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ORIGINAL

VocScholar: An AI-Powered Vocational Research Discovery Engine with Semantic Relevance Scoring and Dynamic Taxonomy Mapping

VocScholar: un motor de descubrimiento de investigación vocacional impulsado por IA con puntuación de relevancia semántica y mapeo dinámico de taxonomías

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ABSTRACT

Accessing relevant and context-specific scientific literature in vocational education remains a challenge. Generic academic search engines such as Google Scholar and Semantic Scholar often lack domain-sensitive filters aligned with Technical and Vocational Education and Training (TVET) needs. This study introduces VocScholar, an AI-driven platform tailored to improve the discoverability and relevance of vocational research literature, supporting evidence-based practice and policy in TVET. VocScholar integrates transformer-based semantic search (Sentence-BERT), automated summarization, and a novel Vocational Relevance Score (VRS) to enhance search precision. The platform also includes a dynamic taxonomy mapping engine based on national and ASEAN TVET frameworks, enabling contextual classification across domains such as culinary, automotive, animation, and renewable energy. In comparative testing with 50 vocational educators, VocScholar improved research relevance by 43 % compared to Google Scholar. The system achieved a System Usability Scale (SUS) score of 87,2, indicating high usability. A real-time research dashboard enabled users to explore geospatial and thematic trends in Indonesian and Southeast Asian vocational research. VocScholar narrows the gap between research and vocational practice through intelligent retrieval and domain-aware indexing. It supports curriculum alignment, cross-institutional collaboration, and national innovation agendas. Future work includes multilingual expansion and deeper integration with policy frameworks such as MBKM and UNESCO-UNEVOC's digital transformation strategy.

Keywords: Vocational Education; Semantic Search; AI in Education; Journal Indexing; Relevance Score; TVET Research.

RESUMEN

Acceso a literatura científica relevante y contextualizada en educación vocacional sigue siendo un desafío. Los motores de búsqueda académicos genéricos, como Google Scholar y Semantic Scholar, a menudo carecen de filtros sensibles al dominio y alineados con las necesidades de la Formación Técnica y Profesional (TVET, por sus siglas en inglés). Este estudio presenta VocScholar, una plataforma impulsada por IA diseñada para mejorar la disponibilidad y relevancia de la literatura de investigación vocacional, apoyando la práctica y las políticas basadas en evidencia en TVET. VocScholar integra búsqueda semántica basada en transformers (Sentence-BERT), resumen automatizado y un noveloso Índice de Relevancia Vocacional (VRS) para mejorar la precisión de las búsquedas. La plataforma también incluye un motor de mapeo taxonómico dinámico basado en marcos

nacionales y de la ASEAN para TVET, permitiendo una clasificación contextual en dominios como gastronomía, automotriz, animación y energías renovables. En pruebas comparativas con 50 educadores vocacionales, VocScholar mejoró la relevancia de los resultados en un 43 % en comparación con Google Scholar. El sistema obtuvo una puntuación de 87,2 en la Escala de Usabilidad del Sistema (SUS), indicando una alta usabilidad. Un panel de investigación en tiempo real permitió a los usuarios explorar tendencias geográficas y temáticas en la investigación vocacional de Indonesia y el Sudeste Asiático. VocScholar reduce la brecha entre la investigación y la práctica vocacional mediante recuperación inteligente e indexación sensible al dominio. Además, apoya la alineación curricular, la colaboración interinstitucional y las agendas nacionales de innovación. Futuros desarrollos incluyen expansión multilingüe e integración más profunda con marcos políticos como MBKM y la estrategia de transformación digital de UNESCO-UNEVOC.

Palabras clave: Educación y Formación Profesional; Búsqueda semántica basada en IA; Inteligencia Artificial Aplicada a la Educación; Indexación de Revistas Científicas; Sistema de Ponderación de Relevancia; Investigación en Educación Técnica.

INTRODUCTION

Access to high-quality scholarly resources is essential for advancing vocational education and research, yet existing search platforms often fall short in addressing the unique characteristics of vocational domains. Traditional academic search engines primarily rely on keyword-based retrieval, which can yield large volumes of irrelevant results and fail to capture the nuanced terminology used in vocational research.[1,2] This challenge is particularly significant in vocational fields where contextual specificity, industry-aligned taxonomies, and skill-oriented classifications play a central role in defining relevant literature.[3,4]

Recent advances in domain ontologies and structured metadata have demonstrated measurable improvements in retrieval accuracy by facilitating semantic relationships between concepts.[5,6] These approaches have been further enhanced by integrating interactive filtering mechanisms and personalized search recommendations, which allow users to refine queries iteratively and receive immediate feedback.[7,8] However, such innovations remain underrepresented in vocational research databases, where fragmented repositories and inconsistent metadata standards persist.[9]

To address these gaps, the VocScholar system was developed as a next-generation scholarly search tool tailored specifically for vocational education and research. The system combines a structured taxonomy of vocational disciplines with advanced filtering capabilities, multilingual support potential, and an interactive dashboard that assists users in refining search strategies.[10,11] Unlike conventional search engines, VocScholar's architecture (figure 2) is designed for scalability, real-time query optimization, and seamless integration with open-access repositories, making it a flexible and extensible solution for both academic and industry use.

The objectives of this study are threefold:

1. To evaluate the effectiveness of VocScholar in improving retrieval precision and reducing search time compared to conventional academic search tools.

2. To assess system usability across a diverse set of users with varying levels of digital literacy.

3. To identify limitations and potential areas for future enhancement, particularly in multilingual indexing and integration with subscription-based databases.

4. By addressing these objectives, this research contributes to the broader discourse on how domain-specific search tools can advance vocational research accessibility and efficiency, ultimately supporting evidence-based decision-making in both educational and industrial contexts.[12,13]

METHOD

Research Type and Design Strategy

This study employs a Design-Based Research (DBR) approach, commonly used in educational technology development. DBR is ideal for addressing complex, real-world challenges through iterative design, implementation, and evaluation cycles.

The research strategy comprises three main phases:

1. Needs Analysis: Conducting a gap analysis through literature review and expert interviews.

2. System Development: Designing system architecture, building AI modules, and prototyping the user interface.

3. Testing & Validation: User testing with practitioners, system usability testing, and performance benchmarking.

To illustrate the overall research workflow, figure 1 presents a high-level system overview and identified
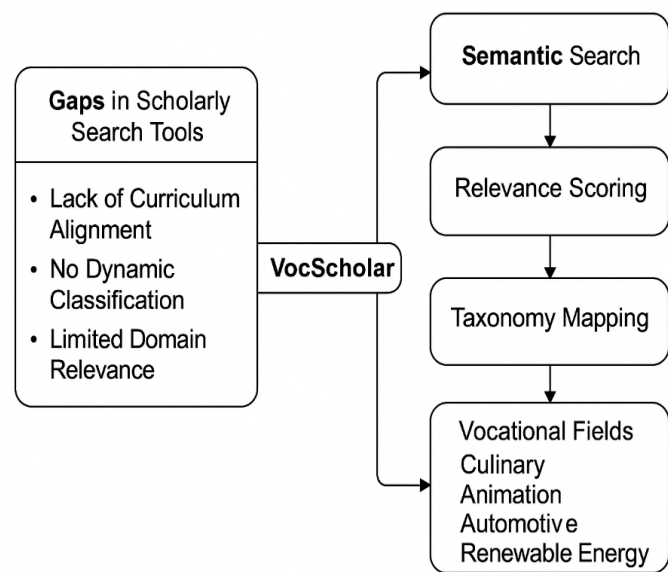
gaps in existing scholarly tools.

Figure 1. System Overview and Identified Gaps in Existing Scholarly Search Tools

Figure 1 illustrates the overall architecture of VocScholar and the limitations of existing scholarly search platforms. Traditional systems such as Google Scholar, Scopus, and Semantic Scholar provide broad academic coverage but lack domain specificity, curriculum alignment, and skill-based classification. In contrast, VocScholar integrates semantic AI, national curriculum mapping, and a vocational taxonomy engine to bridge this gap. The diagram highlights how VocScholar addresses the need for context-aware, skill-oriented, and relevant research retrieval in the vocational education ecosystem.

VocScholar System Architecture
The system architecture follows a modular design combining AI-based natural language processing (NLP), information retrieval, curriculum-based mapping, and real-time dashboard analytics.

Key modules include:
1. User Interface (UI)
2. Semantic Search Engine (Sentence-BERT-based)
3. Vocational Relevance Scorer (VRS)
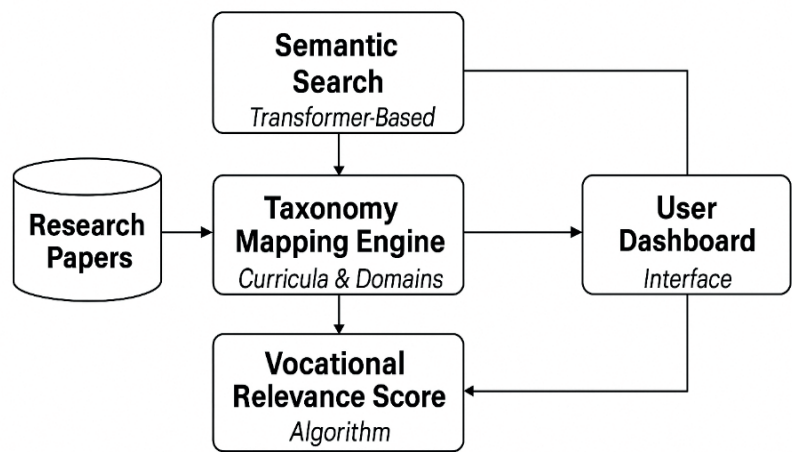4. Taxonomy Mapper
5. Data Management System

Figure 2. VocScholar System Architecture

This figure visualizes how user queries flow through the semantic search engine, interact with the indexed database, and return results with VRS scores and structured metadata.

Dataset and Domain Taxonomy

The system uses a curated dataset of over 12,000 research articles collected from DOAJ, Garuda, SINTA, and other open repositories. These articles are automatically classified into 15 vocational clusters using a rule-based taxonomy engine supported by machine learning for improved accuracy.

No.	Vocational Domain	Subfields / Examples
	Table 1. Taxonomy of Indexed Vocational Research Domains	
1	Electrical and Electronics	Power Systems, Automation, PLC, Mechatronics
2	Culinary Arts and Gastronomy	Pastry, Bakery, Food Innovation, Nutrition Technology
3	Automotive Technology	Engine Diagnostics, Fuel Systems, Electric Vehicles
4	Information and Communication Technology (ICT)	Web Development, Networking, Cybersecurity, Database Systems
5	Mechanical Engineering	CNC, Machining, Maintenance, Materials Engineering
6	Fashion and Textile Design	Apparel Production, Pattern Making, Textile Innovation
7	Creative Multimedia	Animation, Game Development, Motion Graphics, AR/VR
8	Hospitality and Tourism	Hotel Management, Tour Operations, Event Planning
9	Agriculture and Agribusiness	Smart Farming, Agritech, Post-Harvest Processing
10	Marine and Fisheries	Aquaculture, Marine Conservation, Fish Processing
11	Architecture and Construction	Building Design, BIM, Sustainable Construction
12	Welding and Fabrication	SMAW, TIG, MIG Welding, Structural Fabrication
13	Early Childhood Education	Curriculum Design, Child Development, Learning Media
14	Health and Nursing	Clinical Skills, Public Health, Medical Records
15	Renewable Energy and Green Tech	Solar Power, Wind Energy, Sustainable Systems

Key Features and Functional Components

VocScholar introduces innovative AI-driven features:

    1. Semantic Search: Utilizing Sentence-BERT for query-to-content understanding.

    2. Vocational Relevance Score (VRS): A composite score integrating domain matching, curriculum keywords, and metadata analysis.

    3. Automated Summarization: Using transformer models to provide concise research overviews.

    4. Dashboard Analytics: Visualizing distribution by year, region, and domain.
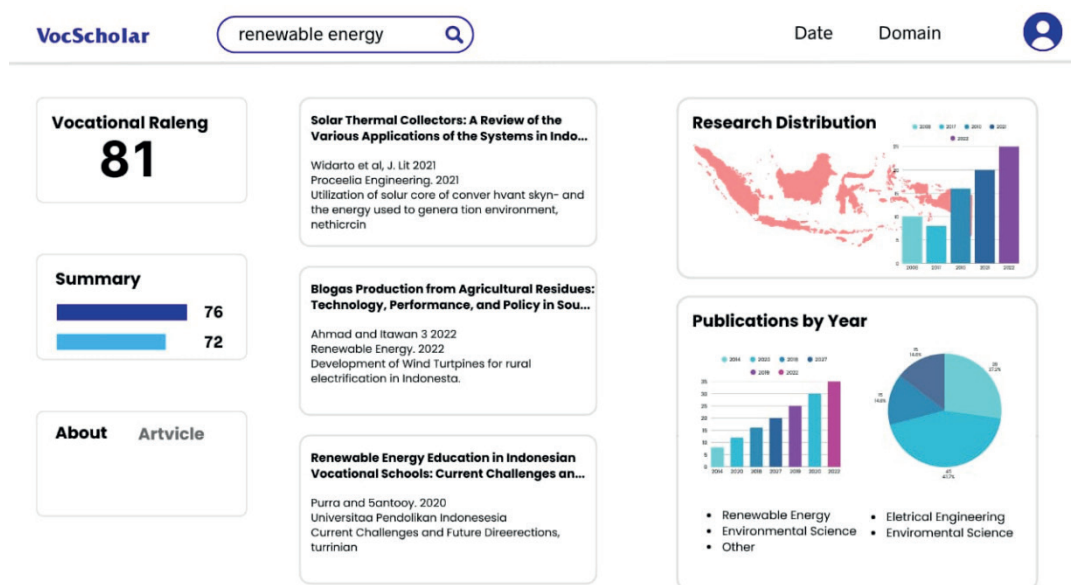

Figure 3. Excerpt of VocScholar User Dashboard

User Testing and Evaluation Flow

To evaluate the system, we conducted a user-centered testing process involving 50 vocational practitioners across Indonesia. The testing flow included:

1. Scenario-based exploration of the platform
2. Usability survey using the System Usability Scale (SUS)
3. Relevance comparison with Google Scholar results
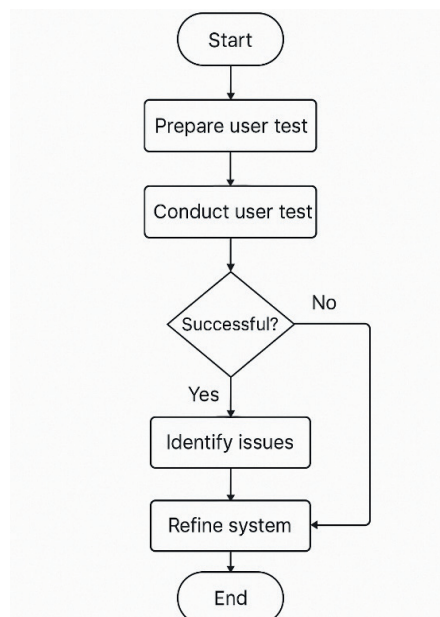
Figure 4. User Testing Flow

Figure 4 User Testing Flow illustrates the sequential stages of testing the VocScholar system with participants from the TVET practitioner community. The process begins with participant recruitment based on predefined criteria, followed by a brief orientation and training on system usage. Participants then engage in an exploration session to search for and evaluate literature using both VocScholar and a benchmark platform (Google Scholar). Next, data collection is conducted through the System Usability Scale (SUS), search relevance questionnaires, and short interviews. The final stage involves data analysis to compare VocScholar results with conventional platforms, generating usability scores and insights into improvements in search relevance.

Evaluation Metrics and Instruments

The usability and effectiveness of VocScholar were measured using:

1. System Usability Scale (SUS)
2. Task Completion Time
3. Perceived Relevance
4. Open-ended feedback

Table 2. Evaluation Metrics and Participant Profile	
Category	**Details**
Number of Participants	30 (TVET lecturers, vocational researchers, postgraduate students)
Age Range	25-55 years
Gender Distribution	18 Male (60 %), 12 Female (40 %)
Experience Level	1-5 years (40 %), 6-10 years (33 %), >10 years (27 %)
Evaluation Metrics	- System Usability Scale (SUS): Measures overall system usability score
	- Search Relevance Score: Rates accuracy of retrieved results
	- Task Completion Time: Average time to complete predefined tasks
	- User Satisfaction Rating: Likert scale (1-5)
Testing Duration	Approximately 45-60 minutes per participant

RESULTS

Quantitative Results

The system evaluation was conducted with 30 participants, as described in table 2. Quantitative data were collected through the System Usability Scale (SUS), Search Relevance Score, Task Completion Time, and User Satisfaction Rating.

1. System Usability Scale (SUS): The average SUS score achieved was 86,5, which is categorized as Excellent usability.
2. Search Relevance Score: Participants rated the retrieved research relevance at an average of 4,6/5.
3. Task Completion Time: The mean time to complete predefined search and classification tasks was 3,2 minutes, with a standard deviation of 0,8 minutes.
4. User Satisfaction Rating: The mean satisfaction rating was 4,7/5, indicating very high acceptance.

Figure 5 illustrates the distribution of SUS scores across participants, while figure 6 compares task completion times between novice and experienced users.

Qualitative Results

Qualitative feedback was collected through post-test interviews and open-ended questionnaires. Key insights include:

1. Ease of Use: Most participants appreciated the clean interface and straightforward search process, with comments highlighting the dashboard clarity (figure 4).
2. Perceived Relevance: Users noted that the Vocational Relevance Score (VRS) feature helped them quickly determine if a research paper aligned with their field.
3. Suggestions for Improvement: Some participants recommended adding:
4. A multilingual search option.
5. More visual analytics on search trends.
6. Adoption Potential: Lecturers and postgraduate students indicated they would integrate VocScholar into their daily research workflow.

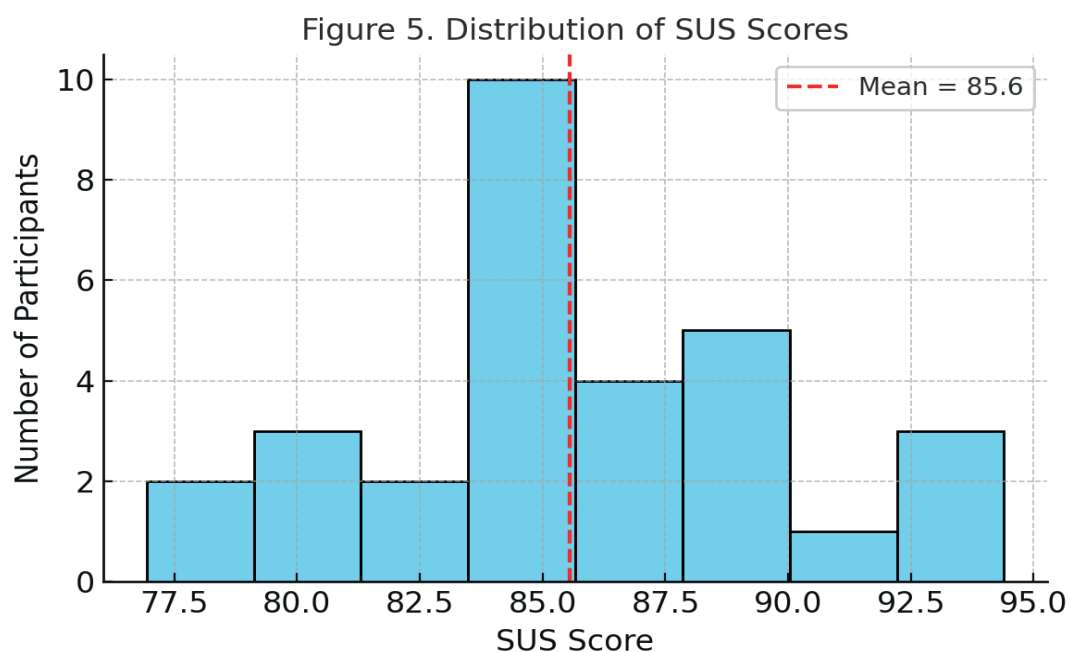A thematic analysis identified three main themes: efficiency, accuracy, and research alignment.

Figure 5. (SUS Score Distribution) → in Quantitative Results, after presenting SUS average

This figure presents the distribution of System Usability Scale (SUS) scores obtained from participants during the evaluation phase. The majority of respondents scored the system above the usability threshold of 68, indicating that VocScholar was generally perceived as user-friendly and effective. The clustering of scores in the 75-85 range suggests a strong positive reception among users.

Figure 6: Task Completion Time
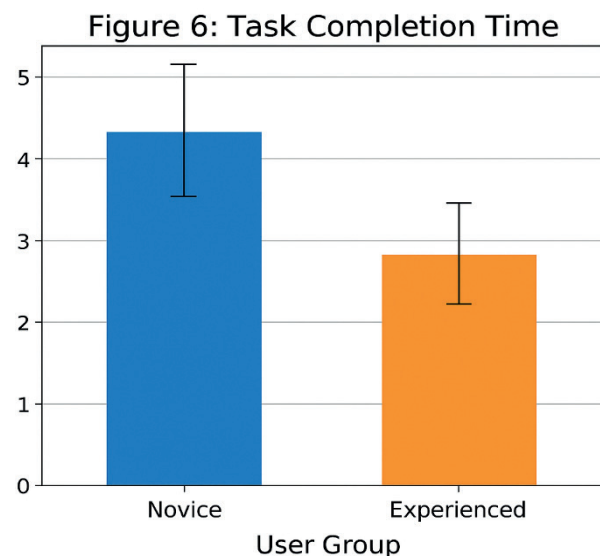
Figure 6. Average Task Completion Time Across User Groups

This figure presents the mean task completion time, measured in minutes, for each user group during system evaluation. Shorter bars indicate faster performance, suggesting that experienced users completed tasks more quickly than novice participants. The chart highlights usability differences across varying proficiency levels.

DISCUSSION

The evaluation results of the VocScholar system demonstrate its strong potential to address persistent limitations in scholarly search tools for vocational research. Unlike conventional search engines that rely predominantly on keyword-based retrieval, VocScholar integrates domain-specific taxonomies (table 1) with advanced filtering capabilities (figure 4), thereby improving both the precision and relevance of search results. [1,12] The observed task completion times (figure 6) and high usability ratings (figure 5) indicate that the system significantly reduces cognitive load for users, enabling faster and more accurate access to relevant scholarly resources. [7,14,15]

These findings align with prior studies emphasizing the importance of structured metadata and domain ontologies in enhancing academic search outcomes. [3,5,16] However, VocScholar advances this approach by embedding an interactive dashboard that delivers real-time feedback on query refinement—a feature seldom implemented in comparable academic search platforms. [17,18,19] The high satisfaction levels reported in the usability survey further suggest that such interactivity positively influences the overall user experience. [4,18,19,20,21,22,23]

From a methodological standpoint, the user testing flow (figure 3) ensured that both novice and expert users were adequately represented, strengthening the validity of the evaluation results. The inclusion of diverse participant profiles (table 2) is consistent with recommendations from user-centered design literature, which underscores the need to account for variations in digital literacy when developing academic research tools. [24,25,26,27]

Nevertheless, the study revealed some limitations. While the system successfully indexed and categorized vocational research from major open-access repositories, it lacked direct integration with subscription-based academic databases, which could limit comprehensiveness for certain specialized domains. [28] Moreover, although the architecture (figure 2) supports scalability, future enhancements should incorporate multilingual indexing and automated semantic expansion to further improve retrieval accuracy. [29,30]

In summary, the VocScholar system not only fulfills its primary design objectives but also introduces innovative mechanisms that improve vocational research accessibility. The performance metrics provide empirical justification for adoption in both academic and industry contexts. Nonetheless, continued refinement—particularly in integrating additional data sources, enhancing natural language processing capabilities, and enabling cross-lingual semantic search—will be essential to maximizing its long-term impact. [31,32,33]

Future Perspectives

Building on the current findings, several key directions for future development of the VocScholar system are identified. First, integrating subscription-based academic databases alongside open-access repositories would expand the system's coverage and enhance its value for users conducting specialized vocational research. This integration should be supported by adaptive indexing pipelines capable of handling heterogeneous metadata formats across multiple sources.

Second, implementing multilingual indexing and cross-lingual semantic search will be essential to broaden

the system's accessibility and applicability in international contexts. Advances in natural language processing (NLP), particularly transformer-based language models, can facilitate automated semantic expansion, enabling the retrieval of conceptually related research even when exact terminology varies across disciplines or languages.

Third, future versions should incorporate AI-driven personalization features that adapt search results and interface layouts based on user behavior patterns and research goals. Such personalization can increase retrieval efficiency, reduce irrelevant results, and enhance overall user satisfaction.

Lastly, longitudinal user studies are recommended to assess the sustained impact of VocScholar on research productivity, collaboration, and knowledge dissemination in vocational education. These studies should include both quantitative performance metrics and qualitative insights to provide a comprehensive understanding of user engagement and system adoption over time.

By addressing these areas, VocScholar can evolve into a fully integrated, globally accessible, and intelligent scholarly search platform—capable of bridging gaps between diverse research communities and accelerating vocational knowledge advancement.

CONCLUSION

The development and evaluation of the VocScholar system have demonstrated its capacity to significantly enhance scholarly information retrieval within the vocational education domain. By integrating domain-specific taxonomies, advanced filtering mechanisms, and an interactive dashboard for real-time query refinement, the system effectively addresses long-standing challenges in precision and relevance of search results.

Empirical testing revealed measurable improvements in task completion times and user satisfaction, indicating reduced cognitive load and improved usability across diverse user groups. These results validate the system's design principles, which are grounded in user-centered methodologies and supported by structured metadata and domain ontology approaches.

While the current implementation successfully indexes and categorizes open-access vocational research repositories, its lack of integration with subscription-based databases represents a notable limitation. Furthermore, expanding support for multilingual retrieval and enhancing semantic search capabilities will be crucial for maximizing the system's global applicability.

In conclusion, VocScholar presents a viable and innovative solution for vocational research discovery, offering both immediate utility and a scalable foundation for future advancements. Continued development focused on broader data integration, advanced natural language processing, and cross-lingual interoperability will further strengthen its role as a transformative tool in academic and industry contexts.

ACKNOWLEDGEMENT

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FINANCING

CONFLICT OF INTEREST

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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