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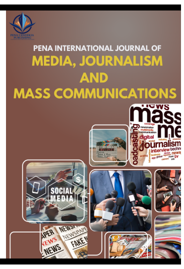

Enhancing Cryptography Learning through Multimedia Based Instruction: Insights from Student Perceptions on Gather Platform

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ABSTRACT

The incorporation of multimedia components such as videos, infographics, quizzes, and simulations has become crucial in improving learning engagement and understanding. However, how effective these methods are primarily hinges on their design in minimising cognitive overload and encouraging active learning. Therefore, this research examined students' views on a multimedia focused learning module through the Gather platform for different academic levels, concentrating on its alignment with the Cognitive Theory of Multimedia Learning (CTML). A group of 30 students shared open-ended responses regarding four main learning checkpoints: video, poster, quiz, and simulation. The analysis revealed that videos were engaging and clear, aligning with CTML's multimedia principles; posters were visually appealing but criticised for too much text, highlighting coherence issues; quizzes effectively reinforced knowledge through active recall; and simulations offered interactivity but faced technical challenges, relating to interactivity and personalisation principles. In general, the results suggest that multimedia learning can significantly enhance student engagement and understanding when crafted in accordance with CTML principles. This research highlights the necessity for a well-balanced design, adaptive assessments, and strong interactive tools to maximise learning results.

1. Introduction
1.1 Literature Review
1.1.1 Background of Study

Cryptography is becoming more prevalent in educational frameworks at all stages, ranging from secondary education to universities, because of its essential function in safeguarding information and

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its ability to improve learning in associated disciplines. In addition, cryptography has become an integral part of the educational paradigm, particularly in the context of online learning and information security. New educational modules emphasising classical cyphers and the history of cryptography have been introduced on online learning platforms. These new modules include visual aids and virtual museums to captivate both students and the general audience [1]. Additionally, encryption algorithms like RSA, AES, and DES have been utilised to safeguard e-learning settings, guaranteeing integrity, confidentiality, and authentication [2]. The research conducted in Switzerland provides an overview of the evolving landscape of encryption and data security technologies. It outlines expectations for how these encryption technologies may advance by 2025 and explores their potential implications for the education sector [3].

1.1.2 Challenges in teaching cryptography

Teaching cryptography at the secondary school level presents both challenges and opportunities, as recent studies and educational initiatives have shown. One significant barrier is the complexity of the content, since cryptography involves advanced mathematical concepts such as public-key cryptography, which often require an understanding of algebraic theorems that go beyond the typical secondary school curriculum [4]. Additionally, the availability of comprehensive teaching materials specifically designed for this subject is limited, making it difficult for teachers to deliver practical lessons. Students also face restricted understanding and engagement with cryptography due to limited exposure to modern practices in the field [5]. Another compounding issue is the lack of teacher preparedness. Many educators lack the specialised knowledge or training required to teach cryptography effectively [6]. This issue is worsened by the lack of specific training programs and resources designed for secondary education.

1.1.3 Multimedia based and immersive learning platforms

Recent research has seen significant advancements in multimedia-based and immersive learning platforms, driven by rapid technological progress and the increasing integration of various multimedia elements into educational environments. The use of multimedia components in modern educational environments combines text, images, sound, video, and animation to increase engagement and accommodate diverse learning preferences. Learner centred strategies are essential to these systems, enabling students to control their learning pace and access resources that align with their individual preferences. This approach has been shown to improve comprehension and retention [7,8]. Furthermore, advancements in technology, such as 5G, cloud computing, and artificial intelligence, have enhanced the functionality of these platforms [9]. Immersive learning platforms utilise Virtual Reality (VR), Augmented Reality (AR), and other immersive media to create highly interactive and engaging educational experiences [10]. The increasing availability of immersive learning is incorporation of AI to provide tailored and adaptive educational experiences [11].

Interactive and simulation-driven platforms are revolutionising cryptography education by utilising web-based resources such as LearnCrypto [12] which offer engaging simulations, visual aids, and intuitive interfaces. Extended Reality (XR) and interactive animations further support learning by creating dynamic environments for problem-solving [13], while Kolb’s Experiential Learning Model incorporates real-world simulations and AI-driven agents for K-12 learners, showing high success rates [14]. Future developments that integrate 5G, big data, cloud computing, and AI are set to deliver even more immersive, tailored, and compelling learning experiences in cryptography education [9, 15].

1.1.4 Cognitive Theory of Multimedia Learning (CTML)

The Cognitive Theory of Multimedia Learning (CTML), which Richard Mayer created, describes how individuals learn from multimedia materials by focusing on three main principles: (i) the use of dual channels for visual/pictorial and auditory/verbal information processing, (ii) the limited capacity of each channel, and (iii) the necessity of active engagement in the learning process [16-17]. It outlines five crucial cognitive processes for effective multimedia learning:

1. Selecting relevant words from the text or narration.
2. Selecting relevant images from the graphics.
3. Organizing selected words into a coherent verbal representation.
4. Organizing selected images into a coherent pictorial representation.
5. Integrating verbal and pictorial representations with each other and with prior knowledge

CTML outlines several principles for designing effective multimedia instruction as [18-20]:

1. Segmenting: Breaking content into smaller, manageable parts to prevent cognitive overload
2. Signaling: Highlighting essential information to guide learners' attention.
3. Modality: Using both visual and auditory channels to present information, which can enhance learning but may need adjustments for ESL learners.
4. Redundancy: Avoiding the simultaneous presentation of identical information in multiple formats (e.g. text and narration) to prevent cognitive overload.
5. Embodiment: Using on-screen instructors to increase engagement.

1.2 Significance of Study

This research aims to assess the effectiveness of an Introduction to Cryptography module when delivered through the Gather platform, with an emphasis on the role of its multimedia elements, such as video, poster, quiz, and simulation, in enhancing learning in accordance with the CTML model. This research expands the understanding of immersive learning technologies in secondary education by presenting empirical data on the effectiveness of a Gather platform. It offers valuable insights for educators aiming to incorporate multimedia principles into teaching intricate subjects. It acts as a resource for future curriculum developers, instructional technologists, and researchers investigating the convergence of multimedia learning, immersive platforms, and cryptography education.

2. Methodology

2.1 Research Design

This study used a qualitative descriptive research design to investigate students' perception of delivering the cryptography concept using the Gather platform. The design was chosen as it enables an in-depth understanding of participant experiences and is appropriate for capturing open-ended feedback. Furthermore, this research utilised the Cognitive Theory of Multimedia Learning (CTML), which guided both the creation of the feedback instrument and the analysis of results by emphasising principles like multimedia, coherence, segmentation, generative processing, and interactivity.

2.2 Development of Module Content and Instrument

The module has been designed and developed in the Gather platform, including four distinct checkpoints. The item that has been developed is an open-ended question delivered through an online platform. The question set consisted of four sections, each linked to a multimedia component, and was created in accordance with the Cognitive Theory of Multimedia Learning (CTML). Figure 1 describes the details of each checkpoint, highlighting their unique features and the pivotal roles they play within the overall structure.

VIDEO	Examined students' views on the video content utilised in the module
	The questions centred on the clarity of explanations, engagement levels, and the effectiveness of visual and auditory elements in facilitating understanding
	These items were intended to evaluate CTML's Multimedia Principle and Segmenting Principle.
POSTER	This component collected feedback on the visual attractiveness, succinctness, and cognitive load of static learning materials.
	Questions aimed to assess whether the posters complied with CTML's Coherence Principle and Spatial Contiguity Principle
QUIZ	Students were encouraged to reflect on the effectiveness of quizzes in reinforcing their learning, including their capacity to consolidate knowledge, offer feedback, and boost motivation.
	It align with CTML's Generative Processing concept, emphasing active cognitive engagement.
SIMULATION	Get students' feedback on their experiences with interactive simulations within the module.
	It aimed to gather insights regarding usability, interactivity, engagement, and overall contribution to comprehending cryptographic concepts.
	This was aligned with CTML's Interactivity and Personalisation Principles, emphasising the importance of learning through action and tailoring content to meet the learner's needs.

Fig. 1. Multimedia components align tu CTML

2.3 Respondent

The respondent included 30 students who were part of the study, representing both lower and upper levels of secondary school. Their involvement was voluntary and kept anonymous, which guaranteed impartial responses and compliance with ethical research guidelines.

2.4 Data Collection

The data collection took place immediately after the student completed their exploration of the Gather platform. Following their virtual journey, the student filled out a detailed feedback form using Google Forms, sharing their insights and experiences from the platform. This feedback was crucial for assessing the user experience and the effectiveness of the features they interacted with during their session.

2.5 Data Analysis

The information gathered from the online feedback form was analysed. Every response was thoroughly reviewed and arranged in accordance with the four multimedia elements of the module: video, poster, quiz, and simulation. Each remark was subsequently assessed and categorised as either positive or negative to reflect students' perceptions clearly.

The research process is depicted in Figure 2, which outlines the various stages and methodologies undertaken throughout the study. This enabled a clear comparison of strengths and areas needing improvement while preserving qualitative insights.

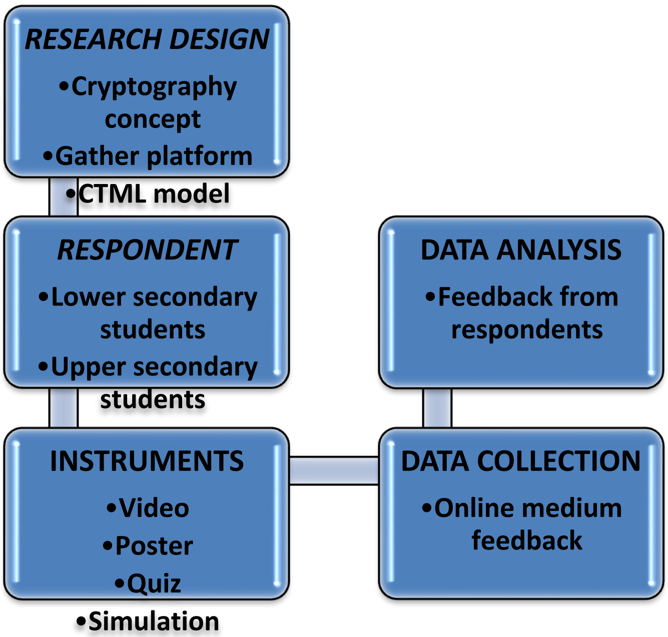

Fig. 2. Research process

3. Results and Discussion

Table 1 illustrates students' feedback on the four multimedia checkpoints, which are video, poster, quiz, and simulation. The video checkpoint generated the highest number of positive reactions, with 17 students, signifying its significant role in enhancing student engagement and understanding. The quiz checkpoint received 15 positive reactions, while posters and simulations garnered 13 and 12 positive comments, respectively, along with a greater number of neutral responses. Negative feedback was minimal across all components, with videos and quizzes each receiving four negative responses, posters four, and simulations three.

Table 1
Students' Feedback (n=30)

Checkpoint	Positive	Neutral	Negative
Video	17	9	4
Poster	13	13	4
Quiz	15	11	4
Simulation	12	15	3

The findings indicate that videos were the most effective part of the module, with 17 positive remarks praising their clarity and their ability to make complex cryptographic concepts easier to understand. This supports CTML's Multimedia and Segmenting Principles, which stress the importance of combining visual and auditory channels and presenting information in digestible portions. The 15 positive comments about the quiz checkpoint highlight its role in facilitating active recall and reinforcement, aligning with CTML's Generative Processing Principle. While quizzes were generally well-received, some students found them challenging, suggesting a need for adaptive difficulty to accommodate different learning abilities.

Posters garnered a more mixed set of reactions (13 positive, 13 neutral, four negative), receiving compliments for their visual attractiveness but facing criticism regarding excessive text. This points to a partial misalignment with CTML's Coherence Principle, which advocates for reducing extraneous information to enhance effectiveness. Simulations, which received 12 positive responses, were valued for their interactive nature and practical engagement related to factors in CTML's Interactivity Principle. Nonetheless, the neutral (15) and negative (three) feedback highlighted technical difficulties and accessibility issues, indicating that strong technical support is crucial to leverage the benefits of interactive learning fully.

4. Conclusion

The study delivered the content through the Gather platform, which illustrated that instruction utilising multimedia can significantly boost student involvement and understanding when it aligns with the Cognitive Theory of Multimedia Learning (CTML) model. Videos and quizzes proved especially effective in aiding comprehension and promoting active learning, while posters and simulations, although helpful, need enhancements in content clarity and technical dependability. In conclusion, the results highlight the necessity of aligning multimedia components with cognitive learning principles to maximise immersive learning experiences for intricate topics such as cryptography**.**

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