulating the lab experience in a virtual format, they help students stay engaged, understand concepts more deeply, and develop essential reasoning skills.

The DIVE Model introduced in this article provides a clear, step-by-step guide for creating these kinds of videos. Built on solid educational theories like Constructivism, Dual Coding, and Cognitive Load Theory, it emphasizes active learning, real-world relevance, and timely feedback all of which are key to effective science education.

When designed thoughtfully, interactive videos don’t just fill the gap left by the absence of physical labs they create new opportunities for exploration, autonomy, and mastery. As we continue to improve online education, it’s essential for educators, designers, and researchers to work together to keep refining these tools and ensure students get the best possible learning experience.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Abrahams, I., & Millar, R. (2008). Does practical work really work? A study of the effectiveness of practical work as a teaching and learning method in school science. International Journal of Science Education, 30(14), 1945–1969.
https://doi.org/10.1080/09500690701749305

[2] Afify, M. K. (2020). Effet de la durée des vidéos interactives dans les environnements d’apprentissage en ligne sur la charge cognitive, les performances cognitives et la rétention de l’apprentissage. Revue Internationale des Technologies en Pédagogie Universitaire, 17(2), 45–54.

[3] Bachelard, G. (1938). La formation de l'esprit scientifique. Vrin.

[4] Bandura, A. (1977). Social learning theory. Prentice Hall.

[5] Brinson, J. R. (2015). Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research. Computers & Education, 87, 218–237. https://doi.org/10.1016/j.compedu.2015.07.003

[6] Chatterjee, S., Anand, A., & Chakraborty, R. (2020). Virtual laboratories and remote experimentation: An effective pedagogical strategy for enhancing laboratory education. Education and Information Technologies, 25(6), 3251–3277.
https://doi.org/10.1007/s10639-020-10159-3

[7] Guo, P. J., Kim, J., & Rubin, R. (2014). How video production affects student engagement: An empirical study of MOOC videos. In Proceedings of the First ACM Conference on Learning at Scale (pp. 41–50). ACM. https://doi.org/10.1145/2556325.2566239

[8] Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. Science Education, 88(1), 28–54. https://doi.org/10.1002/sce.10106

[9] Immordino-Yang, M. H., & Damasio, A. (2007). We feel, therefore we learn: The relevance of affective and social neuroscience to education. Mind, Brain, and Education, 1(1), 3–10. https://doi.org/10.1111/j.1751-228X.2007.00004.x

[10] Kay, R. H., Leung, S., & Tang, H. (2017). Improving video lectures: Learning challenges and instructional strategies. Journal of Educational Technology Systems, 46(3), 283–307. https://doi.org/10.1177/0047239517733546

[11] Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge University Press.

[12] Méheut, M. (2005). Les démarches d'investigation en sciences physiques : Un cadre didactique pour leur mise en œuvre. Aster, 40, 91–123.

[13] Paivio, A. (1986). Mental representations: A dual coding approach. Oxford University Press.

[14] Paivio, A. (1991). Dual coding theory: Retrospect and current status. Canadian Journal of Psychology, 45(3), 255–287.
https://doi.org/10.1037/h0084295

[15] Pellas, N. (2024). The impact of AI-generated instructional videos on problem-based learning in science education. Education Sciences, 14(1), Article 102. https://doi.org/10.3390/educsci14010102

[16] Priyakanth, R., Abburi, R., & Praveena, M. (2022). Design and impact of interactive video content for the improvement of student engagement and learning. International Journal of Educational Research Studies, 2(4), 1–10.

[17] Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. Cognitive Science, 12(2), 257–285. https://doi.org/10.1207/s15516709cog1202_4

[18] Tiberghien, A. (1996). Construction of prototypical situations in teaching physics: Different approaches to modeling. In G. Welford, J. Osborne, & P. Scott (Eds.), Research in science education in Europe: Current issues and themes (pp. 100–114). Falmer Press.

[19] Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.

[20] Zhang, D., Zhou, L., Briggs, R. O., & Nunamaker, J. F. (2006). Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. Information & Management, 43(1), 15–27.

[21] https://doi.org/10.1016/j.im.2005.01.004
Students' active cognitive engagement with instructional videos predicts STEM learning. (2024). Computers & Education, 216, Article 105050. https://doi.org/10.1016/j.compedu.2024.105050