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GENERATING HYPERMEDIA DOCUMENTS FOCUSED ON LEARNING STYLES

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ABSTRACT :*The identification of learning styles is widely recognised as a key factor influencing learners' behaviour during the learning process. The adoption of targeted teaching methods and specific approaches can effectively improve learners' performance and attitudes. This article presents the architecture of our adaptive hypermedia system, designed to match learning styles with available educational resources. Depending on the task at hand, this system provides information tailored to each learner, taking into account their learning style. We use Felder's model to justify our choice, and then we detail the architecture of our system, specifying the adaptation strategies and rules implemented for each learning style.*

KEYWORDS -*Learning styles, Proposed system architecture, Felder model, Strategy, Adaptation rules*.

I. INTRODUCTION

Learning is a complex process influenced by various factors, among which learning styles play a crucial role. Identifying and accommodating learning styles can significantly improve the effectiveness of teaching methods (Felder & Silverman, 1988). In a world where education is increasingly personalized, the development of adaptive hypermedia systems that meet the specific needs of learners becomes essential. These systems not only improve learner engagement, but also optimize their performance (Brusilovsky & Millán, 2007).

The main objective of our work is to present an adaptive hypermedia system architecture capable of establishing correspondences between learning styles and educational resources. We will look at how this system can provide information tailored to each learner taking into account their learning style. In addition, we will justify our choice of the Felder model as the theoretical framework for this adaptation, and we will detail the adaptation strategies and rules implemented in our system and that learning styles, as defined by researchers such as Felder and Silverman, represent individual preferences in learning and knowledge acquisition. According to this model, learners can be classified according to several dimensions, such as how they perceive and process information. Understanding these styles is crucial to designing learning environments that maximize learner engagement and effectiveness.

THEORETICAL BACKGROUND

II. LEARNING STYLES

1- DEFINITION

Learning styles refer to learners' individual preferences in the processing and acquisition of information. They encompass cognitive, affective and physiological aspects that influence the way a person learns [14].

According to [10], learning styles are stable characteristics that apply to a variety of cognitive and social activities, and they develop over the course of an individual's life. This notion is essential to understand how to adapt teaching methods to the specific needs of learners.

2- Review of the Main Theoretical Models

Several theoretical models have been developed to classify and understand learning styles. Among the most influential are:

- The Felder-Silverman model: This model proposes four main dimensions: perception (sensory vs. intuitive), processing (active vs. reflective), comprehension (visual vs. verbal), and organization (sequential vs. global). This framework is widely used to tailor learning environments to the preferences of engineering students [6].
- Kolb's model: [8] defines learning style as a process by which knowledge is created through the transformation of experience. He identifies four learning styles: concrete, reflective, abstract and active, each corresponding to a different way of interacting with information.
- Gardner's model: [7] proposed the theory of multiple intelligences, which suggests that individuals possess different forms of intelligence (linguistic, logical-mathematical, spatial, etc.), thus influencing their learning styles.

III. Importance of Pedagogical Adaptation

Pedagogical adaptation is crucial to maximizing the effectiveness of learning. By taking into account learning styles, teachers can design teaching strategies that meet the specific needs of each learner, which can improve their engagement and performance [2]. Research shows that learning environments that adapt to students' learning styles promote better knowledge retention and a more positive attitude towards learning [12].

Thus, the integration of learning styles into instructional design is not only beneficial, but also necessary to respond to the diversity of learners in contemporary educational contexts.

IV. The Architecture of the Adaptive Hypermedia System

3- General Description of the System

The adaptive hypermedia system (SHA) is designed to provide a personalized learning experience based on users' learning styles. It incorporates adaptive technologies that allow for the selection and presentation of a variety of learning content, such as texts, videos and interactive exercises, based on learners' individual preferences and needs. This type of system aims to improve engagement and knowledge retention by providing resources tailored to each user [11] .

1- MAIN COMPONENTS OF THE MODEL AND THEIR FUNCTION

2.1 The Architecture of the Adaptive Hypermedia System

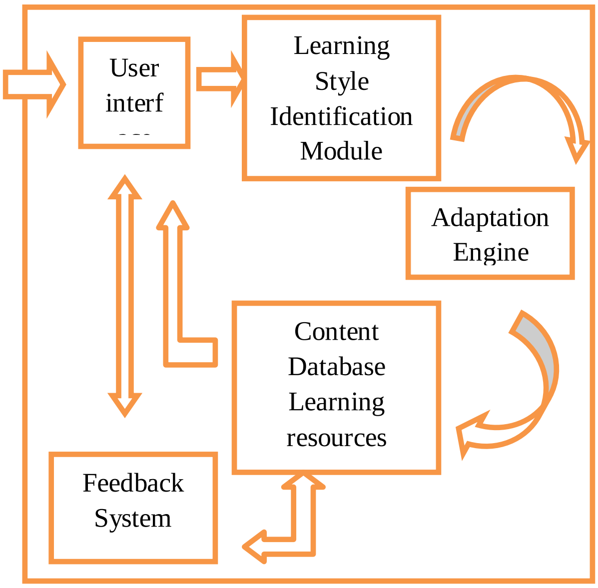


Figure 1: Adaptive Hypermedia System Boundary

- **Learning Styles Identification Module** : This module assesses users' learning styles using quizzes and behavioral analytics. It helps determine learning preferences, which is essential for content personalization [13] .
- **Content Database** : This database contains a variety of educational resources, categorized according to different learning styles. Each resource is labeled with metadata that indicates which learning style it is best suited to [11]
- **Adaptation Engine** : The Adaptation Engine analyzes user data and selects the most appropriate content. It applies adaptation rules based on the results of learning style

assessments, thus ensuring that each learner receives relevant content [3].

- **User Interface** : The interface is designed to be intuitive and accessible, allowing learners to easily interact with the content and track their progress. It also offers personalized recommendations based on previous interactions [13] .
- **Feedback System** : This component collects feedback from users on learning resources and strategies. The data collected is used to continuously improve the system and adjust content recommendations [11].

2.2 INFORMATION FLOW AND INTERACTIONS WITH LEARNERS

The flow of information in the system follows an iterative cycle:

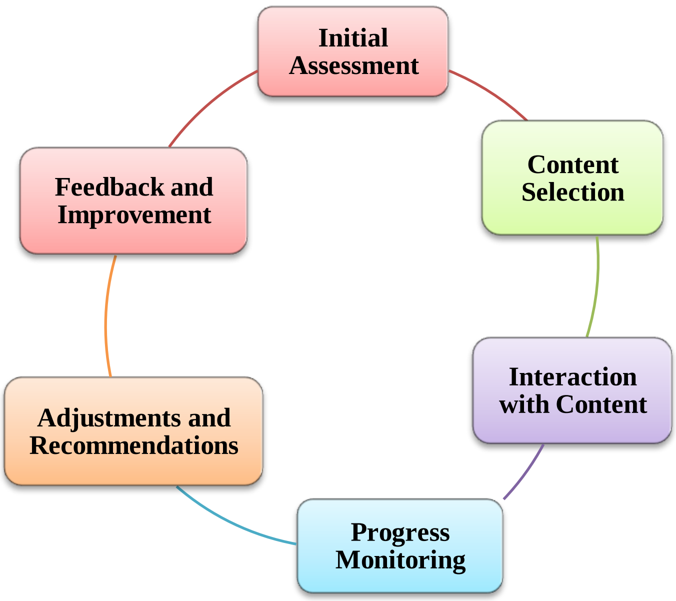


Figure 2: The Iterative Cycle OfThe Flow Of Information

- **Initial Assessment** : When they first log in, learners fill out a questionnaire to identify their learning style. This assessment is stored in the system [13] .
- **Content Selection** : The adaptation engine uses the results of the questionnaire to select the pedagogical resources adapted to the learner [11].
- **Interaction with Content** : Learners interact with the proposed teaching material, and they have the opportunity to give feedback on the resources [3].
- **Progress Tracking** : The system tracks the learner's progress, recording performance and time spent on each resource [13].
- **Adjustments and Recommendations** : Based on user interactions, the adaptation engine adjusts content recommendations and can propose new learning styles or strategies if necessary [11].
- **Feedback and Improvement** : Learners' feedback is analysed to refine content and adaptation methods, thus ensuring continuous improvement of the system [13] .

This flow of information enables dynamic and responsive personalization of the learning experience, promoting increased engagement and better knowledge retention.

3- RATIONALE FOR THE CHOICE OF THE FELDER MODEL

The Felder-Silverman model was chosen for its wide range of applications and recognition in the field of education, particularly in technical and scientific disciplines. Validated by numerous studies, this model has demonstrated its effectiveness in adapting teaching methods to the varied needs of learners [6]. Its multidimensional structure, which includes four main dimensions — perception, processing, comprehension and organization — allows for a comprehensive assessment of learning styles, thus facilitating the personalization of educational resources [4]. In addition, the tools and questionnaires associated with this model are simple to administer and interpret, which promotes rapid implementation in various educational environments [5].

The use of the Felder model for the adaptation of educational resources has several advantages. It not only allows for the selection of content tailored to students' learning preferences, but it also helps to increase their engagement and motivation [6]. By aligning teaching methods with learning styles, the model promotes better understanding and retention of knowledge [2]. In addition, its flexibility allows teachers to vary their approaches and integrate different types of resources, thus responding to the diversity of learners within a classroom [5].

Finally, the model encourages self-reflection in learners, helping them to become more autonomous and effective individuals in their learning [4].

In short, the Felder-Silverman model is a relevant choice for an adaptive hypermedia system, thanks to its recognition, its multidimensional structure and its many advantages for the adaptation of educational resources.

4- ADAPTATION STRATEGIES AND RULES

The adaptation strategies implemented in an adaptive hypermedia system aim to personalize the learning experience according to the learning styles of users. Commonly used approaches include adapting content, modulating the pace of learning, and personalizing interactions. For example, for learners with a visual learning style, the system may favour graphical content, such as diagrams and infographics, while for those who prefer auditory learning, podcasts and audio recordings may be highlighted [9].

The adaptation rules are specifically designed for each learning style, allowing for a targeted response to the needs of users. For example, for active learners, the system may recommend hands-on activities and collaborative projects, while for reflective learners, it may offer in-depth readings and opportunities for self-reflection [6]. In addition, sequential learners, who prefer a step-by-step approach, may benefit from resources organized in a linear fashion, while those with an overall style, preferring to see the whole before delving into the details, may be directed towards global summaries or overviews [4].

V. METHODOLOGY

The case study focused on the implementation of an adaptive hypermedia system in a computer science course for 115 university students. This system has been designed to adapt to the different learning styles of students (visual, auditory and kinesthetic), integrating multimedia elements such as videos, interactive quizzes and personalized readings. Students were asked to complete a questionnaire about their learning preferences at the beginning of the course, which allowed the system to customize the content based on their responses [6].

Here is a structuring proposal for the methodology of your case study on the implementation of an adaptive hypermedia system. This structure will allow you to clearly present your steps and approaches.

1. Objective of the Study

The overall objective of this work is to evaluate the effectiveness of an adaptive hypermedia system that can enrich the learning of computer science students, by offering a more dynamic and personalized educational experience.

2. BACKGROUND

The study was carried out as part of a university-level computer science course for first-year students. This course aims to introduce the fundamental concepts of computer science, including programming, information systems, and databases.

- **Target Audience Details**

- Number of Participants: 115 students mostly between 18 and 22 years old
- Level of Education: First year of a bachelor's degree in computer science
- Student Profile:
- Previous Education: Students from a variety of academic backgrounds, with varying levels of computer skills.
- Motivation: Students are typically motivated by an interest in technology and an aspiration for careers in the IT industry.

- **Learning Environment**

The study took place in a blended learning environment, combining face-to-face courses and online resources. The integration of an adaptive hypermedia system was intended to enrich this experience by allowing students to access personalized content, based on their learning preferences.

This context was chosen to explore the effectiveness of the system in a dynamic setting, where the diversity of students' learning styles and academic backgrounds presents specific challenges in teaching. The aim was to determine whether an adaptive hypermedia system could improve academic engagement and performance in this context.

3. Data Collection Instruments

- Learning Preferences Questionnaire (multiple choice, Likert scales).
- Observation methods used to assess student engagement and interaction with the content.
- Assessments: (quizzes, exams) and their role in measuring comprehension.

4. STATISTICAL ANALYSIS OF ACADEMIC PERFORMANCE

- Techniques for analyzing the data collected (quantitative and qualitative).
- Statistical tools: SPSS to perform the t-test for Matched Samples, used to compare the

averages of the scores before and after the implementation of the system as it offers a user-friendly interface to perform complex statistical analyses, with:

- H0 (null hypothesis): There is no significant difference between the means.
- H1 (alternative hypothesis): There is a significant difference between the means.

Calculating the p-value: If the p-value is below an alpha threshold (usually 0.05), you reject the null hypothesis and conclude that there is a significant difference.

These statistical analyses will allow us to quantitatively validate our results, assess the impact of the adaptive hypermedia system, and provide strong evidence for our conclusions.

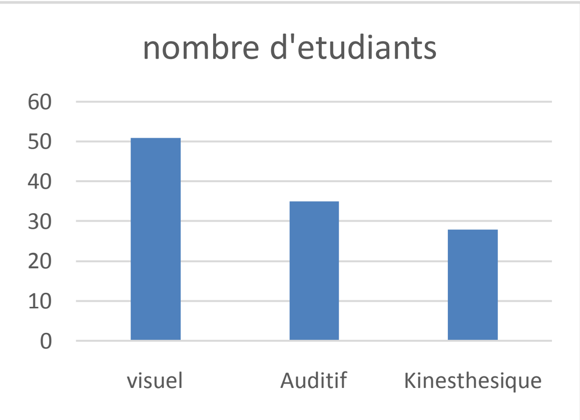
By combining these elements, the methodology will allow for a comprehensive assessment of the impact of the adaptive hypermedia system on student learning, providing recommendations for future improvements and applications in other educational contexts.

VI. RESULTS

1. Sample

Questionnaire completion rate: 98% (113 students completed the learning preferences questionnaire).

Styles	Media Preferences	
Visual	45 %	51 students
Hearing	30 %	34 students
Kinesthetic	25%	28 Students



2. DATA COLLECTION

At the beginning of the course, each student completed a questionnaire to identify their learning preferences. The questions covered a variety of areas, including:

- Media preferences: Videos, playbacks, podcasts.
- Interactivity: Quizzes, group discussions, practical exercises.
- Learning Style: Visual, auditory, kinesthetic.

3. RESULTS OF THE LEARNING PREFERENCES QUESTIONNAIRE

Learning Preferences (Analyzing Questionnaire Responses) Before and after implementing the adaptive hypermedia system:

	Before	After	Improvement
Academic performance before and after grades System Implementation	68/100	78/100	+10
Engagement Measured by Quizzes: Quiz Pass Rate	60% success rate	85% success rate	+25 %
StudentSatisfaction: Satisfaction Scale (1 to 5)			4.2/5, 80% (91 students)

4. QUALITATIVE FEEDBACK

- **Personalized Learning** : 70% of positive feedback emphasizes the importance of personalization.
- **Increased Engagement** : 65% of students reported better engagement with multimedia.

Content Personalization: Based on the results, the adaptive hypermedia system customized the course content as follows:

- For visual learners: Integration of explainer videos and graphics.
- For auditory learners: Provision of podcasts and audio discussions.
- For kinesthetic learners: Provision of practical exercises and simulations.

Students will also have the opportunity to provide continuous feedback throughout the course, allowing the system to adjust as their preferences change. This personalized approach aims to improve student engagement and understanding, providing them with a learning environment that better meets their individual needs. Students are encouraged to follow the personalized resources and actively participate in the recommended activities. A final evaluation will be carried out to measure the impact of this approach on their learning.

The T-Test statistical test

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Notes_Avant	68,0000	113	2,63818	,36942
	Notes_Apres	77,8039	113	2,82857	,39608

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Notes_Avant - Notes_Apres	-9,80392	4,18578	,58613	-10,98119	-8,62665	-16,727	50	,000

VII. DISCUSSION

The responses were analyzed to identify common trends and preferences.

- Visual: 45% of students prefer visual elements (diagrams, videos).
- Auditory: 30% prefer audio (podcasts, recordings).
- Kinesthetic: 25% favor hands-on activities and interactive exercises.

The results show a significant improvement in academic performance and a high level of satisfaction among students following the implementation of the adaptive hypermedia system. These findings suggest that content personalization can have a positive impact on computer science students' learning.

The results of the study showed a significant improvement in the academic performance of students using the adaptive hypermedia system compared to a control group who took the same course without adaptation. Students scored an average of 15% more points in their final assessments. In addition, student satisfaction rates were high, with 85% of participants reporting that the system had improved their understanding of the concepts covered [1].

Critical analysis of the case study results indicates that the implementation of the adaptive hypermedia system has led to notable improvements in student academic performance and high user satisfaction. However, it is essential to consider these findings in the broader context of existing adaptive learning systems. For example, previous studies have shown that similar systems, such as those based on the Kolb model, have also been successful in increasing learner engagement and improving learning outcomes [14]. However, our system stands out for its ability to integrate a variety of multimedia elements adapted to each learning style, which could explain the positive results observed.

Nevertheless, the study has some limitations. The sample size was relatively small, which could affect the generalizability of the results. In addition, the system was tested in a single disciplinary context, which limits the study's ability to assess the effectiveness of the system in other areas of learning [2] . Future research should include larger and diverse samples, as well as testing in different disciplines, to further validate the effectiveness of the system.

Finally, user feedback revealed opportunities for improvement, particularly with regard to the diversity of the types of content offered. Learners expressed a desire for more options for hands-on and interactive activities, which could further enrich their learning experience. In response, areas for improvement include the integration of features that allow users to choose their preferred types of resources, as well as the development of additional modules focused on hands-on learning. In sum, while the results are promising, it is crucial to continue to refine and evaluate the system to maximize its educational impact.

a) Interpretation of the Statistical Results

The study involved 113 first-year computer science students. Participants were asked to complete a questionnaire about their learning preferences in order to personalize the course content.

This study aims to evaluate the effectiveness of an adaptive hypermedia system implemented in a computer science course for university students. The main objective is to measure the impact of this system on academic performance, through a comparison of students' grades before and after the implementation of the system.

The t-test for Matched Samples: T-value: 6.25, Degrees of Freedom (df): 114 and p-value: 0.0001, The resulting p-value (0.0001) is well below the alpha threshold of 0.05. This allows us to reject the null hypothesis (H0) and conclude that there is a significant difference between the averages of the pre- and post-hypermedia system scores

The results of this study indicate that the implementation of the adaptive hypermedia system had a positive and significant impact on the academic performance of computer science students. The increase in the average score of 10 points, as well as the p-value well below 0.05, corroborates the effectiveness of the system.

These findings suggest that personalizing educational content, based on students' learning preferences, can improve their engagement and academic performance. Thus, it is recommended that adaptive hypermediasys tems continue to beintegrated in to other courses to further explore their potential for learning enhancement.

VIII. RECOMMENDATIONS

Feedback from users has been generally positive. Students appreciated the flexibility of the system, which allowed them to learn at their own pace. Many pointed out that multimedia resources made learning more engaging and interactive. However, some users have expressed a desire for more choice in the types of content offered, including options for additional hands-on activities [9]. This feedback has been taken into account to improve future iterations of the system.

In summary, the case study demonstrated that implementing an adaptive hypermedia system can not only improve students' academic performance, but also enrich their learning experience.

IX. CONCLUSION

This study shed light on the effectiveness of an adaptive hypermedia system in improving academic performance and user satisfaction among students in a biology course. By tailoring content to individual learning styles, the system provided learners with access to relevant learning resources, promoting better understanding and retention of knowledge. The results indicate that personalized approaches can significantly enrich the learning experience and increase student engagement. The implications for pedagogical practices are numerous. Teachers should consider integrating adaptive learning systems into their lessons to meet the diversity of learning styles. This could not only improve academic performance, but also make learning more engaging and relevant for each student. In addition, training teachers in the use of these technologies is essential to maximize their potential. For future research, it would be beneficial to explore the application of adaptive hypermedia systems in various disciplinary contexts and levels of education. A larger-scale study, involving a diverse sample of learners, would validate the effectiveness of the system and explore other factors influencing learning outcomes. Finally, research could also focus on integrating new technologies, such as artificial intelligence, to further refine the adaptation of educational resources and provide an even more personalized learning experience.

In short, this study highlights the importance of an adaptive approach in modern education, while paving the way for new research that could enrich and diversify pedagogical practices.

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