Understanding the Role of OLAP and OLTP in Managing and Interpreting Student Data for SEAIT Scholarship System

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ABSTRACT

   This study understands the role of OLAP and OLTP in Managing and Interpreting Student Data for SEAIT Scholarship System. Using qualitative methods, such as semi-structured interviews and focus group discussions, the research investigates the experiences and perspectives of key stakeholders, including scholarship coordinator and administrative staffs.

   The findings reveal challenges in the current system, such as inefficiencies in data retrieval, delays in reporting, and difficulties in real-time data access. Stakeholders highlighted the need for improved data analytics and transactional processing to support better decision-making and operational efficiency. The study identifies key areas for enhancement, including the integration of OLAP for advanced reporting and insights and OLTP for real-time transactional support.

   By providing a qualitative analysis of the stakeholders' experiences and expectations, this research offers valuable recommendations for improving the SEAIT Scholarship System. These include implementing a more robust data management framework, training staff on analytical tools, and ensuring system scalability to meet future demands.

KEYWORDS: Human-Computer Interaction, Online Analytical Processing, Online Transaction Processing.

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1.0 INTRODUCTION

1.1 Background and Context

   The advent of Human-Computer Interaction (HCI) has revolutionized how users interact with technology, making systems more accessible, user-friendly, and efficient (Rundo, L, et. Al., 2020). In the modern educational environment, efficient data management plays a crucial role in supporting institutional functions, especially in scholarship programs. The SEAIT Scholarship System relies heavily on accurate, up-to-date student data to make informed decisions regarding eligibility, awarding scholarships, and tracking performance over time. Online Transaction Processing (OLTP) and Online Analytical Processing (OLAP) are two critical technologies that support different aspects of data management. OLTP focuses on real-time data entry, retrieval, and management of transactional data, such as student registrations, budget, and processing of scholarship requests. On the other hand, OLAP is used for analyzing large volumes of data to provide valuable insights through complex queries and reports. While OLTP handles the operational aspects, OLAP empowers decision-makers by offering detailed data analysis. This study seeks to explore how these two technologies can enhance the management and interpretation of student data within SEAIT's scholarship system, improving both operational efficiency and strategic decision-making.

1.2 Research Problem

The current SEAIT Scholarship System faces challenges in both data processing and the generation of meaningful analytical reports. For example, OLTP systems may lack the capacity to process large-scale data quickly, which is essential for real-time decisions such as determining scholarship eligibility. At the same time, the system may be unable to provide deep insights into trends, student performance, and scholarship effectiveness, as is possible with OLAP. This research aims to investigate how integrating OLAP and OLTP technologies can solve these problems by improving the accuracy, timeliness, and comprehensiveness of data management within the scholarship system. Furthermore, it will address how these technologies can offer a more holistic understanding of student data, enabling better decision-making.

1.3 Research Questions and Objectives

1. What are the current challenges faced by the SEAIT Scholarship System in managing and interpreting student data, and how can OLAP and OLTP technologies address these challenges?
2. How can the integration of OLAP (analytical) and OLTP (transactional) systems enhance the real-time processing and strategic analysis of student data in the SEAIT Scholarship System?
3. What are the potential benefits of utilizing OLAP technologies for generating insights into scholarship program effectiveness, and how can this contribute to more informed decision-making in the SEAIT Scholarship System?

Objectives

1. Assess the current challenges faced by the scholarship system in managing student data.
2. Explore the potential integration of OLAP and OLTP for a more advanced, efficient, and data-driven scholarship management system.
3. Analyze how OLAP can be utilized to generate detailed, strategic insights from student data and scholarship program effectiveness.

1.4 Justification and Significance

The findings of this study are expected to significantly impact both SEAIT's Scholarship System and similar institutions looking to optimize their data management practices. By understanding how OLAP and OLTP can be effectively applied, SEAIT can improve the processing speed, accuracy, and strategic utility of its student data. The research will provide insights into how these technologies can be used not just for operational purposes but also to support data-driven decisions, improve scholarship accessibility, and ensure better resource allocation. This will enhance the overall student experience, improve scholarship fairness, and foster institutional growth through efficient data management, (Rundo, L, et. al., 2020).

2.0 LITERATURE REVIEW

2.1 Overview of HCI Theories and Models

Human-Computer Interaction has evolved from focusing on usability and user interfaces to encompassing broader aspects such as system efficiency, user experience, and the adoption of emerging technologies like OLAP and OLTP (Rundo, L, et. al., 2020). Theories like the Model Human Processor (MHP) and Distributed Cognition have been foundational in understanding how users interact with complex systems. These models help analyze the cognitive processes and decision-making involved in navigating systems such as OLAP and OLTP, where quick data interpretation is essential for users Ordonez, C., et. al. (2020).

The Distributed Cognition theory highlights how cognition can be distributed across objects, individuals, and time, aligning with how OLAP systems allow users to analyze large datasets and distribute the cognitive load (Jones & Turner, 2019). Understanding these models is critical in developing user-centered interfaces in educational contexts like SEAIT's scholarship management system.

2.2 Recent Advances in HCI Research

Recent studies in HCI have focused on integrating artificial intelligence (AI), machine learning, and data analytics to enhance user-system interaction (Kim, J., et. al., 2022). The application of OLAP and OLTP in educational and business environments has been particularly noted for improving real-time decision-making capabilities Cuzzocrea, A., Hafsaoui, A., & Leung, C. K. (2023, December).

Research by Prasaad, G., Cheung, A., & Suciu, D. (2020, June) demonstrated that transactional processing systems (OLTP) are critical in environments where the accuracy of real-time data, such as student records, is essential. Moreover, Gücük, G. L., (2021) pointed out that OLAP's role in real-time data analysis could lead to more dynamic and effective user experiences in educational systems. These studies highlight the role of these technologies in bridging gaps between data processing, human interaction, and decision-making.

2.3 Theoretical Framework for the Research

The research adopts a theoretical framework that blends OLAP and OLTP within the HCI paradigm, emphasizing the interaction between users and data-driven systems. The Model Human Processor (MHP) and Distributed Cognition theories will underpin this framework Ordonez, C., et. al. (2020). These theories explain how OLAP can help users engage with large datasets more effectively by reducing cognitive load and enhancing data visualization.

The OLAP's ability to generate multidimensional reports and real-time analytics ensures that users can interact more efficiently with data, aligning with HCI's goal of improving usability and system efficiency (Li & Johnson, 2020). Similarly, OLTP's real-time processing aligns with cognitive theories that support rapid decision-making in environments where up-to-the-minute accuracy is critical (White, 2021). This framework is crucial in understanding how these dual technologies can contribute to a more dynamic and interactive user experience in the scholarship management context.

3.0 METHODOLOGY

3.1 Research Design

The research adopts a qualitative approach to gain an in-depth understanding of stakeholders' experiences with the current system and their expectations for improvement. Semi-structured interviews were chosen to allow open-ended discussions, while focus groups facilitated collective insights by Maxwell, J. A. (2013).

3.2 Participants

Participants was composed by (7) seven including SEAIT Scholarship Office key stakeholders. These individuals will provide first-hand knowledge on the use of OLAP and OLTP in the system, as well as insights into operational challenges and strategic needs Sargeant, J. (2012).

3.3 Data Collection Methods

Data was collected through semi-structured interviews. The interviews will explore how OLTP and OLAP are currently used, the challenges faced in data processing, and the potential benefits of integrating both systems. Focus groups will provide a platform for group discussions on how OLAP and OLTP could improve the scholarship system DiCicco-Bloom, B., & Crabtree, B. F. (2006).

3.4 Data Analysis

Data collected from interviews and focus groups was analyzed using thematic analysis to identify recurring themes and insights regarding how OLAP and OLTP impact the scholarship management process. This analysis highlighted participants' perceptions and uncover patterns in how these technologies influence data processing and system efficiency DiCicco-Bloom, B., & Crabtree, B. F. (2006).

3.5 Ethical Considerations

This research upholds ethical standards by obtaining informed consent, ensuring confidentiality, and protecting the privacy of participants. All data collection and analysis procedures will comply with SEAIT's ethical guidelines for research. According to Tripathy (2013), maintaining participant anonymity and confidentiality is essential to ethical research practices, particularly in studies involving personal data collection. The participants were informed about the research goals and their right to withdraw at any time during the process. By applying these ethical practices into the research design, the study not only protected participants' rights but also ensured the integrity and credibility of the research process.

4.0 ADVANCED HCI DESIGN

4.0 System Architecture

The architecture of the advanced HCI system designed for SEAIT's scholarship management integrates both Online Analytical Processing (OLAP) and Online Transaction Processing (OLTP) components to provide automation, efficient data handling and analysis. The system is built with a multi-tiered architecture:

Key Components and Interactions

- **User Interface:** Connects to the application layer, providing an interactive interface for users to access both OLAP and OLTP functions.
- **Application Layer:** Contains the core logic for OLAP and OLTP operations, facilitating data processing, real-time transactions, and interaction between the OLAP engine for data analysis and the OLTP engine for student registration and transaction management.
- **Database Layer:** The Database Layer stores and manages data, utilizing a relational database for OLTP transactions and a multidimensional data warehouse for OLAP analysis.
- **OLAP Engine**: Communicates with the data warehouse and application layer to process multidimensional data for complex queries.
- **OLTP Engine:** Handles real-time updates and transactions, maintaining data integrity across scholarship records.
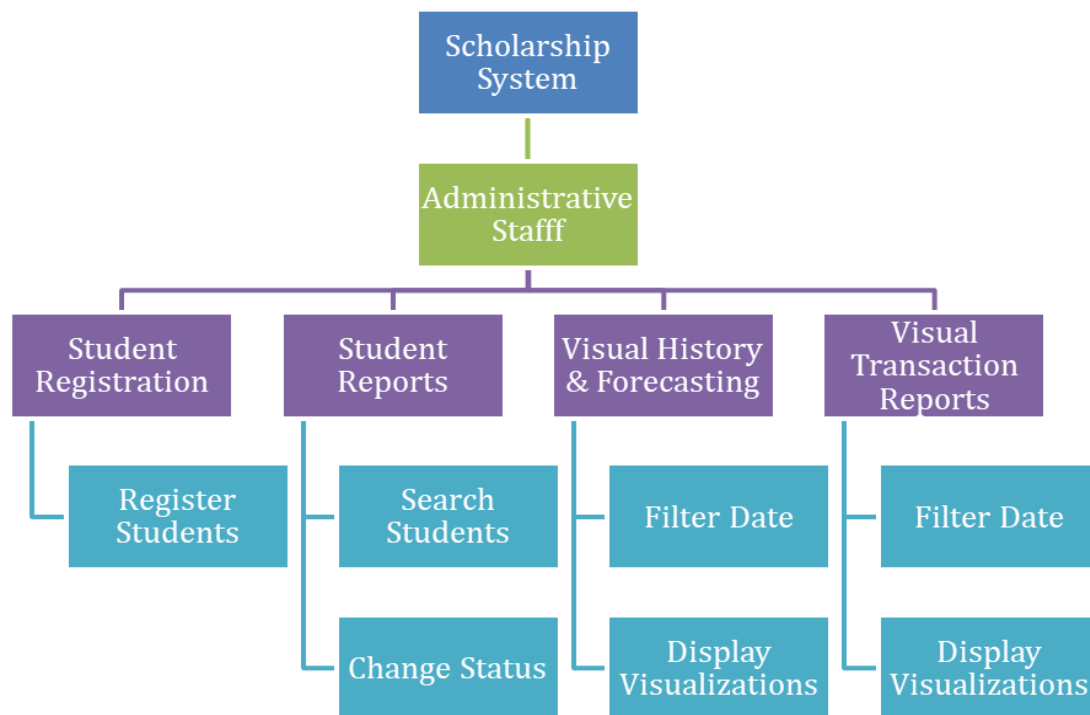
4.2 Features and Functionalities

This system provides a combination of OLAP and OLTP functionalities to support SEAIT scholarship management needs. Each feature is designed to address the research problem by enhancing usability, functionality, and responsiveness within the system.

The Features and functionalities:

Manage Student Data and Student Registration:

Simplify administrative tasks, allowing input, update, and retrieval of student information, ensuring data accuracy and accessibility.

Manage Analytics Report:

Provides dynamic insights into student performance and system usage, offering valuable data for informed decision-making.

Visual Transaction Reports and Visual Forecasting Reports:

Transform raw data into graphical representations, making trends and financial activities easier to interpret.

Performance Task Reports:
Track and assess achievements, supporting the monitoring of progress and compliance with scholarship requirements.
Automated Calculation:
Minimizes manual errors and accelerates computations, particularly in financial or performance-related areas.
Profile Visual Rating
Delivers an intuitive and graphical assessment of staff profiles, aiding in quick evaluations for eligibility or status review.

4.3 User Interface Design
The user interface (UI) is designed with principles of clarity, simplicity, and accessibility in mind. Key design considerations include:

Login Interface

Figure 1: Login Page

In this figure shows the scholarship system login page.

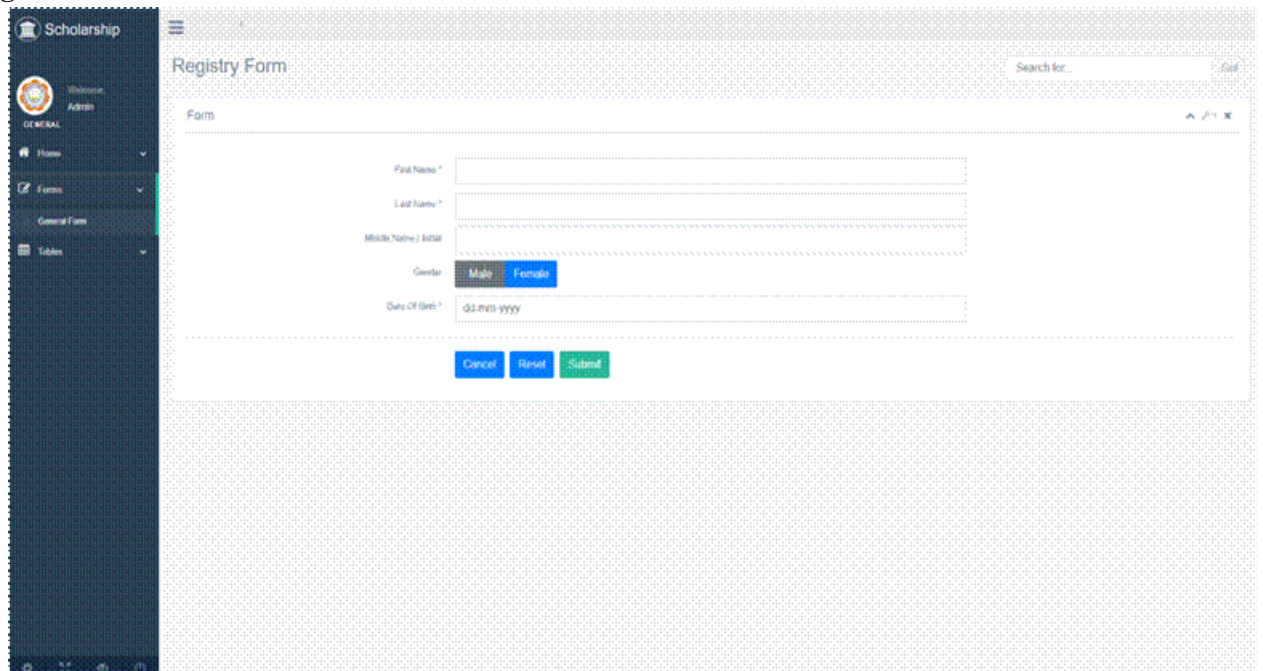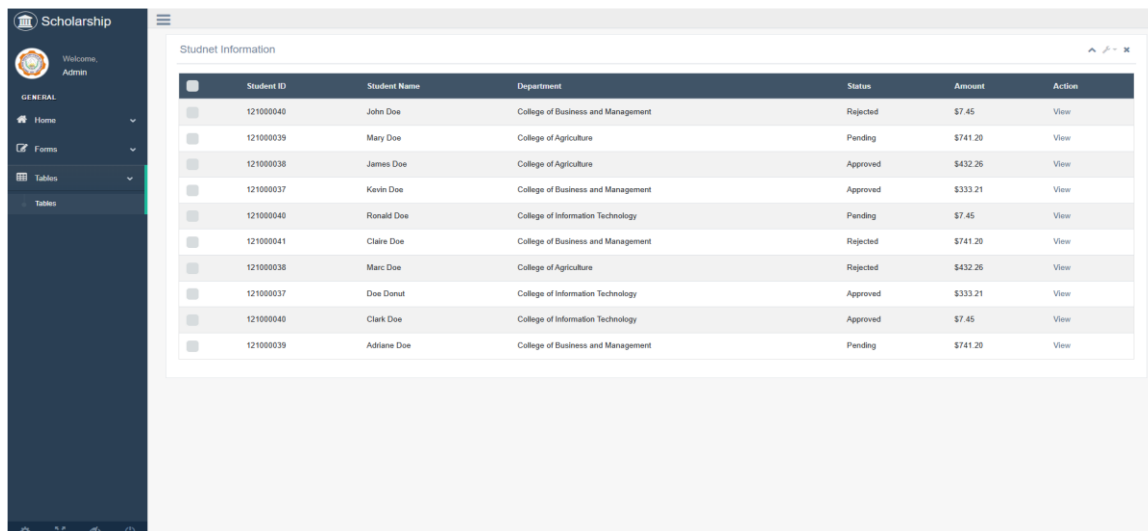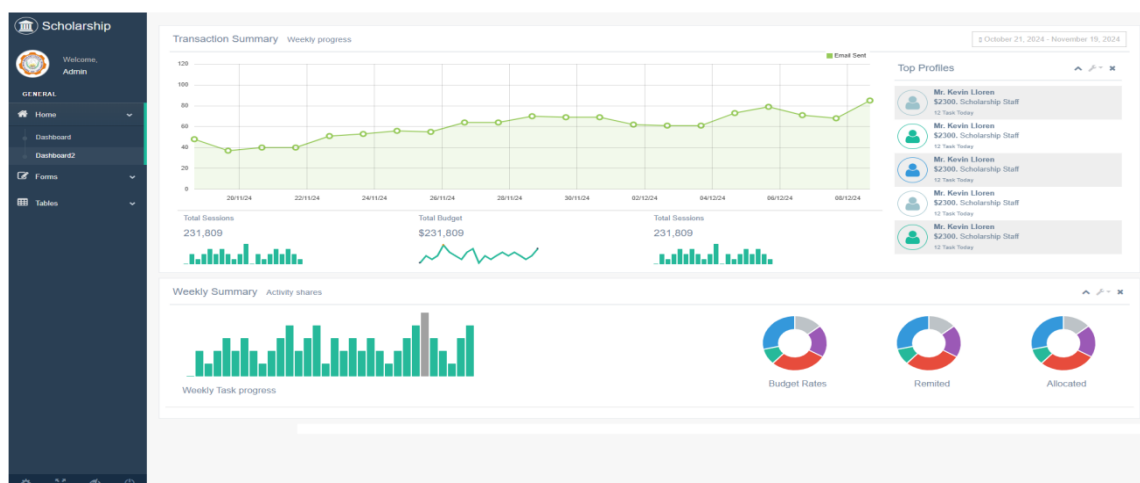**Student Registration**

Figure 2 Scholarship system registration.

Student Information Reports

In this figure shows the scholarship system's student information reports.

Visual Transaction Report

In this figure shows the scholarship system visual transaction report.

5.0 EVALUATION AND RESULTS

5.1 Usability Testing

Usability testing conducted with SEAIT staff members who use the scholarship system. Regarding familiarity with OLAP and OLTP concepts among the seven respondents, the responses showed varied levels of understanding. A minority expressed a strong familiarity with these concepts, indicating confidence in their expertise. Meanwhile, a significant proportion rated themselves as moderately familiar, suggesting a basic working knowledge. Another substantial group described their familiarity as limited, highlighting the need for further exposure or training in these areas.

5.2 Performance Metrics

The system's performance is evaluated through four key aspects: Data Analysis and Interpretation, Efficiency, Accuracy, and Integration. In terms of data analysis, the system demonstrates a strong ability to process and present information effectively, enabling users to make well-informed decisions. This capability is reflected in its consistent support for interpreting complex data, ensuring that users can extract meaningful insights to guide their actions. Efficiency is another notable feature of the system, as it allows users to complete essential tasks quickly and with minimal effort. Processes such as generating reports are simplified, significantly enhancing user productivity and reducing unnecessary delays. The system excels in accuracy, maintaining a high level of data integrity. Users can rely

on the system to deliver precise and error-free results, which is critical for decision-making and maintaining trust in the data.

The system's advance integration is to ensure a smooth flow of information. This capability minimizes disruptions and enhances the overall user experience, as data can be shared and utilized across various functions without issues. Collectively, these attributes underscore the system's reliability and effectiveness in addressing user needs and enhancing operational processes.

5.3 Comparative Analysis

The comparative analysis between SEAIT's existing scholarship system and the proposed advanced HCI system, which integrates OLAP and OLTP technologies, reveals notable differences in usability, speed, and data processing. The current system, primarily relying on OLTP, handles real-time transactional tasks such as student registration and scholarship processing. However, it faces challenges during peak periods, resulting in delays and inconsistencies. Additionally, the lack of advanced analytical tools limits the system's ability to generate valuable insights on scholarship trends, program effectiveness, and resource allocation, hindering strategic decision-making.

In contrast, the advanced HCI system addresses these challenges by combining OLAP's powerful data analysis capabilities with OLTP's real-time processing. This integration enhances usability by simplifying complex data through user-friendly visualizations and multidimensional reports, reducing cognitive load for staff. The system also improves speed, enabling faster data processing and decision-making. With real-time updates and predictive analytics, the advanced system offers a more efficient and accurate approach, empowering decision-makers with data-driven insights and improving overall operational efficiency. Thus, the integration of OLAP and OLTP technologies provides a substantial upgrade to SEAIT's scholarship management system.

5.4 Results and Findings

The qualitative interviews with seven administrative staff members revealed significant insights into the challenges and opportunities for improving the SEAIT Scholarship System through the integration of OLAP and OLTP technologies. Respondents had varied levels of experience in managing the system: three with less than one year, three with 1-3 years, and one with over six years. This range of experience provided a well-rounded perspective on the operational and strategic challenges faced by the scholarship system. The respondents had varying levels of experience with the system, as summarized in **Table 5.1** below:

This table provides an overview of the respondents' positions, experience, and familiarity with OLAP/OLTP

Table 5.1: Respondent Profiles

Respondents	Position at SEAIT	Years Involved with SEAIT
1	Administrative Staff	1-3 years
2	Administrative Staff	less than 1 year
3	Administrative Staff	1-3 years
4	Administrative Staff	less than 1 year
5	Administrative Staff	1-3 years
6	Administrative Staff	more than 6 years
7	Administrative Staff	less than 1 year

concepts, which frame their perspectives on the system's challenges and opportunities.

The recurring issue is the system's difficulty in handling large volumes of data during peak periods, such as enrollment. Five respondents identified a lack of analytical tools to generate detailed insights, such as identifying trends in scholarship applications or assessing program performance. Four respondents also expressed concerns about data accuracy, citing frequent inconsistencies caused by manual or outdated processes. Notably, the respondent with over six years of experience emphasized that while OLTP suffices for daily operations, it falls short in supporting long-term strategic planning, a critical need for the scholarship program's growth and effectiveness.

The potential benefits of integrating OLAP and OLTP technologies were consistently recognized by the respondents. All seven emphasized the necessity of real-time processing to minimize delays in application approvals

and scholarship awarding. Six respondents noted that OLAP could empower the system to generate deeper insights into student data, such as identifying patterns in scholarship success rates and understanding resource allocation trends. This integration was seen as a solution to enhance decision-making processes, optimize resource distribution, and improve overall operational efficiency.

The interviews revealed a gap between immediate operational needs and the system's capacity for long-term strategic analysis. Respondents highlighted that while current processes focus on managing daily transactions, they lack the capability to address broader organizational goals, such as evaluating the overall effectiveness of the scholarship program. This finding underscores the importance of integrating advanced analytical capabilities to bridge this gap and align the system with institutional objectives.

Therefore, findings suggest that the SEAIT Scholarship System faces significant challenges in both data processing and analysis, but integrating OLAP and OLTP technologies presents a viable solution. By addressing these limitations, the system could achieve greater efficiency, accuracy, and strategic utility, ultimately improving the scholarship program's effectiveness and accessibility.

5.5 Individual Respondent Analysis

- ➢ Respondent one is an administrative staff member who has been involved with the SEAIT scholarship office for 1-3 years. They stated they are familiar with the use of OLAP and OLTP. In the follow-up question, they said that OLAP could support improved decision-making by providing insights into student performance and resource allocation. However, they expressed frustration with the system's slow processing during peak periods, emphasizing the need for optimization to handle large volumes of student data more efficiently.
- ➢ Respondent two is an administrative staff member who has been involved with the SEAIT scholarship office for less than 1 year. They stated they are not familiar with the use of OLAP and OLTP. In the follow-up question, they said they needed more training to understand how OLAP works. They also noted that the current system struggles with data accuracy, often leading to discrepancies in records that complicate their tasks.
- ➢ Respondent three is an administrative staff member who has been involved with the SEAIT scholarship office for 1-3 years. They stated they are somewhat familiar with the use of OLAP and OLTP. In the follow-up question, they said they appreciated OLTP's effectiveness in processing real-time transactions but pointed out the lack of predictive capabilities. They suggested that OLAP could help forecast trends in scholarship applications and allocations.
- ➢ Respondent four is an administrative staff member who has been involved with the SEAIT scholarship office for less than 1 year. They stated they are not familiar with the use of OLAP and OLTP. In the follow-up question, they said they needed automated processes to reduce errors and improve data validation, noting that manual entry often leads to inconsistencies that delay report generation.
- ➢ Respondent five is an administrative staff member who has been involved with the SEAIT scholarship office for 1-3 years. They stated they are somewhat familiar with the use of OLAP and OLTP. In the follow-up question, they said they found the system usable once learned but indicated that more structured training could help staff leverage OLAP for trend analysis and strategic decision-making.
- ➢ Respondent six is an administrative staff member who has been involved with the SEAIT scholarship office for more than 6 years. They stated they are not familiar with the use of OLAP and OLTP. In the follow-up question, they said they faced challenges with slow processing during enrollment and stressed the importance of real-time processing to minimize delays in scholarship transactions.
- ➢ Respondent seven is an administrative staff member who has been involved with the SEAIT scholarship office for less than 1 year. They stated they are somewhat familiar with the use of OLAP and OLTP. In the follow-up question, they said they saw potential in OLAP for identifying trends in scholarship success rates but mentioned that the system's manual processes often result in errors, necessitating better data validation.

6.0 DISCUSSION
6.1 Interpretation of Findings

The findings of this study highlight critical challenges and opportunities within the SEAIT Scholarship System, addressing the research questions posed. The current reliance on OLTP for transactional processes has been

effective for real-time operations but shows significant limitations in handling large-scale data during peak periods. These challenges underscore the system's inadequacy in providing both operational efficiency and comprehensive data analysis, limiting the ability to evaluate program effectiveness and resource allocation. The integration of OLAP with OLTP was widely seen as a solution to these issues, offering advanced analytical capabilities that could uncover trends, evaluate scholarship success, and enhance real-time decision-making. The findings suggest that bridging this gap could significantly improve the accuracy, timeliness, and strategic utility of the scholarship system. These results have implications for advanced Human-Computer Interaction (HCI) by demonstrating the importance of user-centered, data-driven systems that facilitate both operational and strategic goals.

6.2 Contributions and Innovation

This research contributes to the HCI field by emphasizing the importance of integrating transactional and analytical data systems in contexts that require real-time processing and long-term planning. The proposed integration of OLAP and OLTP within the SEAIT Scholarship System represents an innovative approach to addressing common data management challenges in educational institutions. By providing an efficient, data-driven solution, this study highlights how advanced analytics can empower users to make informed decisions while enhancing system usability. Furthermore, the study demonstrates how HCI principles, such as efficiency, accuracy, and user satisfaction, can guide the development of more robust data management systems. The proposed integration model introduces a novel framework for combining operational and strategic functions, aligning technical capabilities with institutional goals to achieve greater impact.

6.3 Limitations and Future Work

Despite its contributions, this study has certain limitations. The sample size was limited to seven administrative staff members, which may not fully capture the diverse perspectives of all stakeholders, such as senior management. Additionally, the study primarily focused on qualitative insights, which may benefit from complementary quantitative analysis to validate findings further. Future research should explore the implementation of OLAP and OLTP integration in real-world scenarios to assess its practical feasibility and impact. Investigating the scalability of the proposed system across different institutional contexts would also provide valuable insights. Moreover, future work could involve the development and usability testing of a prototype system to refine its design and ensure alignment with user needs. By addressing these limitations, subsequent research could strengthen the evidence base and contribute to the broader adoption of integrated data management systems in educational settings.

7.0 CONCLUSION

7.1 Summary of Key Findings

This research explored integrating Online Analytical Processing (OLAP) with Online Transaction Processing (OLTP) in the SEAIT Scholarship System, focusing on Human-Computer Interaction (HCI). The current OLTP-only system, while suitable for daily transactions, faces delays during peak periods, data inconsistencies, and lacks analytical features, impacting productivity, decision-making, and usability. Incorporating OLAP addresses these issues by enhancing data visualization, real-time processing, and multidimensional analysis, improving efficiency, user satisfaction, and reducing cognitive load. The proposed system aligns with HCI principles by providing a user-centered, intuitive interface that supports both operational needs and strategic insights.

7.2 Final Remarks

The integration of OLAP and OLTP in the SEAIT Scholarship System enhances both operational efficiency and strategic decision-making in education. This research emphasizes the importance of balancing functionality and user experience, addressing diverse stakeholder needs. It highlights the transformative potential of merging analytical and transactional capabilities, serving as a model for user-centered data management systems. From an HCI perspective, the study advances the development of interactive systems prioritizing usability, efficiency, and innovation.

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APPENDICES

Appendix A: Interview Questions

1. What specific challenges do you face in managing student data within the current scholarship system?
2. Can you provide examples of situations where data management issues have affected decision-making or operations?
3. How does the current system handle large volumes of data, and what are its limitations?
4. How do you think real-time processing (OLTP) could be improved to better handle scholarship registrations and transactions?
5. What types of analyses or insights would be most beneficial for strategic planning and decision-making in the scholarship system?
6. In your opinion, how could combining real-time processing and strategic analysis improve overall data management?

7. How do you currently evaluate the effectiveness of the scholarship program?
8. What insights or trends would you like to uncover from student and scholarship data to improve program outcomes?
9. What benefits do you foresee from using advanced analytical tools like OLAP in the scholarship system?

Appendix B: Observation Notes

Observation Date: November 4, 2024
Location: Scholarship Office
Observer: Brendyll John Patricio
Participant: Administrative Staff
Description of Interaction:

· The staff logs into the system.
· The staff navigates to the "Student Information" section and selects a student's data for evaluation.
· Observations are made about the time it takes for the system to retrieve and display student data.
· The staff proceeds to generate analysis report, selecting specific filters for a targeted analysis.
· The staff took a minute to interpret data and level of task accomplished.

Appendix D: Thematic Code Analysis

D.1 Code Book

Theme	Code	Description	Quote
Current Challenges	Data Analysis	Difficulty in analyzing large volumes of student data, especially during peak times like enrollment.	"The system struggles to analyze high volumes of data, especially when a lot of students register."
	Data Inaccuracy	Errors and inconsistencies in data due to outdated processes or manual entry.	"We often have discrepancies in the records."
	Slow Processing	The system's lag during peak periods, leading to delayed transactions and reports.	"It takes too long to generate reports when everyone is using the system at once."
Impact of OLAP and OLTP Integration	Improved Analysis	OLAP's ability to analyze data trends, which supports strategic decision-making.	"OLAP could help us identify trends in scholarship success rates."
	Real-Time Processing	OLTP's capacity to manage real-time transactions and updates in the scholarship program.	"OLTP helps us process student registrations quickly and accurately."
Benefits of OLAP	Decision-Making	OLAP supports improved decision-making by providing insights into student performance and	"With OLAP, we can make better decisions about funding and student support."

		resource allocation.	
	Predictive Analysis	The potential of OLAP for forecasting trends in scholarship applications and allocations.	"OLAP can help us predict which programs are growing and adjust our resources accordingly."
System Usability	Ease of Use	How user-friendly and intuitive the system is for staff and administrators.	"The system is fairly easy to use once you get the hang of it."
	Training Needs	The need for more training or guidance for staff unfamiliar with OLAP and OLTP systems.	"I think many of us need more training to fully understand how OLAP works."
Data Accuracy and Integrity	Data Validation	Measures to ensure data accuracy and consistency across both systems.	"We need better data validation checks to avoid manual errors."
	Error Reduction	Using technology to minimize errors in data entry and processing.	"Automated processes should help reduce the human error in data input."