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Scientific articles

Preferencias sensoriales: VALK tradicional versus plataforma multimedia VARK-MM

Sensory preferences: traditional VARK versus VARK-MM multimedia platform

Preferências sensoriais: Plataforma multimídia tradicional VALK versus VARK-MM

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Resumen

El estudio examinó cómo una plataforma interactiva multimedia (VARK-MM) afecta las preferencias sensoriales de aprendizaje de estudiantes universitarios en el área de Sistemas Computacionales, frente a las preferencias medidas con el cuestionario tradicional VALK. Para ello se empleó un diseño descriptivo, transversal y cuantitativo, en el que participaron 299 estudiantes de tres instituciones públicas en México mediante el cuestionario VALK y dos adaptaciones multimedia del modelo VARK, diseñadas específicamente para este estudio y enfocadas en las materias de Bases de Datos y Programación. Ambos instrumentos mostraron alta fiabilidad y validez, lo que permitió identificar diferencias significativas en

las preferencias auditiva y lectora/escritora comparadas con el cuestionario VALK. Los resultados mostraron una disminución significativa en la preferencia auditiva promedio, que pasó de 0.292 a 0.221 en la materia de Bases de Datos, mientras que la modalidad lectura/escritura aumentó de 0.175 a 0.252. De manera similar, en la materia de Programación se registró una reducción de la media en la preferencia auditiva de 0.298 a 0.222 y un incremento en la lectora/escritora de 0.175 a 0.257. Al parecer, el uso de multimedia puede alterar las preferencias sensoriales y sugiere una transformación de los estudiantes, pasando de ser agentes de recepción lineal a aprendices activos, potenciada por la interactividad y el impacto visual de los medios empleados actualmente. La plataforma fue bien aceptada (84 %) y valorada positivamente como herramienta de aprendizaje. Este estudio concluye que la integración de contenidos interactivos en la educación es crucial y que la plataforma VARK-MM puede ser adaptada a diversas materias, sirviendo como herramienta diagnóstica para identificar preferencias de aprendizaje para una asignatura específica.

Palabras clave: preferencias sensoriales, plataforma multimedia, estudiantes universitarios, sistemas computacionales.

Abstract

This study examined how a multimedia platform (VARK-MM) influences the sensory learning preferences of undergraduate students in the Computer Systems area, in comparison to the traditional VARK questionnaire. Using a descriptive, cross-sectional, and quantitative design, 299 students from three public institutions in Mexico were surveyed using the VARK questionnaire and two instruments derived from VARK-MM, focusing on databases courses and programming courses. Both instruments demonstrated high reliability and validity, revealing significant differences in auditory and reading preferences compared to the VARK questionnaire. The results showed a significant decline in auditory preference alongside an increase in the read/write modality for both Databases (from 0.292 to 0.221 and 0.175 to 0.252, respectively) and Programming (from 0.298 to 0.222 and 0.175 to 0.257). The use of multimedia appears to influence sensory preferences and suggests a transformation in students, shifting from linear recipients of information to active learners, a process enhanced by the interactivity and visual impact of contemporary media. The platform received high acceptance (84 %) and was positively evaluated as a learning tool. This study concludes that integrating interactive content into education is essential and that the VARK-MM platform

can be adapted to various subjects, serving as a diagnostic tool to identify learning preferences for a specific course.

Keywords: sensory preferences, multimedia platform, university students, computer systems.

Resumo

Este estudo examinou como uma plataforma multimídia interativa (VARK-MM) afeta as preferências de aprendizagem sensorial de estudantes universitários da área de Sistemas de Computação, em comparação com as preferências medidas pelo questionário VALK tradicional. Utilizou-se um delineamento descritivo, transversal e quantitativo, envolvendo 299 estudantes de três instituições públicas do México. O questionário VALK e duas adaptações multimídia do modelo VARK, especificamente desenvolvidas para este estudo e focadas nas disciplinas de Bancos de Dados e Programação, foram utilizados. Ambos os instrumentos apresentaram alta confiabilidade e validade, permitindo a identificação de diferenças significativas nas preferências auditivas e de leitura/escrita em comparação com o questionário VALK. Os resultados mostraram uma diminuição significativa na preferência auditiva média, de 0,292 para 0,221 na disciplina de Bancos de Dados, enquanto a preferência de leitura/escrita aumentou de 0,175 para 0,252. De forma semelhante, na disciplina de Programação, registrou-se uma diminuição na preferência auditiva média, de 0,298 para 0,222, enquanto a preferência de leitura/escrita aumentou de 0,175 para 0,257. Aparentemente, o uso de multimídia pode alterar as preferências sensoriais e sugere uma transformação nos estudantes, que passam de receptores passivos a aprendizes ativos, potencializada pela interatividade e pelo impacto visual das mídias atualmente empregadas. A plataforma foi bem recebida (84%) e avaliada positivamente como ferramenta de aprendizagem. Este estudo conclui que a integração de conteúdo interativo na educação é crucial e que a plataforma VARK-MM pode ser adaptada a diversas disciplinas, servindo como ferramenta diagnóstica para identificar preferências de aprendizagem em um curso específico.

Palavras-chave: preferências sensoriais, plataforma multimídia, estudantes universitários, sistemas computacionais.

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Introduction

According to Fleming (2012), the way a person processes information is influenced by both their interests and how the information is presented. To explain these differences, the author proposed the VARK model, which classifies preferences into four modalities: visual, auditory, reading/writing, and kinesthetic. In this study, the acronym VALK is used exclusively to refer to the Spanish version of the original VARK questionnaire, due to the linguistic adaptation of the category “ Read / Write ” as “Lectura/Escritura” (Reading/Writing), which necessitates the use of the letter 'L' in the acronym, without implying any modifications to the original construct. From this point forward, this convention will be maintained throughout the manuscript.

The approach proposed by Fleming (2012) facilitates the pedagogical understanding of how some individuals feel more comfortable learning through visual resources such as graphics, audio, written texts, or hands-on experiences. Although many people have a dominant modality, others combine several in their learning process (Fernández Cruz & Narváez Trejo, 2021). Various studies have used the VALK questionnaire to adapt educational resources to students' sensory preferences and thus optimize their learning (Ortega-Torres *et al.* , 2020). In general terms, although it provides a framework for Understanding how people prefer to receive content (Brown *et al.* , 2014) and its effectiveness as a tool for improving learning remains a subject of debate. A growing body of research suggests that multimodal instructional methods based on cognitive principles offer a more effective and scientifically supported approach to education. Furthermore, based on researchers' experience during previous applications of the instrument, it has been observed that several of its questions are temporally detached from the respondents' context. Additionally, both the content of the questions and their response options are presented solely in text format and are unrelated to the topics of study that are of interest to the participants. Therefore, the overall objective of this study is to compare students' learning preferences using the traditional version of the VALK questionnaire and a custom-designed multimedia instrument. This paper adapts the VARK model to a contextualized multimedia environment, using topics of academic interest to the participants. The study then defines the object of study, describes the particularities of the methodological approach employed, presents the results obtained, analyzes them in the discussion, and finally presents the conclusions of the work.

VARK Model

The VARK model was developed by Neil D. Fleming in 1987 as a tool to identify preferences in the reception and processing of information, with the purpose of improving teaching and learning strategies (Fleming & Mills, 1992). Although it was not conceived for measuring learning styles, but rather for diagnosing sensory preferences, its application has significantly influenced pedagogical practices, promoting pedagogical approaches that seek to adapt instruction to the different ways in which students prefer to interact with information.

The first applications focused primarily on improving comprehension through multimodal intervention, integrating the use of visual aids, lectures, assigned readings, and interactive activities. Since then, educators have begun to employ diverse teaching materials, such as infographics (for visual learners), podcasts and debates (for auditory learners), structured writing exercises (for reading/writing learners), and role-playing or simulation activities (for kinesthetic learners), in order to improve participation and knowledge retention (Arifin) . *et al.* , 2025). For example, Carcamo and Pino (2025) found that the use of digital texts enriched with improved visual elements significantly increases reading comprehension in university students, especially when the materials present clear organization and thematic relevance.

In his meta-analysis, Tomić *et al.* (2023) found that the VARK questionnaire is generally valid and reliable for identifying sensory preferences, especially in fields such as medicine, kinesiology, and economics. However, the relationship between these preferences and academic performance is complex, making it important to consider various additional factors. While the VARK model has been widely adopted and has guided various pedagogical practices, its methodological rigor and empirical support require further analysis. Despite its widespread use, the VARK model has been the subject of significant criticism regarding its empirical validity. In particular, the consistency of the evidence supporting the correlation between sensory preferences and improvements in academic performance has been questioned, as well as the stability of these preferences over time. Furthermore, several authors have pointed out that categorizing sensory preferences into four modalities may oversimplify learning processes, which involve the dynamic interaction of multiple cognitive systems. In this sense, it is argued that students benefit more from integrative instructional approaches than from exclusive adaptation to a specific modality (Willingham et al., 2015).

Multimedia

The Multimedia comprises elements such as text, images, audio, video, animations, simulations, and interactive multimedia platforms using technology to facilitate comprehension or memorization, constituting an essential part of Information and Communication Technologies (Guan *et al.* , 2018). Regarding its components, in Abdulrahman 's meta-analysis *et al.* (2020), which analyzed 82 research articles, found that text is the most frequently used multimedia component in educational settings (26.8%), followed by video (19.5%), audio (18.3%), images (18.3%), and animation (11.0%), while annotation and 3D are less common. The combination of text, images, audio, video, and animation tends to improve learning outcomes, although the choice of components should be tailored to the content and educational context, such as the use of audio in language classes or visual elements in biology. The combinations in the reviewed studies range from two to six components, with most applications using combinations of two or four components. Five or six components are rare, but all incorporate at least two. These results highlight the importance of adapting multimedia design to the target audience, subject matter, and teacher profile.

Interactive multimedia in computer systems studies

In the teaching and learning process for undergraduate degrees in Computer Systems Engineering, it is necessary for students to interact with educational materials to improve their understanding of complex topics. The use of interactive media in education is fundamental, as it promotes student autonomy, overcomes limitations of experience, motivates learning, and offers a comprehensive educational experience . *et al.* , 2019). Interactive multimedia offers an alternative to the traditional teaching process. Its interactive and exploratory nature helps break the monotony of passive learning. Under this premise of interactivity, hierarchical frameworks for participation have been established, hence Naps *et al.* (2002) developed a taxonomy of six levels of student interaction with visual tools: no visualization, passive visualization, answering questions, changing input data, building visualizations, and presenting to others. It was found that the higher the level of interaction, the better the learning. According to Imtiaz (2019), understanding data structure algorithms requires a deep understanding, for which only a few algorithm visualization tools (AVTs)

have proven effective, the most notable being... Interactivity is the key factor for successful learning.

Thus, for example, the strategy Visual Kinesthetic Pseudocode supports novice programming students by facilitating the understanding of complex concepts before coding. Unlike textual pseudocode, which can be confusing due to its ambiguity, this strategy combines visual and kinesthetic elements to promote active learning and better comprehension. Each action produced by a click is associated with the corresponding code. Students visually and physically construct algorithms, a dynamic that reduces misunderstandings and strengthens the connection between logical thinking and actual code. (Odisho) *et al.* , 2016).

According to Cervantes Márquez *et al.* (2017) found that the growing preference for kinesthetic learning among engineering students highlights the need for teaching tools that promote direct interaction with the concepts being learned. This fosters a more meaningful experience, as it links learning with sensory actions, facilitating the understanding of abstract processes such as data structures.

Stimoli *et al.* (2024) evaluated a basic programming instruction program for four adult women with intellectual disabilities, using JClick (an environment for creating, delivering, and evaluating educational activities) and a methodology based on an explicit teaching model with gradual support and guided practice. The approach facilitated autonomous learning and the consolidation of skills through repetition and feedback. JClick enhanced participation through visual and manipulative elements, and the creation of educational content strengthened the participants' self-esteem and active role in inclusive environments.

Multimedia learning

Multimedia resources can be classified according to their delivery medium, such as screens and speakers; their presentation mode, such as words and images; or their sensory modality, such as auditory and visual (Mayer, 2002). This perspective is based on the principles of Cognitive Load Theory (Sweller , 1988), which explains the limitations of information processing in working memory. Within this framework, the cognitive theory of multimedia learning posits that information is processed through two main channels, visual and auditory, each with a limited capacity. For learning to occur, the student must select, organize, and integrate words and images with their prior knowledge (Mayer, 2005).

Mayer (2002) proposes the foundational multimedia design principle that people learn better with words and images combined than with words alone. This principle gives rise to a series of guidelines for designing materials aimed at optimizing multimedia learning. According to Mayer (2017), these principles are organized into three categories, according to the cognitive processes they seek to support. To reduce unnecessary processing, the principles of coherence, signaling, and redundancy are proposed. Spatial contiguity, which involves placing related text and images together, and temporal contiguity, which consists of presenting them simultaneously, are also included. To manage essential processing, associated with content complexity, the principles of segmentation and pre-training are applied. The modality principle, which recommends the use of audio narration instead of written text, is also considered. Finally, to foster generative processing, aimed at motivating the learner, the principles of personalization and voice are included. Likewise, the principle of embodiment is incorporated, which involves the use of animated agents with expressions and gestures that accompany the content.

In conclusion, it's worth noting the relationship between Mayer's multimedia learning principles and Fleming's VARK model. Both approaches aim to improve learning by considering, on the one hand, students' preferences and, on the other, the effective presentation of information. In this sense, Mayer's principles can be applied by adapting the questions of the traditional VALK questionnaire to university students. This allows for improvements in the design of the content included in the questions. Furthermore, if these questions are linked to topics of academic interest, it's possible to implement a multimedia platform optimized for their training needs. This way, their sensory preferences can be measured in a contextualized manner.

Materials and methods

A quantitative study was conducted with a descriptive and cross-sectional design of prospective data collection.

Sample

A non-probability convenience sampling method was used, selecting pre-existing groups from three public universities located in the central and southeastern regions of Mexico, specifically in the states of San Luis Potosí and Veracruz. These institutions were chosen based on the accessibility and availability of the study groups.



As an inclusion criterion, only regular students were considered, defined as those formally enrolled in the current academic year, with a full course load and no outstanding coursework. Participants were also required to have previously passed Programming and Database courses, thus ensuring a foundational knowledge for interacting with the proposed platform.

Participants

The study involved 299 university students from 11 groups enrolled in the Computer Systems degree program. The mean age of the group was 20.5 years ($SD = 1.86$), with 28% female representation (84 participants). It is important to note that, although the initial characterization included all participants, the application of the VARK-MM1 and VARK-MM2 instruments resulted in the formation of specific subsamples, as not all students completed both questionnaires during the scheduled sessions.

Tools

The application of the instruments was organized according to the technological support used. The questionnaires on sensory preferences and opinions regarding multimedia instruments, The data collection was administered via Google Forms, which were distributed by the researchers through a link sent via institutional email or by projecting a QR code during the in-person session. The multimedia tools, on the other hand, were implemented natively within the electronic platform designed for the study. The characteristics of each tool are detailed below.

Sensory preferences

The VALK questionnaire was used to investigate individual preferences in information reception. This instrument consists of 16 questions that reflect everyday situations, assessing inclinations toward sensory modalities such as visual, auditory, reading/writing, and kinesthetic. Fleming (2012) points out that these modalities are not mutually exclusive, suggesting that the boundaries between them may be ambiguous.

The questionnaire presents four response options per item, allowing for multiple selection that reflects the multimodal nature of learning (Leite et al., 2010). Due to this structure, the most appropriate confirmatory factor analyses (CFAs) are those that employ

structural equation models with robust estimation, ideal for evaluating the covariance between multiple latent dimensions simultaneously (Wong & Chin, 2018).

Regarding reliability measures for the different sensory subscales, values ranging from 0.69 to 0.85 were reported for the visual, auditory, reading/writing, and kinesthetic modalities. Specifically, Leite et al. (2010) obtained coefficients of 0.73, 0.79, 0.84, and 0.69, respectively; while Wong and Chin (2018) reported values of 0.85, 0.82, 0.84, and 0.77 for the same dimensions. Correlations between these subscales showed ranges from moderate ($r = 0.416$) to strong ($r = 0.799$). In this study, the Spanish version of the questionnaire was used (VARK™ questionnaire © Copyright Version 7.8 2014, property of VARK Learn). Limited, Christchurch, New Zealand). The items used (see Table 1) correspond to those reported by Fuentes-Mejía *et al.* (2018).

Multimedia platform

The platform, called VARK-MM, is distinguished in two ways: both its content and response options incorporate multimedia elements, and its questions are geared toward the participants' educational interests. The name VARK-MM was chosen to maintain a direct reference to the original theoretical model proposed by Fleming. Unlike the acronym VALK, used in this study for the Spanish version of the questionnaire, the name VARK-MM preserves the conceptual consistency of the model, avoiding potential ambiguities arising from linguistic adaptations that do not alter the construct. The platform allows for the creation of as many instruments as needed; in this case, one was generated for the Databases course (VARK-MM1) and another for the Computer Programming course (VARK-MM2), both fundamental to the Bachelor's Degree in Computer Systems.

Each instrument consists of 10 items, each corresponding to a specific topic within the subject (see Table 2). A six-point Likert scale, ranging from “Not at all” (1) to “Very much” (6), is used to assess preference for each item. A six-level (even) scale was selected to eliminate central tendency, requiring participants to define an acceptance or rejection stance toward the presented multimedia content, thus avoiding neutral responses that could bias the sensory preference assessment. Multimedia content is presented for each item to be associated with the perception channels of the VARK model.

Table 1. VALK Questionnaire: Questions and Selection Frequency

Questions	Accumulated selections
1. You help a person who wants to go to the city center.	363
2. You choose your food at a restaurant or cafe.	444
3. You finish a competition or test, and would like some feedback or advice.	422
4. You are preparing an important speech for a class or a special occasion.	411
5. You are planning a vacation for a group of people and would like their feedback on the plan.	370
6. You want to learn a new video game.	530
7. A group of tourists wants to learn about the parks in your region. You...	420
8. A website has a video that shows how to make a special chart. You could learn more from it .	512
9. You remember the time when you learned to do something new, such as riding a bicycle or skating.	439
10. Besides price, what would most influence your decision to buy a new book?	448
11. You use a website to learn how to take photographs with your cell phone.	455
12. You like websites.	521
13. Do you cook any special dishes for your family?	467
14. You are about to buy a cell phone. Besides the price, what else influences your decision?	503
15. Do you prefer a teacher or a lecturer?	505
16. You have a problem with your knee. You would prefer that the doctor...	426

Source: Own elaboration

Table 2. VARK-MM instruments and their items

	VAR-K-MM1	VAR-K-MM2
Item	Issue	Issue
1	Stages of the design of a relational database (DB)	Cycle <i>for</i>
2	Design products	Conditional
3	Types of cardinality	Cycle <i>while</i>
4	Data dictionary	Algorithm concept
5	Most common objects in a relational database	Properties of an algorithm
6	SQL and its sublanguages	Functions
7	DML commands in general	Concept of variables
8	DML write commands	Accountants
9	<i>Select</i> clauses	Accumulators
10	Special operations of the <i>select</i>	Types of variables

Source: Own elaboration

To optimize the design of this content, Mayer's principles (2017) were applied within each modality, aiming to mitigate extrinsic cognitive load and avoid unnecessary intermodal redundancy. For the visual modality, images with minimal text were used, and the principles of multimedia, signaling, spatial contiguity, and coherence were applied. For the reading/writing modality, only structured text was used, along with the principles of segmentation and signaling. For the auditory modality, only audio was used, without on-screen text, and the principles of modality and voice were applied. Finally, in the kinesthetic modality, the aim was to promote meaningful experiences, as described by Cervantes Márquez. *et al.* (2017), interactive activities with little text have been developed, using the JClíc platform. These activities align with level three of the taxonomy by Naps *et al.* (2002), called "answering questions," in which the student must answer questions generated by the system about the presented visualization in order to progress. The design principles applied in this case were redundancy and temporal contiguity.

The platform allows for the dynamic integration of content, so the various files are uploaded as each instrument is completed. Initially, instructions and a link to a demonstration video are presented. Figure 1 shows an example, corresponding to the topic "Types of Cardinality" in the Databases course. The procedural flow for each item is divided into the following steps: 1) When each question is presented, a traffic light is displayed to allow the participant to prepare. 2) Following this, one of the four content types is presented randomly for each topic. 3) To advance from one type to another (next button), an option must be selected. 4) Although not required, it is possible to return (previous button) without selecting any option. 5) When a participant answers an item in the survey, they choose an option from 1 to 6 according to the content type. At the end, the scores obtained for the 10 items are added together to generate a total score for each sensory modality. Therefore, the total score ranges from 10 (minimum value of 1 per item) to 60 points (maximum value of 6 per item). These results are automatically stored for subsequent statistical analysis.

Figure 1. Cardinality Types (VARK-MM1).

TIPOS DE CARDINALIDAD

Image

Audio

Text

Interactive

Source: Own elaboration

VARK-MM Opinion Questionnaire

To obtain additional information about the multimedia instruments, an anonymous, non-mandatory questionnaire was implemented, with two questions: “Share your opinion about the survey” and “Describe how you felt when answering it.”

Procedure

Sensitization

Participants were informed of the study's objective, expected results, work procedures, and estimated time for completing the activities. Those who agreed to participate in the project signed an informed consent form and were subsequently assigned individual access credentials: a unique user ID and a temporary password to access the VARK-MM

platform, thus ensuring data traceability and participant anonymity in accordance with ethical research protocols.

Application

The sessions were held in computer labs on various days during the semester. Initially, the purpose of the session was explained, participants were verified to have logged in with their previously assigned personal information, and the instructions were read aloud. They were asked to raise their hands to ask questions or to indicate they had finished, after which they remained seated until everyone had completed. It is important to emphasize that standardized supervision was in place to minimize distractions, and all groups followed the same protocol.

During the first session, the VALK questionnaire was administered to 299 students. As Fuentes-Mejía et al. (2018) point out, participants had the option to select multiple responses per item or leave it unanswered. In two subsequent sessions, both the multimedia instrument and the accompanying opinion survey were administered over a total of one hour. Participants were informed that there was no time limit, but the session was scheduled for 15 minutes. Only 249 students completed VARK-MM1, and 226 completed VARK-MM2. This difference was due to the fact that not all students who had participated in the second session attended the third administration.

Data processing

For the exploratory factor analysis (EFA), the Factor software (version 12.01) was used. According to Lorenzo-Seva and Ferrando (2013), it is distinguished by being a widely used tool for performing an EFA, since it was specifically designed for this purpose and offers the added advantage of being free software.

Due to the ordinal and polytomous (Likert-type) nature of the items, whose data did not follow a normal distribution and the sample size was greater than 200, the polychoric correlation matrix was used (Lloret et al., 2017). Optimal parallel analysis was used to determine the number of dimensions present (Timmerman & Lorenzo-Seva, 2011), and subsequently, the robust unweighted least squares (RULS) method was used for factor extraction.

In the confirmatory factor analysis (CFA), in addition to calculating the factor loadings, various metrics were used to assess the model fit:



- The comparative fit index (CFI),
- The non-normed adjustment index (NNFI),
- The goodness-of-fit index (GFI),
- The root mean square residue (RMSR).

In all other cases, SPSS software was used to calculate descriptive statistics and perform comparative analyses. Specifically, to compare preferences between the instruments, the Wilcoxon signed-rank test for paired samples was used, given the non-normal distribution of the data. Effect size (Hedges ' g) and statistical power were estimated using G* Power , with the former calculated from the means and standard deviations obtained in SPSS.

Finally, for the textual processing of the survey “About the VARK-MM,” the inductive content analysis technique was used to interpret and extract a complementary qualitative component (mixed design or secondary qualitative component). For the qualitative processing of the survey “About the VARK-MM,” an inductive content analysis technique was followed, structured in a sequence of four phases:

1. Preparation and segmentation: Following Erlingsson and Brysiewicz (2017), the text was initially fragmented into units of meaning to facilitate its handling.
2. Coding and categorization: Based on Elo and Kyngäs (2008), an open coding was carried out that allowed the grouping of recurring words and phrases into thematic categories.
3. Refinement: The contextualization and decontextualization process proposed by Bengtsson (2016) was applied to debug the initial codes.
4. Final abstraction: The process concluded with the synthesis of the categories for the interpretation of the final results . This methodological integration allowed the transformation of open responses into structured and refined data for the diagnosis of the platform.

Results

VALK

Of the total selections per question (see Table 1), question “6. You want to learn a new video game” received the most selections, while question “ 1. You are helping someone who wants to go downtown” received the fewest. Additionally, the overall proportion of preferences by modality was calculated by dividing the total number of selections in each

modality by the total number of selections recorded in the instrument. Based on this procedure, it was found that preferences were highest for the visual and kinesthetic modalities, with values of 29.8% and 28.0%, respectively. No significant difference was observed between the two, with the lowest percentage of preference being obtained for the reading/writing modality at 17.2% (see Table 3).

Table 3. VALK Questionnaire: percentages by item and modality.

Questions	Modalities			
	V	TO	L	K
1. He is helping a person who wants to go to the city center.	11%	71%	6%	12%
2. You will choose your food at a restaurant or cafe.	10%	13%	50%	27%
3. A competition or test has ended, and I would like some feedback or advice:	22%	37%	19%	23 %
4. You have to give an important speech for a class or a special occasion.	9%	19%	35%	36%
5. You are planning a vacation for a group of people and would like their feedback on the plan.	35%	51%	0%	14%
6. He wants to learn a new video game.	31%	21%	16%	31%
7. A group of tourists wants to learn about the parks in your region. You...	36%	36%	10%	18%
8. A website has a video that shows how to make a special chart. You could learn more from:	38%	18%	9%	34%
9. Remember the time you learned to do something new, such as riding a bike or skating.	8%	37%	6%	49%
10. Besides price, what would most influence your decision to buy a new book?	25%	32%	17%	25%
11. You are using a website to learn how to take photographs with your cell phone.	13%	24%	21%	42%
12. He likes websites.	37%	25%	18%	20%
13. She is going to cook a special dish for her family.	44%	17%	19%	20%
14. You are about to buy a cell phone. Besides the price, what else influences your decision?	27%	14%	39%	20%
15. Do you prefer a teacher or a speaker?	25%	27%	8%	40%
16. He has a problem with his knee. He would prefer the doctor to:	19%	47%	6%	28%
Global (weighted average by total selections)	25.0%	29.8%	17.2%	28.0%

Note: Percentages were calculated based on the total number of selections for each item ($n = 16$). Due to the multimodal nature of the questionnaire, which allows for multiple responses per question, the horizontal sum of the modalities (V+A+L+K) represents 100% of the preferences expressed for each situation presented. Source: Author's own elaboration

VARK-MM

For all subscales, high internal consistency was found, with Cronbach's alpha coefficients ranging from 0.833 to 0.926 for VARK-MM1 and VARK-MM2 (see Table 4-A). In terms of internal consistency, all item-total correlations appeared satisfactory, and no substantial changes occurred in the alpha coefficient when individual items were removed.

For both instruments, the appropriateness of factor analysis was determined using Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, both of which exceeded 0.854. Furthermore, all four subscales showed statistically significant results ($p < .01$ in all cases), with specific χ^2 values reported in Table 4-B. Measures of sampling adequacy (MSA per item) were greater than 0.50 in all cases (Lorenzo-Seva & Ferrando, 2021), and polychoric correlations were non-zero and less than 0.90, supporting the suitability of factor analysis. All average factor loadings per subscale were greater than 0.60 (see Table 4-B).

In all subscales, the EFA revealed a single factor that explained a significant percentage of the total variance. In particular, the Visual subscale of the VARK-MM1 showed the lowest percentage of explained variance (44.6%), while in the VARK-MM2, this value reached 66.6% for the same subscale.

Finally, in the confirmatory factor analysis (CFA), the fit indices reflected a generally adequate model (see Table 5). In both instruments, the goodness-of-fit index (GFI) indicated a good fit (≥ 0.95). The values of the comparative fit index (CFI) and the non-normed fit index (NNFI) were acceptable (≥ 0.90) for VARK-MM1 and adequate (≥ 0.95) for VARK-MM2, suggesting that, although the model is adequate, it could benefit from further improvements. Furthermore, only in the VARK-MM1 instrument, the root mean square residual (RMSR) values of 0.082 and 0.081, respectively, suggest that this model could benefit from further improvements, while in the other subscales the fit was good or acceptable (≤ 0.08).

VARK-MM1

In the sensory preference assessment for VARK-MM1 (see Table 6), the topic with the highest average grade was 7. *DML Commands in General* in the Visual and Auditory subscales, and 3. *Types of Cardinality* in the Reader and Kinesthetic subscales. In this instrument, the least accepted topics were 8. *DML Writing Commands* in the Visual and Auditory modalities, while 1. *Stages of Relational Database Design* was least accepted in

the Auditory subscale, and 2. *Design Products* in the Kinesthetic subscale. To find the proportion of preferences, the sum of the choices per modality was divided by the total number of selections. Thus, it was found that the highest preference corresponded to the kinesthetic modality (26.7%) and the lowest to the auditory modality (22.6%), obtaining no appreciable differences between the visual and reading/writing modalities, both remaining as the second preference, with values of 25.5% and 25.2%, respectively.

Table 4. Psychometric properties by subscale in VARK-MM1 and VARK-MM2

Scale	Subscale	(TO)	(B)			
		Cronbach's alpha	KMO	χ^2	MSA	Factor Loading (Average)
VARK-MM1						
	Visual	0.834	0.855	1659.60	0.800	0.634
	Auditory	0.898	0.855	2958.29	0.830	0.714
	Reader	0.901	0.897	3131.49	0.870	0.731
	Kinesthetic	0.885	0.919	3210.04	0.881	0.728
VARK-MM2						
	Visual	0.926	0.908	4050.63	0.857	0.792
	Auditory	0.954	0.939	5455.58	0.923	0.854
	Reader	0.942	0.898	4955.12	0.846	0.834
	Kinesthetic	0.940	0.939	5136.63	0.921	0.842

KMO = Kaiser–Meyer– Olkin ; χ^2 = Bartlett's test of sphericity chi-square statistic (df = 45, p < .01 in all cases); MSA = measure of sampling adequacy.

Source: Own elaboration

Table 5. Model fit and variance explained by subscale in VARK-MM1 and VARK-MM2

Scale	Subscale	Total variance explained (%)	CFI	NNFI	GFI	RMSR
VARK-MM1						
	Visual	44.6	.928	.908	.975	.082
	Auditory	56.9	.957	.945	.984	.079
	Reader	58.4	.952	.938	.984	.081
	Kinesthetic	59.0	.982	.977	.992	.057
VARK-MM2						
	Visual	66.6	.977	.971	.993	.059
	Auditory	75.8	.980	.974	.995	.054
	Reader	72.7	.976	.970	.994	.060
	Kinesthetic	73.9	.989	.986	.997	.044

CFI = Comparative Fit Index; NNFI = Non-normed Fit Index; GFI = Goodness of Fit Index;

RMSR = Root Mean Square Residual.

Source: Own elaboration.

VARK-MM2

In VARK-MM2 (see Table 6) , item 10. *Types of Variables* obtained the highest average rating in the visual, reading/writing, and kinesthetic subscales, while item 7. *Concept of Variables* stood out in the auditory modality. Conversely, the least appreciated items were 1. *FOR Cycle* in the auditory, reading/writing, and kinesthetic modalities, and 2. *Conditional* in the visual modality. Similar to the previous instrument, the proportion of preference per participant was calculated by dividing their choices by modality by the total of their accumulated responses. Comparing these proportions, the following decreasing order was found: kinesthetic (26.6%), reading/writing (25.5%), visual (25.3%), and auditory (22.6%).

Table 6. Descriptive values of the subscales of the VARK-MM instruments.

VARK-MM1								
Item	Visual		Auditory		Reader/writer		Kinesthetic	
	Average	OF	Average	OF	Average	OF	Average	OF
1	4.39	1.071	4.49	1.218	4.39	1.071	4.49	1.218
2	4.37	1.161	4.44	1.207	4.37	1.161	4.44	1.207
3	4.89	1.004	5.20	1.043	4.89	1.004	5.20	1.043
4	4.53	1.039	4.95	1.185	4.53	1.039	4.95	1.185
5	4.47	1.077	4.84	1.125	4.47	1.077	4.84	1.125
6	4.35	1.201	4.58	1.391	4.35	1.201	4.58	1.391
7	4.77	1,080	5.09	1.079	4.77	1,080	5.09	1.079
8	4.21	1.282	4.48	1.428	4.21	1.282	4.48	1.428
9	4.49	1.236	4.77	1.227	4.49	1.236	4.77	1.227
10	4.43	1.181	4.69	1.321	4.43	1.181	4.69	1.321
VARK-MM2								
1	4.61	1,160	4.67	1.157	4.61	1,160	4.67	1.157
2	4.67	1,080	4.83	1.130	4.67	1,080	4.83	1.130
3	4.73	1.028	4.77	1.107	4.73	1.028	4.77	1.107
4	4.81	0.994	4.95	1.033	4.81	0.994	4.95	1.033
5	4.67	1,000	4.97	1.057	4.67	1,000	4.97	1.057
6	4.68	1.049	5.00	1,000	4.68	1.049	5.00	1,000
7	4.81	0.968	5.09	1.033	4.81	0.968	5.09	1.033
8	4.62	1.104	4.79	1,270	4.62	1.104	4.79	1,270
9	4.82	0.940	5.04	1.047	4.82	0.940	5.04	1.047
10	4.91	0.953	5.12	1.008	4.91	0.953	5.12	1.008

Note: Scale 1–6; SD = Standard Deviation. Source: Author's own elaboration

About the VARK-MM

Based on inductive content analysis, 379 units of analysis were identified derived from the question “Opinion about the survey.” This figure does not correspond to the number of participants, but rather to the total number of coded segments. Of these, 84% were positive assessments, 5% negative, 5% neutral, and the remaining 6% were classified as out of context. Among the positive assessments, the most frequent reasons were: reinforcement of knowledge (34%), promotion of different learning styles (22%), interactivity (15%), use of diverse media (14%), and clarity of information (9%). The 20 negative opinions were mainly associated with perceived confusion ($n = 13$), tediousness ($n = 5$), and length of the instrument ($n = 2$). Regarding the question “How did you feel?”, 151 units of analysis were identified, a lower number due to the shorter length of the responses, as not all participants answered this question. Of these, six reflected discomfort (e.g., boredom, stress, strangeness, fatigue, pressure, or fear of being evaluated). In contrast, the majority of units corresponded to positive ratings, associated with categories such as fun, comfort, interest, and entertainment. Additionally, six suggestions for improvement were identified, primarily related to the interface.

Comparison of instruments

In the VALK, VARK-MM1, and VARK-MM2 questionnaires, the proportion of preference for each modality was obtained for each participant by dividing their number of choices by the sum of the four modalities. For the comparison between the VALK and the two multimedia instruments (VARK-MM1 and VARK-MM2), only participants with complete data for all three instruments were considered ($n = 190$) to ensure comparability between measurements. This figure differs from the sample sizes reported in Table 7, where $n = 219$ corresponds to the comparison between VALK and VARK-MM1, and $n = 205$ to the comparison between VALK and VARK-MM2, both performed using pairwise comparisons of instruments. From this analysis, statistically significant differences ($p < .001$) were observed in auditory and reading/writing preferences. In particular, the reading/writing modality showed an increase, while the auditory modality showed a decrease. When obtaining the effect sizes (Hedges' g) for the auditory modality, medium size values were obtained (Cohen, 1988), with values of 0.689 for VARK-MM1 and 0.721 for VARK-MM2. Similarly, for the reading/writing modality, large sizes were obtained, with indices of -1.127

and -1.126, respectively. The negative sign in these latter indices reflects the direction of the difference, indicating a substantial increase in reading/writing preference in the multimedia instruments compared to the traditional VALK. When comparing the means by subscale between the multimedia instruments, no statistically significant differences were observed in any subscale ($p > .05$ in all cases). However, a change in the order of preferences was identified: in VARK-MM1, the visual modality predominated over the reading/writing modality, while in VARK-MM2, the reading/writing modality surpassed the visual modality.

Table 7. Comparison of the proportion of preferences by channel (VALK vs. VARK-MM)

	VALK		VARK-MM1		Wilcoxon test	
	(n=219)					
Channel	Average	OF	Average	OF	Z	P
Visual	0.252	0.090	0.257	0.035	-1.008	0.314
Auditory	0.292	0.099	0.221	0.048	-8.822	< .001
Reader/writer	0.175	0.069	0.252	0.033	-10.945	< .001
Kinesthetic	0.281	0.090	0.269	0.045	-1.709	0.087
	VALK		VARK-MM2		Wilcoxon test	
	(n=205)					
Channel	Average	OF	Average	OF	Z	P
Visual	0.249	0.088	0.254	0.028	-0.904	0.366
Auditory	0.298	0.098	0.222	0.049	-8.832	< .001
Reader/writer	0.175	0.070	0.257	0.027	-10.772	< .001
Kinesthetic	0.279	0.092	0.267	0.044	-1.508	0.132

SD = Standard deviation; Z = Wilcoxon and deals with related samples; Source: Own elaboration

Discussion

The main findings and their comparison with previous studies will then be described for each instrument.

VALK

In their study with 98 university students from central Mexico, Esquivel et al. (2024) found a similar order of preferences to the present study, although with slight modifications, with values of 30.2% for auditory, 28.8% for kinesthetic, 20% for visual, and 21% for reading/writing. As in Esquivel et al. (2025), when dividing the proportions corresponding to each channel, a similar percentage and order were obtained for all preferences: auditory and kinesthetic at 29%, followed by visual at 25%, and reading/writing at 17%. Fernández and Narváez (2021) found similar results, as the 69 students in an English program had a greater preference for the auditory modality, but their second choice was reading/writing.

On the other hand, focusing on the kinesthetic modality, the study by Vargas et al. (2023) with participants from different programs, regions, and funding sources, showed a primary preference for this channel, similar to the overall value of 28% found in the traditional VALK questionnaire used in this study, with a proportion of 31%. It is noteworthy that, among their 1,619 participants, the reading/writing modality was the second most chosen. Regarding the results of Jiménez et al. (2019) with Dentistry students, there is a similarity in terms of preferences for auditory and kinesthetic learning, although in their case, these appeared as the second and third most preferred modalities (24% auditory and 23% kinesthetic), with the visual modality being the most popular at 34%. Along the same lines, Torres et al. (2023) who worked with 305 nursing students, there was similarity in the main selection by the kinesthetic modality, although in their case the reading/writing modality was the second most chosen, as in Vargas et al. (2023).

Regarding the possible reasons for the order of preferences in this study, the following interpretations can be made based on the observed data. Questions 6, 8, and 12, which received the most responses, were related to the satisfaction that, as an interpretive hypothesis, students derive from access to digital environments and devices. As for those that received fewer choices (1, 4, 5), this could be because the situations presented involve a commitment to people who are not well known.

By modality, the items where auditory preference predominated are related to giving or receiving instructions, especially from trusted figures. Questions showing a high preference for the kinesthetic modality are related to activities involving learning physical or practical skills. Meanwhile, questions with a higher incidence of the visual modality are connected to activities facilitated by reviewing videos or images. Finally, regarding

variations in the reading/writing modality, those with the highest participation are associated with tasks requiring reading or careful writing.

VARK-MM

Internal consistency (Cronbach's alpha) and factor structure (EFA and CFA) analyses suggest that both instruments are reliable and valid for diagnosing sensory preferences. However, some subscales could be strengthened by revising specific items and adjusting the RMSR indicators, especially in the visual and reading/writing dimensions of VARK-MM1, which would optimize the accuracy of factor loadings in future applications.

Regarding the change in the hierarchy of visual and reading/writing preferences between the two multimedia instruments (see Table 7), this can be interpreted from the differences in the means of both subscales, which show a greater relative preference for the reading/writing modality in VARK-MM2. This result can be attributed, firstly, to the greater organization and structuring of the textual content in this instrument, which facilitates comprehension. Furthermore, the topics covered in VARK-MM2, focused on programming, involve the use of syntax and structures that require more detailed reading. In contrast, visual resources do not always allow for sufficiently precise representation of these elements, which could limit their effectiveness in this context.

To date, the authors' review identified no studies of a multimedia instrument specifically designed to diagnose sensory learning preferences. This lack of research prevents direct comparisons with other studies, positioning the results of this investigation as preliminary evidence and, at the same time, highlighting the need to generate new empirical data to compare and validate the findings.

VALK vs. VARK-MM

When comparing preferences between the traditional VALK instrument and the VARK-MM instruments (see Table 7), a statistically significant decrease was observed in the auditory modality and an increase in the reading/writing modality. The effect size was moderate for the auditory modality and large for the reading/writing modality, according to Hedges' *g coefficient*. In both cases, the statistical power ($1-\beta$) exceeded the 80% threshold, with values greater than .90, indicating adequate sensitivity for detecting the observed effects.

The decline in preference for the auditory modality can be interpreted in terms of the thematic context and the content design. In particular, topics related to databases and

programming involve structures and relationships that often require visual or textual support for proper understanding. In this sense, the exclusive use of audio may have been less effective compared to other, more structured formats. Likewise, the complexity of the content may have increased the cognitive load when the information was presented solely in auditory format.

On the other hand, the increased preference for the read/write mode in multimedia tools may be associated with the organization and clarity of the textual content. The design of these materials aimed to use accessible and structured language, avoiding excessive use of technical jargon as much as possible, which may have facilitated comprehension. Furthermore, the platform allowed students to move forward and backward through the content, promoting self-paced learning and information review—aspects that could have contributed to a greater preference for this mode.

Conclusions

The findings of this study demonstrate that the VARK-MM multimedia platform is a relevant alternative for diagnosing sensory preferences in university students of Computer Systems. Compared to the traditional VALK questionnaire, a significant decrease in auditory preference and an increase in reading/writing preference were observed. This pattern suggests a possible association with the design and organization of textual materials, as well as with the technical nature of the content—factors that could influence how students process information. In this sense, the results indicate that multimedia environments can influence the expression of sensory preferences and promote more active forms of interaction with content, based on elements such as interactivity, information organization, and the navigation possibilities offered by the platform, which can influence attention, motivation, and cognitive load management.

Furthermore, the platform's high acceptance rate reinforces its potential as a flexible and adaptable teaching tool for different subjects, offering teachers and researchers a complementary approach for subject-specific contextualized diagnosis and for understanding how students prefer to learn. The reliability and validity observed in the VARK-MM, supported by factorial evidence, solidify its use as a diagnostic instrument. However, the need for specific adjustments in some subscales is acknowledged, particularly in the visual and reading/writing modalities of VARK-MM1, where certain fit indicators (such as the RMSR) suggest areas for improvement.

In summary, this study provides empirical evidence on the relevance of integrating interactive content into higher education and highlights the usefulness of multimedia platforms such as VARK-MM to enrich teaching and learning processes, while opening new lines of research on topics to explore.

Future lines of research

This study has some limitations that should be considered when interpreting the results. First, the sample was obtained through non-probability convenience sampling, comprising students from three public universities in central and southeastern Mexico, which limits the generalizability of the findings to other academic contexts or regions. Second, although the instruments showed adequate levels of reliability and validity, some subscales of the VARK-MM1, particularly in the visual and reading/writing modalities, showed fit indicators that could be optimized (for example, the RMSR), suggesting the need to refine certain items to improve their factorial consistency. Third, the cross-sectional design of the study prevents the analysis of the evolution of sensory preferences over time or the establishment of causal relationships. Furthermore, contextual factors may have influenced the results, such as the students' familiarity with the use of digital devices, the specific characteristics of the content assessed (database and programming courses), and the order in which the instruments were administered. In the latter case, the instruments were administered in a fixed order, which could have introduced sequence effects that were not controlled for.

For future research, it is recommended to expand the sample to include institutions from different regions and with a greater diversity of academic programs, in order to increase the representativeness of the findings. Likewise, it would be pertinent to develop longitudinal studies that allow for analyzing how sensory preferences evolve throughout a student's university career or based on prior experience with digital environments. Regarding the instrument, it is suggested that new versions of the VARK-MM be designed, incorporating improvements in the visual and reading/writing subscales, particularly in those adjustment indicators that showed opportunities for optimization. Similarly, it is important to compare the instrument with other diagnostic models in terms of convergent validity, temporal stability, and sensitivity to the application context. Finally, it is proposed to deepen the qualitative component of the study through the use of more structured mixed methodologies,

in order to systematically integrate students' perceptions of the use of multimedia platforms in their academic training.

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